Design of automatic pull-up and chin-up machine as automatic tools to count pull-up and chin-up repetition test

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Abstract

The Purpose study currently there are no clear rules and tools about how minimum a height of lift when doing pull-ups or chin-ups, which are categorized as one repetition batch. Thus, this research aims to make an automatic sensor to count the number of repetitions of pull-ups and chin-ups automatically. Material and method overall, 15 male athletes participated in this study. Making automatic pull-ups and chin-ups tools using an infrared sensor (microchip, Arduino Uno Atmega328p model) programmed in C ++ language to measure the minimum height limit of a person when doing pull-ups or chin-ups. In this study, participants were required to perform 2 types of measurement movements, namely pull-ups and chin-ups. Results this study shows a strong correlation between automatic and manual tests. This can be seen by the significance of the correlation test between automatic and manual pull-ups ($p = 0.004$), and also automatic and manual chin-up tests ($p = 0.001$). Conclusion the automatic pull-up and chin-up tool successfully perform automatic measurements of the pull-up and chin-up tests after being compared to the measurements using a meter stick.

Keywords

Automatic sensor, Fitness, Gym, Body building

1. Introduction

Body building or fitness is an activity that aims to increase a person's muscle mass [1]. Generally, bodybuilders or athletes use this concept to increase their strength or power [2,3]. They believe that by increasing muscle mass, their muscle power index will increase. Controlling nutritional intake, creating a strict exercise schedule, and regulating dehydration are several ways bodybuilders can increase their goals in getting the expectations they want when doing fitness activities [4].

According to some previous literature, there are various kinds of movements in fitness itself [5]. Experts classify them based on body segments, namely the lower body and the upper body [6,7]. For example, some movements in fitness that support upper body development are push-ups, pull-ups, chin-ups, planks, back-ups, and various other movements that focus on the development of the upper body muscles [8]. Conversely, some movements such as squat jumps and half squats are some examples of movements that aim to train the development of the lower body muscles [9].

Pull-up is a type of movement, which is used in resistance training and is widely used in various needs in strength training and muscle endurance conditioning [10,11]. Pull-ups themselves are used to train and measure the ability of a person's biceps brachii muscles. This is due to the characteristic of pull-ups that require a person to lift their body (against gravity) as best and as much as possible. The more reps you have, the better the biceps brachii muscle strength of the person. Apart from pull-ups, there are also types of movements that resemble pull-ups, namely chin-ups [12]. Chin-ups have the same characteristics, it's just different in the type of doing it where the chin-ups have different mechanics and anatomical pull-up grips when doing these movements [12].

Some experts and sports practitioners conclude and feel that there are some difficulties when measuring pull-ups and chin-ups. The concrete problem that they found was at this time there were no clear rules and tools about how minimum a height of lift when doing pull-ups or chin-ups which were categorized as one repetition batch. Because it is not surprising that there is often debate between experts and practitioners when doing the process of measuring pull-ups or chin-ups.

On the other hand, several previous studies have revealed some findings regarding automatic tools that can be used to assist the validator when validating measurements [13]. In this automatic tool, it applies simple digital principles that can help the validator quickly and validly validate. Because of this, we think that an automatic tool is needed that can help the validator in validating measurements when an athlete or bodybuilder performs pull-ups and chin-ups so that it can reduce the risk of incorrect assessments or validations during the assessment process. Thus, this research aims to make an automatic sensor to count the number of repetitions of pull-ups and chin-ups automatically.

2. Material and Method

Participants

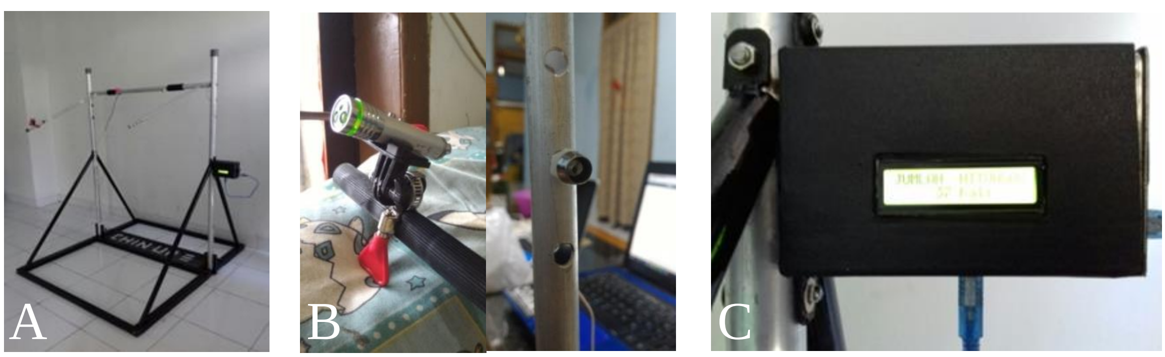
A total of 15 male athletes participated in this study. All athletes went through a screening purposive sampling based on established inclusion and exclusion criteria. The inclusion criteria set were: (1) participants were members of the fitness team at least during the last 3 years, (2) had no musculoskeletal injuries in the last 3 months, and (3) were used to doing pull-ups and chin-ups as part of their fitness program that is run. Meanwhile, participants who had a history of injury for the last 3 months and the chronic upper-body injury became the exclusion criteria in this study. All participants received an explanation of the objectives and risks of this study. After receiving an explanation, they signed informed consent as a form of their consent to participate in this activity. This study has passed the Ethics committee test, which was issued by the Poltekkes Bandung (…………… ..). The characteristics of the participants can be seen in the table. 1.

Tab 1. Anthropometric characteristics of participants.

Variables	Participants $\bar{X}(SD)$
Age (years)	21.43± (1.75)
Weight (kg)	60.76± (2.99)
Height (cm)	169.7 ± (2.10)
BMI (kg/m^2)	21.07 ± (0.97)

Testing setup

The manufacture of this automatic pull-up and chin-up tool consists of several major parts, namely the support using aluminum and iron, a sensor to detect the height of the participant, and a display to display the sensor readings. The sensor used is an infrared sensor (microchip, Arduino Uno Atmega328p model) programmed in C ++ language to measure the minimum height limit of a person when doing pull-ups or chin-ups. In this study, using 3 sensors, each of which is placed on the crossbar at the front of the pole, at the back, and at the bottom to detect pull-up or chin-up movements that touch the three sensors with the specified height and distance. The three sensors will calculate if the chin-up movement is done correctly. Images of automatic pull-ups and chin-ups can be seen in figure 1



Abbreviations:

A - fully automatic pull-up and chin-up design; B - Infrared sensor; C - Display monitor

Assessment

In this study, participants were required to perform 2 types of measurement movements, namely pull-ups and chin-ups. Participants are asked to do 1 repetition maximum in each of these movements. Two administrators (n = 2) were appointed as measurement judges, while the participants performed pull-ups and chin-ups, they stood on a bench to calculate manually using a meter stick of the distance of each participant's lift. The lift distance is calculated when the participant's chin has passed the sensor pole, and the administrator calculates the distance between the chin and the sensor pole using the meter stick. Manual results using a meter stick are analyzed and tested for their correlation with automatic results issued by automatic pull-ups and chin-ups.

Statistical Analysis

The values are presented as mean ± SD. A Leveney test was used to check normal distribution. A one-way ANOVA and Bivariate correlation test were used to determine significant or no significant differences between manual tests using ameter stick and automatic pull-up and chin-up test. Statistical significance was accepted at the p<0.05 level. The tests were performed by using the SPSS software V.21.0.

3. Result and Discussion

Table. 2 shows the statistical analysis test between tests using automatic pull-ups and chin-ups with manual tests using a meter stick. A one-way ANOVA showed that there was no difference between automatic and manual pull-ups (p = 1.000), and these results were also seen in the automatic and manual chin-up test, where there was no significant difference (p = 1.000). More specifically, this study shows a strong correlation between automatic and manual testing. This can be seen by the significance of the correlation test between automatic and manual pull-ups (p = 0.004), and also automatic and manual chin-up tests (p = 0.001).

Table. 2 Relationship between automatic and manual test on the pull-up and chin-up test

PU-AU (cm) $\bar{X}(SD)$	PU-MA (cm) $\bar{X}(SD)$	*p*-value[a]	*p*-value[b]	CU-AU (cm) $\bar{X}(SD)$	CU-MA (cm) $\bar{X}(SD)$	*p*-value[a]	*p*-value[b]
4.75 ± (0.68)	4.75 ± (0.58)	1.000	0.004*	4.69 ± (0.95)	4.69 ± (0.87)	1.000	0.001*

Abbreviations:
The values are presented as mean ± SD.
PU-AU, automatic pull-up; PU-MA, Manual pull-up; CU-AU, Chin-up automatic; CU-MA, manual Chin-up.
a Statistical with one-way ANOVA
b Statistical with Bivariate correlation test
* Statistically significant between automatic and manual assessment (p <0.005).

Discussion

This research has shown that automatic pull-ups and chin-up machines have been successfully developed to assist trainers, bodybuilders, or experts in measuring and validating pull-ups and chin-ups. It can be seen that there is no difference between an automatic pull-up and the chin-up machine with manual tests using a meter stick. In more detail, it is hoped that this study can add to the previous literature regarding the use of automatic devices in helping sports practitioners in measuring and validating a movement.

Several previous studies have supported the findings of this study, regarding the effectiveness of an automatic device that can help sports practitioners measure the sports movement [14,15]. For example, Syahruddin et al. [14] made Infrared Sensor Technology (IST), which aims to measure the length of the anterior superior iliac spine (ASIS) to the mat when doing a split test. In his findings, Syahruddin revealed that the success of finding the IST would make it easier for the validator to validate the results of the split test performance. In more detail, in their findings, Syahruddin et al. assumed that parallax errors could be prevented when the validator used IST, considering that parallax error is a state of limited vision when looking at the meter stick.

There have also been several previous studies that have suggested that the current use of automatic should be done immediately given the very wide need and development of exercise [16, 17]. For example, Haugen et al. [16] have examined the validity and reliability of the use of a stopwatch between one person and another as a measure of speed. In their findings, Haugen et al. revealed that the difference in response time to pressing the stopwatch button between one person and another is 0.04–0.05 s. This can increase the likelihood of occurring human error, and result in less accurate results. In conclusion and suggestion, Haugen et al. recommend using a beam photocell as a standard measuring tool for measuring speed.

Finally, the findings in this study support previous research which states the importance of using automatic machines as part of the measurement and validation of a sports movement. We are aware that automatic pull-up and chin-up machines still have several shortcomings, such as (1) validity and reliability tests are needed to answer doubts related to this tool, as well as to test the accuracy and quality of results, (2) automatic pull-ups and chin-ups machine requires an innovative development in the future, the use of the simple material is needed so that the automatic mobility of the pull-up and chin-up machine can be better and more efficient. Apart from some of these shortcomings, hence it does not reduce the benefit value sof this finding, which can help trainers, bodybuilders, or experts in measuring and validating pull-ups and chin-ups automatically.

4. Conclusion

This study shows that there is a strong correlation between automatic testing for pull-ups and chin-ups with manual tests using meter sticks. This shows that the automatic pull-up and chin-up tool has successfully carried out automatic measurements of the pull-up and chin-up test and measurement.

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