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# Developing a Maximal Leg Power Device Using Ultrasonic Sensor with Liquid Crystal Display

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## ABSTRACT

Auto technology is a new breakthrough in developing devices related to sports enhancement. Therefore, the purpose of this study was to develop a device based on ultrasonic sensor using a liquid crystal display to maximise leg power. The components of the new device are a microcontroller ATMEGA-328, liquid crystal display and HC-SR04 ultrasonic sensor. The study was conducted in the laboratory of sport science, faculty of sport and health education, Indonesia University of Education. Ten students from Sport Science study program were recruited as samples. A prototype of maximal leg power measurement device was invented and results showed that there were no significant differences between auto and manual testing. However, the device can be used to determine maximal leg power more accurately, easily and effectively.

*Keywords:* Leg power, liquid crystal display, Microcontroller, Ultrasonic sensor, Vertical jump

## INTRODUCTION

According to (Dolezal, FRESE, & LLEWELLYN, 2016); Choukou, Laffaye, & Taiar, 2014); Buckthorpe, Morris, & Folland, 2012; Cancelacarral et al., 2016) technological advances have contributed to rapid innovations especially in all fields especially in sports. According to (Rusdiana et al., 2016) Australia, Germany, China, and South Korea are already using advanced technology in sports science by setting up sports laboratories such as JISS (Japan Institute of Sports Sciences), BIS (Beijing Institute of Sports), and AIS (Australian Institute of Sports)in an effort to improve performance in sports.

However, in Indonesia, investment in high-technology sports equipment is limited due to costs. An athlete's performance can be measured through use of technology via physical fitness test and measurement.

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(Samozino, Morin, Hintzy, & Belli, 2008); Cormie, McCAULLEY, & McBRIDE, 2007); Cormie, Mccaulley, Triplett, & Mcbride, 2007) state that test is an instrument that is used to obtain information about a person or an object, while the measurement is the process of gathering information. Therefore, tests and measurements using technology have high validity compared with manual testing. Additionally, technology driven devices help to effectively evaluate an athlete's performance by identifying his/her weaknesses or mistakes that can later be addressed during training (Feeney, Stanhope, Kaminski, Machi, & Jaric, 2016). Physical fitness refers to flexibility, speed, strength and endurance. Muscle explosive power or often referred to as power is an important component of physical fitness. Pazin, Bozic, Bobana, Nedeljkovic, & Jaric, 2011) suggest that strength is the ability of muscles to perform contractions in order to raise tension on a muscle.

Power muscle limb (Pazin, Berjan, Nedeljkovic, Markovic, & Jaric, 2013); Hasselgren, Olsson, & Nyberg, 2011) especially leg power is needed in almost all sports, including athletics, aquatics and games such as basketball, soccer, badminton, tennis and other sports (Cuk, Markovic, Nedeljkovic, Ugarkovic, Kukolj, & Jaric, 2014); Lesinski, Muehlbauer, & Granacher, 2016). According to (Sleivert & Taingahue, 2004) explosive power is the ability to perform maximum strength in a short time. Pazin, Berjan, Nedeljkovic, Markovic, & Jaric, 2013 define power as the ability of muscles to direct maximum force in a very quick time. In order to obtain a large repulsion and high speed, an athlete must have great power leg. So powerful legs are the driving force at the time of repulsion in order to obtain vertical velocity (Shu et al., 2016; Beck, Ye, & Wages, 2015).

A conventional or modern technological approach can be used to measure the power of limbs; the former is a vertical jump test using a ruler and chalk and manually calculated based on scores. These results are used as an indicator to measure the power of the leg. The higher the jump, the greater the leg power (Feeney et al., 2016, 2016; Arnold, Joke, & Megan, 2015).

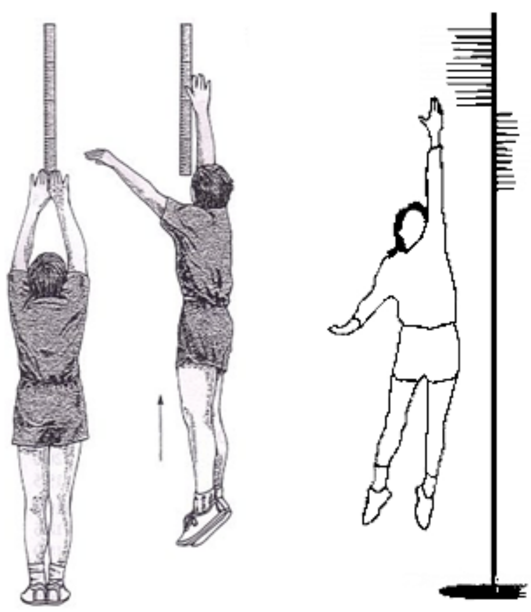

*Figure 1.* Leg power testing manual using vertical jump technique

Along with technological advances in the sport, especially in the field of test and measurement, various tests and measurements of leg power have been developed and mass produced. One is manufactured by the Japanese company Takei such as vertical jump mat and Takei 5414 jump test product. This instrument is equipped with sensors and LED display. The calculation result is automatically recorded (Whitmer, Fry, Forsythe, Andre, Lane, Hudy, & Honnold, 2015).

*Figure 2.* Leg power testing device (Takei jump 5414 and vertical jump mat)

The other leg power measuring device which is more accurate, using a three-dimensional approach, is AMTI Force and Motion. The AccuPower is AMTI's portable solution for jumping and power analysis. It uses Hall Effect sensors to accurately measure ground reaction forces while allowing for internal amplification and high overload protection on all axes. The AccuPower interfaces directly with a computer via a convenient USB or RS-232 connection and comes bundled with a powerful AccuPower Software (Belli et al., 2008).

*Figure 3.* Leg power Device 3D AMTI Accupower and software analysis

Thus, the purpose of this study was to develop a tool to measure the power limbs through a vertical jump test based on auto ultrasonic sensor with a liquid crystal LED display. This tool can be used for measuring leg power in improving the performance of athletes.

## METHODS

The Research and Development (R & D) method used to test the effectiveness of the product measure leg power using vertical jump test. Below is a step by step illustration of the research and development method (Choukou et al., 2014).

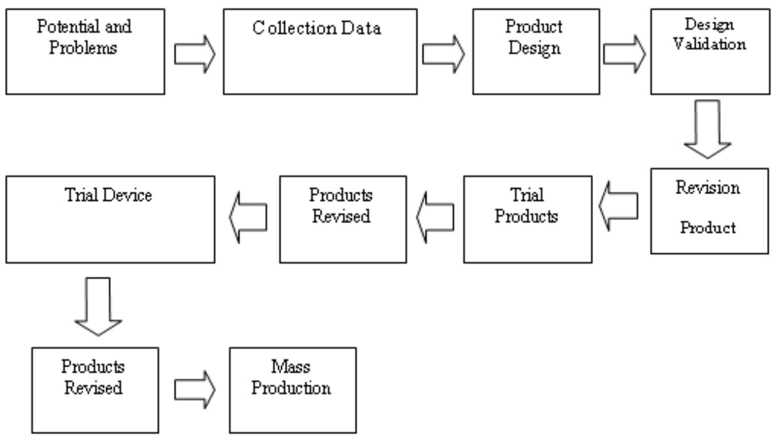


*Figure 4.* Diagram R & D Research methods procedure

### Design Validation

According to (Choukou et al., 2014) a process design validation activity is vital to evaluate the design of products. Thus this tool must also be judged on its effectiveness by experts.

### Product design improvement

Design improvements are made subject to feedback and validation from experts. Weaknesses are addressed and if there are no problems detected, the product will be tested directly.

**Trial Product.** The trial product is a type of feasibility assessment device. In this case the trial products will be used vis a vis the samples according to the needs of analysis. Tests are also conducted to determine the device quality.

## RESULTS DAN DISCUSSIONS

### Prototype Product

This device measures leg power using vertical jump technique approach and the results are displayed in the box on the Liquid Crystal Display.

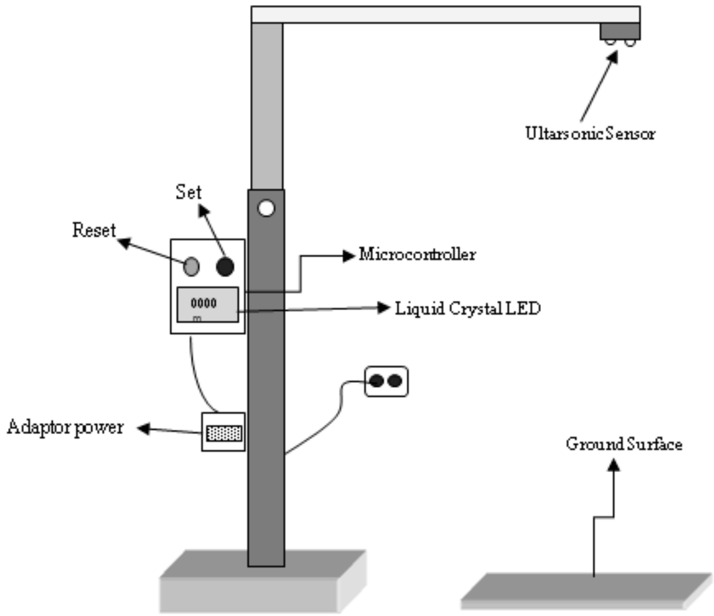


*Figure 5.* Prototype of leg power device

## Product Development

Sensor circuit: The sensor used is HC-SR04 ultrasonic sensor which serves as the sender, receiver and controller of ultrasonic waves. The sensor is placed in the upper beam pole which aims to detect an object in the radar sensor. When the mast is lowered or increased, it will adjust the height of the sample, so long as these sensors can reach an object and perform the calculation.

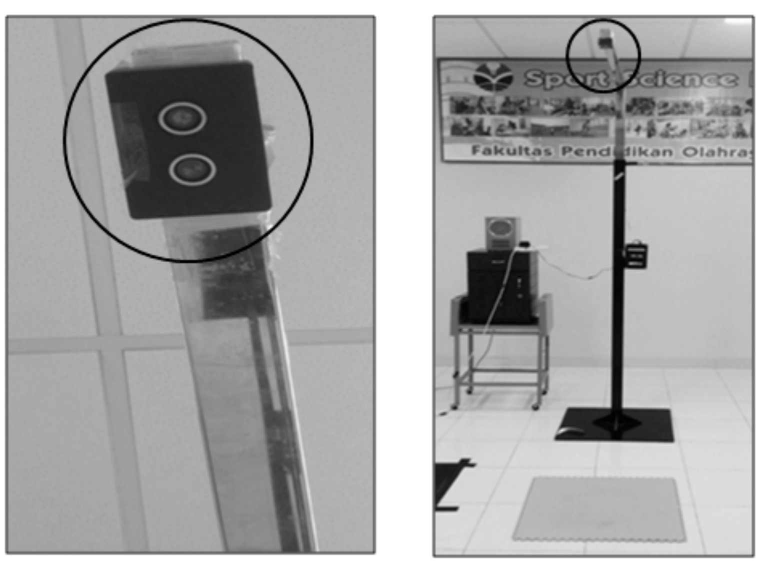

*Figure 6.* Sensor HC-SR04 ultrasonic

Bar and Cables: The pole is made from iron and stainless steel. The cable is a special sensor cable 1.5 mm diameter with an overall length of 4 meters. It is connected through the top of the pole and made in such a way to make it look presentable. When the mast is raised or lowered to adjust the cable, it will not affect the latter.

**Liquid Crystal LED Display.** On the surface of the box, there is a liquid crystal display, reset switch and set. The LCD serves as a data viewer in the form of characters, letters, numbers or graphs. The reset switch works to restore the calculation or if an error occurred in the calculation. The switch is set to work when the microcontroller is powered or ready for use with an object detected by the sensor. The button then sets the time used before the results of automatic calculations. While the components in the box is a microcontroller, breadboard, resistors and wires microcontroller as the centre of the data processing, in this tool microcontroller serves as the Reset-Set, the incoming sensor data, the incoming voltage and counter. The microcontroller is ATMEGA 328, and connects Board Arduino Uno to the computer using a USB cable or power supply with AC to DC adapter or battery to power it. Resistors are electronic components with two poles that can be used to stem the flow of electricity when there is electrical voltage between the two poles. The resistors are usually part of an electronic circuit. Breadboard is a basic construction of an electronic circuit and is the prototype of an electronic circuit.

**How the device works.** The first step is to connect the adapter to an AC voltage source, push the "ON" button on the adapter, then the Liquid Crystal Display will be up and running.

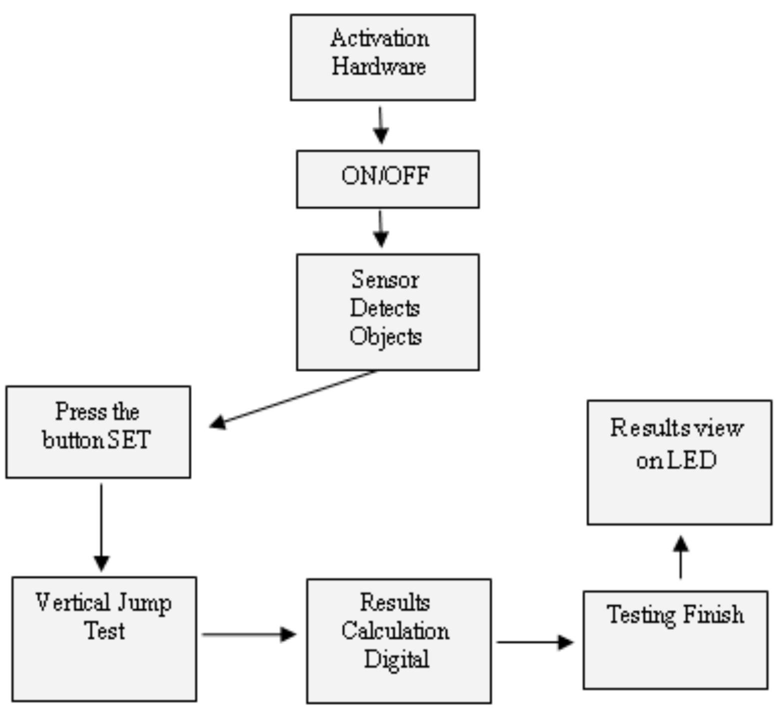


*Figure 7.* Structure of the workings device system

Then Ultrasonic Sensor HC SR-04 will detect an object. Before starting the test, make sure the object is in place and once detected the distance between the head of the sample to the sensor and then press the button on the box set. Then sample the motion jump to the fullest. The object jumps should lead to an ultrasonic sensor is above the pole. After that, the results will appear on the LCD.

**Trial Product.** The trial involved 10 students from the sport science program and the experiment was conducted in the laboratory of the faculty.


*Figure 8.* Trial device testing

Table 1 shows the results of average value of leg power for manual, 52.1cm, and auto, 49.3cm. The average value of vertical jump test manually and using the sensor was different, the value of the former is lower compared, a difference of less than 3cm.

Table 1
*Results of trial leg power test auto vs manual*

| No | Subject | Results (cm) | |
|---|---|---|---|
| | | Vertical jump test manual | Vertical jump test auto |
| 1 | A | 54 | 51 |
| 2 | B | 56 | 52 |
| 3 | C | 52 | 49 |
| 4 | D | 47 | 45 |
| 5 | E | 54 | 52 |
| 6 | F | 53 | 49 |
| 7 | G | 44 | 40 |
| 8 | H | 58 | 56 |
| 9 | I | 61 | 59 |
| 10 | J | 42 | 40 |
| | Sum | 521 | 493 |
| | Means | 52.1 | 49.3 |

These results indicate that the manual test is less accurate due to human error. However, results show the t value 26.022 < 2.262, thus, H0 is accepted. Which means there is no significant difference using an auto measuring device and manual.

## CONCLUSION

This device can be used to determine the maximum leg force and power more accurately, easily and effectively. Results show there was no significant differences between auto and manual testing. However, the average value was different, the auto test was lower than manual. This means that the auto test is more accurate than the manual.

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