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Design of Power Sensor Based Test Instrument for Limb Muscle

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Abstract This study aims to develop a power sensor-based leg muscle test instrument where the instrument changes the concept from manual to digital and develops a manual for using the test tool. The products produced are the Power Limb Muscle Test Kit, and a manual for using the Power Limb Muscle Test Kit. This research was established by adjusting the research and development model of Borg & Gall. The development method used includes several stages: 1) investigating the contents of the product being developed, 2) elaborating the initial product, 3) expert validation, 4) field testing, 5) product modification. The sampling technique applied was purposive sampling with Phase I trials of 10 students of physical education, health and recreation, Sriwijaya University and Phase II trials of 20 students of sports education study program, Universitas Bina Darma. Additionally, from the Phase I trial, as many as 10 students of physical education, health and recreation showed 96% criteria of Very Eligible, subsequently from the Phase II trial, as many as 20 students of sports education study program showed 91% in the Very Eligible category. Based on these results it can be concluded that a power sensor-based leg muscle test tool can be used to measure leg muscles. The renewal of the results of this study is a measuring instrument that uses sensors as a medium for collecting data so that the results are more accurate, effective and efficient.

Keywords Test Kit, *Power* Limb Muscle, Sensor Based

1. Introduction

Sports significances and its existential parts forms qualitatively new standards, models, directions of life and oblige as a humanization area and human sports dimension [1]. The world health organization has established clear procedures concerning the minimum amount of physical action required to maintain human health and fitness. For example, it is recommended that ages between 18 and 64 get at least 150 minutes of moderate-intensity physical activity weekly or 75 minutes of vigorous-intensity physical activity [2]. The development of science and technology is felt to have abundant positive influences marked by the advance of technology utilized in sports. Technology has various utilities in the field of sports [3]. Technological innovation in sports can escalate the effectiveness, efficiency, and accuracy hence it may support in measuring *power* leg muscle. In today digital era, there is a requirement for a new revolution for the advance

of digital instruments of sports. Therefore, it easily accomplishes something has been estimated to be realized together into reality. The improvement of these sports equipment is an achievement for sports societies because it creates more advanced and modern sports. Facilities and infrastructure are required surely for the advance sports worldwide [4]. Any technology used in sport is based on the assumption of acquiring and enhancing skill acquisition and sporting performance [5]. The utilization of wearable technology in sports is to increase performance and avoid injury [6]. Technology produced by humans can make life better and easier, but it can also make human life difficult [7]. Devices used to measure a person's physical quantity have become a part of many people's daily lives. While simple devices primarily produce statistical values from the numbers measured or calculate events in a more specific sport [8]. The new technology in this research is a *power sensor based test tool for limb muscle.*

Power is the explosive power of a muscle or the ability of a group of muscles to contract in a short time [9]. Leg muscle power is the element of maximum speed and maximum strength resulting from leg muscle contraction [10]. Leg muscles are very essential and compulsory for almost all sports since it is a basic physical skill for an athlete that wants to be improved. Human needs progressively lead individuals establish technological revolutions and new tracks for sports organizations through advanced instruments [11]. Lower body strength was measured through the vertical jump test with the results used as a measure of neuromuscular fatigue and athlete readiness [12]. The newest improvements in technological invention in sports are needed for facilities and infrastructure. The technological innovation then is projected to escalate effectiveness, efficiency, and accuracy hence it can contribute in more valid tests and measurements. The innovative technology in this research is sensor-based test and measurement technology for vertical jump. It purposes to measure the jump height designed by utilizing digital technology. The significance of research is to help sports coaches and educators to train young athletes so that they can improve their jumping capability. It is because jumping becomes an ultimate method in practically all sports. Furthermore, the general designation of this research is to modify the guidebook test and measurement instruments towards the technology utilization. At the end, the research projection is to escalate the test equipment validity level.

Vertical jumps are vital aspects in many sports [13]. The current test instruments and leg muscle power measurement (vertical jump) have been observed during the physical education students undertake physical test still use the manual method. The athlete or tested whose one hand has been smeared with flour, stands, raises the hand attached to the wall where the tape measure has been glued, then the tested jumps as high as possible with his hand touching the meter which has been glued to the wall, the difference between the height of the hand and the height achieved is the result measured from the vertical jump [14] [15] [16] [17] [18].

This has actually become a matter for which the test validity and measurement of *vertical jumps* is debatable since it is not impossible when the *tester* makes a jump, not intermittently the tip of the hand or finger touching the meter which cannot be noticed by the evaluator. Accordingly, it is frequently not conjure that athletes have to jump for repeated measurement. Besides, the result of flour sticking to the meter wall is not imaginary making the evaluator doubt to decide where the completion point of the achievement *tester's* is. Therefore, the assessment must smear the flour stuck to the meter wall before the *testator* jumps back. It spends plentiful energy and effort. At that time, whether it was the *tester* who conducted the test and the evaluation that measured the test, it is the best if in the digitalization period there should be appropriate technology utilization to hold up the results and time efficiency. It is projected that there will be an appropriate technological innovation to assist and realize the test and leg muscles power measurement. Therefore, those test and measurement are more accurate and its validity is incontestable because of the technological media utilization. Moreover, it is estimated to be competent to deprive the misgivings that have occurred so far.

The previous research examined 3 vertical jumps assessed biomechanically using sensors [19]. Estimate the reliability and validity of the criteria from the Jump and Reach Tests for assessing squat, countermovement, and drop jump performance [20]. Vertical jump test using two-dimensional motion capture (Mocap), micro G-Flight sensor, and PUSH accelerometer technology. This instrument is not connected to an android mobile phone [21]. Develop a digital-based test instrument volleyball service skills [22]. Develop an Android-based model of measurement in shot put [23]. Develop a product an android application for the basic elements of rhythmic gymnastics [24]. So from the research gap researchers are interested in developing a sensor-based vertical jump test instrument that is connected to an Android mobile phone. This tool is expected to be able to answer the problems that so far the vertical jump test is still done manually.

2. Material Methods

This research belongs to qualitative research and development studies. It is utilized since the research based on the issues carried [25]. In this study, the research sample does not recognize but the research subject, the subject is taken from the entire object under research and is projected to exemplify the entire population [26]. The subject sampling of the research was taken by using the total sampling technique. The total sampling was chosen because [27] the total population is less than 100 and the entire population is the subject of all research. Then the research subjects will be explained in Table 1 below:

The approach used in this research is [28] a process or steps to develop a new product or improve an existing product, and can be accounted for. Development focuses not only on needs analysis, but also on broad issues of early-late analysis, such as contextual analysis [29]. This study uses a development model from Borg and Gall. Research and development process of the research utilizes quantitative approach. Meanwhile, the research design is *Research* & Development (R&D) from Borg and Gall which consists of ten steps, among others [30]. This study used a Research and Development approach because it developed a new instrument to measure leg muscle power using sensors. so it is appropriate to use this development research method with the following research stages:

1) Research and Information Collecting
2) Planning
3) Develop Preliminary of Product
4) Preliminary Field Testing
5) Main Product Revision
6) Main Field Test
7) Operational Product Revision
8) Operational Field Testing
9) Final Product Revision
10) Dissemination and Implementation

For more details regarding the development steps that will be carried out by researchers can be seen in Figure 1 below:

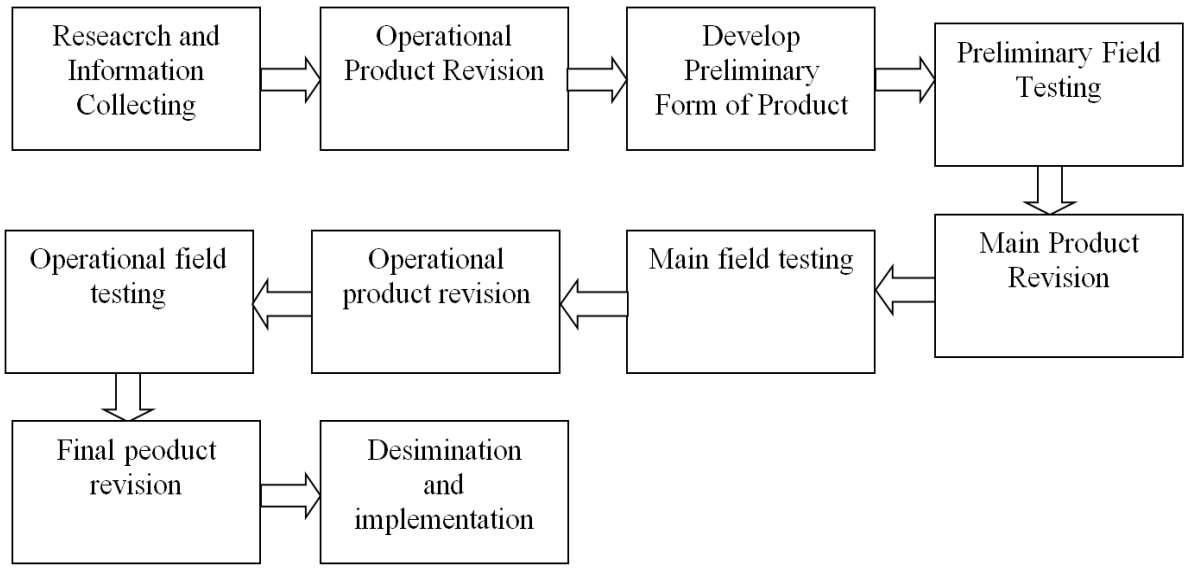


Figure 1. Development Research Steps Borg and Gall

Table 1. Criteria and Research Subjects

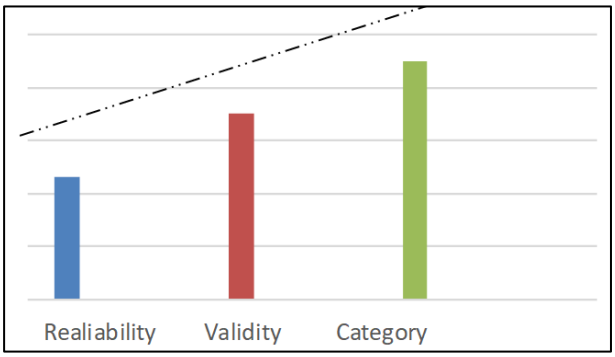
No	Research Phase	Number of Subjects	Criteria	Instrument
1	Initial Product Design	3	3 sports lecturers	Interview
2	Expert Evaluation	3	1 IT expert 1 Measurement test expert 1 Sports academic	Interview
3	Small Group Try Out	10	Study Program Physical Education Students	Tools sensor-based leg muscle power test and measurement
4	Field Try Group	20	Study Program Physical Education Students	

The data collection technique in this study was using research instruments. The research instrument is a tool used to measure the observed natural and social events (research variables) [31]. Instruments are tools or facilities used by researchers in collecting data so that their work is easier and the results are better, in the sense of being more efficient, complete, and systematic so that they are easy to process [25]. From the understanding of research instruments according to the experts above, it can be concluded that research instruments are research methods carried out to measure and retrieve data directly from the field through empirical and systematic studies. Before the test instrument (data collection tool) is used, the researcher conducts a test of the instrument, the purpose of the instrument test is to see the level of test reliability and test validity of the instrument that the researcher has made. Instrument trials were conducted on similar subjects outside of the research subject. The results of test reliability and test validity of instrument variables can be seen in table 2 below:

Table 2. Test Result Instrument

No	Reliability Of The Tes	Validity Of The Tes	Category
1	0.82	0.86	Very Hight

From table 2 it can be seen that the results of the instrument testing that the researcher did were in the very high category so that the instrument that the researcher made could be distributed to the research subjects. An explanation of the results of table 2 can be seen in Figure 2 of the histogram below.



Gambar 2. Histogram Test Result Instrument

The analysis technique in this research aims to organize the data in a meaningful way so that it can be understood. This technique is used to get the results of quantitative data analysis with percentages carried out by distributing questionnaires to test subjects. The formula for data processing from the distribution of questionnaires per test subject is as follows:

$$P = \frac{X}{X_i} x100\%$$

P = Percentage of evaluation results of test subjects

X = Number of score answers by test subjects

Xi = Maximum number of answers in the aspect of assessment by test subjects

100% = Constant

The results of the questionnaire were analyzed with the following criteria:

Table 3. Likert Scale Category

Rating	Value
Strongly Disagree	1
Disagree	2
Medium	3
Agree	4
Strongly Agree	5

With a Likert scale, the variables to be measured are translated into variable indicators. Then the indicator is used as a starting point for the preparation of instrument items which can be in the form of statements or questions. The data obtained through a questionnaire was then tested using the percentage test. The percentage test will be tested using the formula:

$$P = \frac{F}{N} x100\%$$

P = Percentage
F = Total obtained
N = Number of respondents

The collected data were analyzed using quantitative descriptive analysis techniques which were expressed in the distribution of scores and percentages of the predetermined rating scale categories. After presenting in percentage form, the next step is to describe and draw conclusions about each indicator. The suitability of aspects in developing test equipment and measuring *power* leg muscle based on sensors can use the following table:

Table 4. Eligibility Category

Percentage of Achievement	Interpretation
< 21%	Strongly Disagree
21% - 40%	Disagree
41% - 60%	Moderate
61% - 80%	Agree
81% - 100%	Strongly Agree

In Table 4 mentioned percentage achieved, the scale of values and interpretation. To determine the feasibility of using media tools. Table 4 as a reference for assessing the data generated from expert validation.

3. Result and Discussion

3.1. Result

In this time, the vertical jumps still use manual measurement methods without current science and technology. It becomes the disadvantages especially in digital era because there is no better technology in the field sports for measuring high jumps. Hence, it is expected that this instrument can response the encounters of science and technology, especially in sports advance; testing and measurement. Furthermore, to response the challenge of accelerating the development of sports technology, scientific studies (research) must be carried out with appropriate technology to produce innovative products that can answer the challenges of the digitalization era of sports.

In addition, in this study the researchers developed test and measurement instruments for vertical jumps by transitioning traditional (manual) test and measurement instruments toward the technology that is projected to meet the encounters of digital period as well as testing and measurement. The tool accuracy is beyond doubt since it has a sensor to measure a person's jump height. When testing and measuring vertical jump, where the model stands on a platform designed as a vertical jump test and measurement instrument, the model performs a vertical jump, the sensor detects the leg jump closest to the sensor, the combined results are combined. on Android, measurement results are measured in centimetres.

3.2. Collecting Information on Test Equipment and Measurement of Power of Limb Muscles

Figure 3. Grafik Needs Analysis Chart

After undertaking the research process, the researcher expects to analyze the needs to see how far the needs of the users of the tool are by calculating the quantitative data that has been explained through the needs analysis questionnaire. The users here are 10 users including trainers for 5 sports; among others water sports, taekwondo, basketball games, volleyball games, athletics, along with 5 athletes as models who routinely carry out vertical jump tests and measurements. From these results it is known that the comparison is as follows:

100% of athletes and coaches already know the vertical jump test and measurement tools. Moreover, there are 70% of athletes and coaches consider that the vertical jump test is ineffective and has doubtful validity. Next result is 100% of athletes and coaches have never known and used digital tests. However, 100% of athletes and coaches require digital vertical test kits and measuring devices to measure leg muscle strength.

3.3. Product Design of Sensor-Based Leg Muscle Power Test Equipment

The design of vertical jump sensor-based test and measurement instruments developed by researchers can be seen in the description below, along with information about the tools parts utilized to design the product development of vertical jump sensor-based test and measurement tools

Modalities Test and Measurement Equipment *Power* Limb MuscleBased Censorship:

Objective: To measure *power* limb muscle

Equipment: Equipment test and measurement *power* muscle leg Sensor-Based

Implementation

1) *Testing* stand on the mat
2) The sensor is positioned on the pad to measure the height of the jump
3) *Testing* implements a *vertical jump*
4) The part is measured by utilizing cm
5) The result of the jump that is measured is the foot closest to the sensor
6) The jump result is linked to the Android device for the computation.
7) The classification is categorized as correct if the *tester* jumps up with straight legs.
8) The classification is categorized as fail if the *tester* jumps up with bent legs (bent knees).

3.4. Product Trial of Phase I and Phase II

Trials were directed on 10 students of physical education, health and recreation, Sriwijaya University. It targets to deliver feedback and assessment of the trials results taken on samples in order to comprehend the level of tool efficacy and the sensor-based leg muscle power test instrument effectiveness. Therefore, it complies the theoretically and empirically feasible standards. The data achieved is then utilized as a base to create modifications at the next stage. The results achieved in the field after leading the Phase I trial are the work of test tool for leg muscle power. The sensor-based system utilized worked moderately well and the jumps results taken are interpreted perfectly by the distance calculation sensor (cm) which is linked directly to the IOP system on Android that has been fine listed. From the trials results conducted by researchers on 10 students of physical education, health and recreation, Sriwijaya University, it can be perceived that the sample

considered in the questionnaire form by agglomerating them into 2 aspects, namely, material clarity and material aspects. Therefore, of the 20 questions, the results of athletes' answers then are grouped into 5 categories, namely SS (Strongly Agree), S (Agree), SD (Medium), TS (Disagree), STS (Strongly Disagree) with an assessment of 5,4,3,2,1. In the first phase of the test on athletes resulted outlined through the presentation formula for the maximum number of answers/scores x 100% with the following results.

The 10 small groups in trial I samples with a total score of 1,938 were divided by a maximum score of 2,000 x 100%. It was resulted in a presentation of 96% with Very Eligible criteria. Meanwhile, the 20 trial II samples showed a total score of 1,833 divided by a maximum score of 2,000 x 100% that resulting in a presentation of 91% with the criteria of Very Eligible.

Table 5. Results of Phase I and Phase II Trial Research

No	Respondents	Total	Score Maximum Score	Percentage
1	X10	1,938	2,000	96%
2	X20	1,833	2,000	91%
Very Eligible				

Table 5. Shows the results of the research in the first phase of the trial phase, all of which are in the Very Eligible category. To see the first stage of the trial results, it can be seen in Figure 5. The histogram is as follows:

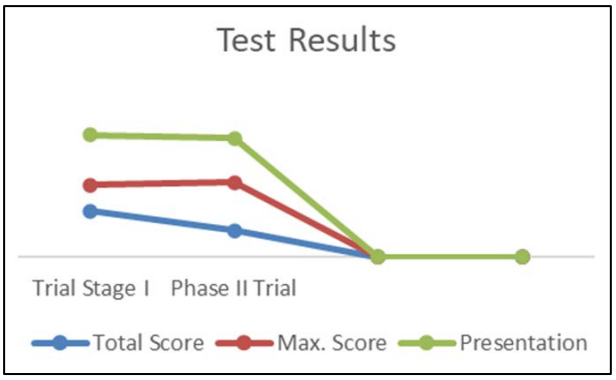


Figure 4. Design Tool Limb Muscle Power Test Sensor-Based

The results of Figure 5. The lines above explain that the total score, the maximum score, has a very close relationship with the percentage results, the more the number of subjects studied, the higher the percentage level. So from the results of trials carried out this product is said to be very feasible to be disseminated.

4. Discussion

Several previous studies have attempted to develop technology-based tests and measurements such as: touched on the effectiveness and efficiency of the product development of exercise programs general preparation physical based on Android [32], designed and evaluated a mobile application that could be used as an alternative in measuring the Physical Fitness [33], developed a volleyball skill test instrument[34] [35], produce development products for physical education sport and health learning media based on android applications[36]. The development of the vertical jump test instrument that has ever been of digital based vertical jump test instruments [37] and developed with camera kinect [38]. Determine the reliability of a simple and quick test to assess isometric posterior lower limb muscle force [39]. Developed the validity, and reliability of manual muscle testing equipment with integrated limb position sensor [40]. However, this development has not been integrated with mobile phones with android.

The sensor-based instrument for leg muscle power test that the researcher developed used jump distance calculation. It was related to the android system which was very applicable. The instrument utilized technology hence the tests result performed without any hesitation for the validity grade. The using of applicable technology influenced the sensor-based leg muscle power test validity. The improvement process was performed through research and development procedures included planning, production and evaluation. This product was advanced with the expert's assist who mastered engineering of electronics and mechatronic. This progress went through numerous phases, among others the design, the tool frame and the last but not least was the instrument installation phase which connects to the android system. Subsequently, the initial product was produced and then the expert carried out the appraisal. Additionally, the product then was tested on the samples. At the valuation stage, it was carried out on test and measurement experts; IT media experts and sports academics experts. The next research phase was the Phase I and Phase II product trials.

In the progression of validating test and measurement experts, IT media experts and sports academics utilize content validity [18]. It was validity based on the expert opinion about the instrument feasibility while it was used to collect the data. Evidence of content validity is achieved by experts' agreement, namely test and measurement experts, technology media experts and sports academics. The validation showed the continuation to the next phase because the tool is declared feasible and there are no modifications to this test instrument.

The quality of "Development of Sensor-Based Limb Muscle Power Test Equipment" was included in the category of "**Very Eligible**". It could be proven from the results of the assessment analysis which was showed "**Very Eligible**" from the three experts, both test and measurement experts, technology media experts and sports academics as well as in trial assessment (Phase I trial and Phase II). Samples or Respondents were eager to this product because they were interested to try it. Moreover,

they enthusiastically asked questions about how it works and applies. This product can be distributed as a sensor-based leg muscle power test tool. Based on the research findings, it was comprehended that there were advantages and disadvantages of this instrument when the researchers conducted Phase I and Phase II trials. The benefits included (1) Providing efficiency and effectiveness to the sample in conducting tests and measurements, especially leg muscle power, (2) Helping the sample to identify the height of the jump, (3) The tool is portable, means it can be carried anywhere, (4) Increasing knowledge about technological advances, (5) Measurements are made by jumping between the feet closest to the sensor. (6) The jump result is linked through the android system, (7) Changing the manual tool towards the use of technology. However, there were still some disadvantages of this product, namely (1) cannot read jump heights above 3.5 meters. (2) The board must be covered by a mat hence when jumping the sample feels soft. Novel technologies considered valid and reliable for the vertical jump height with jump-and-reach testing measurement of [41]

5. Conclusions

Based on the research results, the researcher concludes that sensor-based test tool for leg muscle power is possible to be used in conducting tests and evaluating vertical jumps. The development of the test tool that the researcher developed makes sports stakeholders can perceive more easily the tests and measurements, especially for the vertical jumps athletes. Besides, it can also be utilized as evaluation material, particularly in improving athlete's jumps.

This research development creates sensor-based product for leg muscle power test which is projected to work effectively and efficiently. Therefore, it can attract the coaches along with athletes to regulate the results of athlete's jump. In addition, it helps the future researchers too in conducting the same research. This test instrument is projected to deliver accessibility in assessing the athlete's jump height. Besides, it was also estimated for the accuracy to evaluate the athlete's ability results to jump. In the implementation of tests and measurements, the data then put directly into the Input-Output Processor (IOP) device on the Android system.

6. Suggestion

The results of this study can be used to measure leg muscle power. This test instrument already uses sensor technology to make it easier to do leg power tests and the resulting data is more valid. This instrument is also a new invention resulting from the development of a leg muscle power test instrument by previous researchers. This instrument is appropriate for use by school teachers and lecturers in tertiary institutions to measure the leg muscle abilities of students and students. This research can be developed by other researchers so that it will produce new, better research.

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