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Push-Up Counter (PUC) as an instrument of arm muscle strength: Validity and reliability

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ABSTRACT

Accurate physical condition measurement results are obviously determined by the quality of the instrument, namely a valid and reliable instrument. Developing a push-up measurement tool combined with technology is an urgent need. Moreover, this study aims to determine the validity and reliability of the Push-Up Counter (PUC) as a sensor-based measurement of arm muscle strength. This research is development research that focuses on uncovering the validity and reliability values of PUC using a quantitative approach. The validity value was obtained from the assessment of three experts by conducting questionnaire which has four main aspects, namely: instructions, components, safety, and usage. 30 athletes/students were involved as the subject participants in measuring the PUC reliability. Furthermore, the data collection were analyzed by using SPSS to determine the value of r. This study found that the PUC was valid (r = 0.88). The Cronbach Alpha value of this reliability instrument was r = 0.41. Referring to the validity and reliability result, it can be concluded the PUC was feasible and elligible to be used in measuring the arm muscle strength in the process of physical test. However, PUC operation is not yet integrated with smartphones. These results also provide opportunities for further research in developing application-based PUC devices or Android.

Keywords: Push-up counter; validity; reliability

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INTRODUCTION

Peak athletic performance, whether in individual or team sports, is heavily reliant on the athlete's exceptional physical condition, enabling them to reach their full potential during training and competitive events (García et al., 2022; Yudhistira & Triyoliyus, 2020; Yudhistira et al., 2021). The fundamental elements of physical conditioning encompass endurance, strength, speed and flexibillity (Orr et al., 2022; Sidik et al., 2019). Achieving these advancements in physical condition typically involves a meticulously planned and well-structured training programme (Bompa & Buzzichelli, 2019). Moreover, the effectiveness of an athlete's training regimen hinges on the coach's adeptness in tailoring it to the individual athlete's unique attributes, considering both strengths and weaknesses (Salaga & Juravich, 2020; Ansell & Spencer,

2022). This is where precise physical condition tests and measurements come into play, assuming a pivotal role by furnishing coaches with the essential data required to design an optimal training regimen that harnesses each athlete's full potential.

A well-structured training program serves as an invaluable compass for coaches endeavoring to elevate their athletes' physical condition and overall performance (Salimin et al., 2020). Furthermore, in order for coaches to formulate and execute a systematic training program successfully, they necessitate evidence-based guidelines (Razak et al., 2020). One of which based on the guideline is that the results of physical condition test and measurement. One crucial facet of these guidelines revolves around the utilization of data obtained from physical condition tests and measurements. These test results provide the cornerstone upon which coaches construct precise and effective training regimens, thereby enhancing athlete performance (Hudain et al., 2023; Suryadi et al., 2023; Vavilov et al., 2020). In this context, the imperative for accurate, technology-supported tests and measurements becomes increasingly evident, as they furnish a more nuanced comprehension of an athlete's muscle strength and conditioning. This, in turn, ensures that the training program is meticulously tailored to each athlete's distinct requisites and capabilities, thereby culminating in their overall triumph.

Many coaches are looking for and need a valid, credible, easily accessible, and inexpensive instrument to determine the muscle strength athletes, both before and after being given strength training (Bergeron et al., 2015; Lloyd et al., 2016). However, currently there are still test and measurement results which are inaccurate because the process has not been supported by the use of technology. Even though the current findings state that technology can help limit human abilities in sports (Kim & Ko, 2019; Ratten, 2020). One of the the test and measurement in the sport in question is the measurement of arm muscle strength using a 30-second push-up instruments (Cengizel & Cengizel, 2022). The process of calculating push-up movement based on the Standard Operating Procedures (SOP) is difficult to be achieved consistently, especially by the test person. The Standard Operating Procedures (SOP) as mentioned are whether an athlete has positioned their chest ± 5 cm with the floor and elbows forming a right angle (90°) when the body in the low position, as well as ensuring both arms are extended when the body is pushed up (Ajisafe, 2019; Clemons, 2019).

Field experiences have uncovered a pressing issue, spanning assessments conducted during the Bali Provincial Sports Week (Porprov) 2022, the Bali National Sports Week (PON) 2021, and the evaluation of prospective students at the Faculty of Sport and Health, Universitas Pendidikan Ganesha in 2022. This issue revolves around the upper body strength test, specifically the 30-second push-up evaluation, where the absence of technological support has led to multiple interpretations, as highlighted by research findings indicating a strong demand for a technology-assisted push-up counter among coaches and athletes participating in Porprov Bali 2022 (Artanayasa et al., 2022).

Conducting manual tests without adequate aids or tools has resulted in unreliable data due to inaccuracies in body positioning, the ascent and descent movements, and the absence of precise and consistent motion detection. In contrast, employing a standardised procedure with sensors has proven to yield more dependable results, as exemplified by the development of a sensor-based volleyball passing test demonstrating superior validity compared to manual assessments (Destriana et al., 2022). Moreover, the introduction of an infrared-based reaction speed test in 2019 and the creation of the FitLit trainer in 2021, both sensor-based tools, have showcased their high validity in measuring and enhancing the reaction speed of volleyball athletes (Pojskic et al., 2019; Lima et al., 2021). Therefore, it can be said that technology can actually make the process of measurement more valid and effective. Besides being valid, an instrument must also meet reliability requirements, namely that the measurement results will remain specifically reliable even though the measurements are for various athletes (Markwick et al., 2015).

Given the description of these critical issues and the results of the needs analysis conducted, there is an urgent need to address the gap in the field of arm muscle strength measurement tools. This gap is evident in the absence of a reliable and technologically assisted solution for the 30-second push-up test. To bridge this gap, the current research aims to develop the Push-Up Counter (PUC), an innovation that promises to assist testees and testers in minimising human errors and misperceptions while calculating scores in the 30-second push-up test. The next step in addressing this gap is to assess the validity and reliability of the PUC as an

innovative tool. Therefore, the primary objective of this research is to unveil the level of validity and reliability of this newly developed instrument, offering a novel contribution to the field.

METHOD

This research includes development research that adopts Borg and Ga A needs analysis has been carried out and is currently entering the validity and reliabili testing stages.The approach used in this study was a quantitative approach that the focuses on describing the value of the validity and reliability of PUC. Three experts were selected and involved to evaluate the PUC to obtain the validity of the innovatice device. The validity is defined as a measurement of the level of accuracy of measuring instrument in a study (Heale & Twycross, 2015). The three experts reffered were an exercise test and measurement expert, electrical engineering expert and fitness center trainer. The three validators validate PUC by filling out a modified questionnaire from Ramli and Ahmad (2022) based on four main elements: instructions, components, safety, and usage.

The result of the experiment conducted by 30 athletes is a process to measure the reliability level of PUC. Reliability is an indicator of the constancy or stability of the value generated in the measurement process repeatedly using the same instrument (Surucu & Maslakci, 2020). Thirty athletes who are also students in the Departement of Physical Education, Health and Recreation, Faculty of Sport and Health, Universitas Pendidikan Ganesha (aged 21.1 ± 0.7 years old) from sport branches: 6 people archery, 3 *pencak silat* specialists fighting, soccer as goalkeeper 2 people and and 3 people playing field players, 8 people basketball, 4 people athletics throwing numbers, and swimming four people are selected to measure their arm muscle strength by using PUC.

The selection of research subjects above is based on the predominance of the physical conditions needed by athletes in that sport. Archery athletes, not only need biceps and back muscle strength when pulling on the bowstring, but also triceps and deltoid (thrust) muscle strength during the anchoring, thigting, and aiming phases (Sládek et al., 2022). *Pencak silat* athletes also need strength or power in the triceps muscles to punch straight ahead (Muhammad et al., 2020). Throwing activities for football goalkeeper, basketball players, and athletic athletes (javelin throw and shot put) also utilize the strength and power of the triceps muscles (Nagamoto et al., 2022; Guimarães et al., 2021; Iturricastillo et al., 2022; Rusli et al., 2023; Takanashi et al., 2020), and gives power advantages to players when making body contact with opposing players (Ruivo et al., 2016).

After the data were collected, it were analysed descriptively by using Statistical Packages for Social Science (SPSS) to find out the validity value and the Cornbach Alpha value to find out the reliability. The validation value classification used refers to the opinion of Guilford (Sugiharni, 2018), as shown in table 1.

Table 1. Questions from Needs Analysis of Digital Technology-Based Push Up Test Development Questionnaire

No	Value	Criteria
1	rxy < 0.00	Invalid
2	0.00 < rxy < 0.20	Very low validity
3	0.20 < rxy < 0.40	Low validity
4	0.40 < rxy < 0.60	Medium validity
5	0.60 < rxy < 0.80	High validity
6	0.80 < rxy < 1.00	Very high validity

Push-up data from 30 subjects that ve been collected based on measurement by the PUC are then tested for Cronbachs Alpha reliability with a significance level of 5%. If the Cronbach Alpha value > r table, PUC is declared reliable. If the Cronbach Alpha value < r table then PUC is declared unreliable.

RESULTS AND DISCUSSION

The questionnaire that contains statement items which used to measure the validity value of PUC filled out by experts consisting of four main components, namely instructions, components, safety, and usage. Based on Table 2, the value of the PUC is r = 0.88 (n = 3). The validation value of expert 1 is r = 0.88. The

validation value of expert 2 is r = 0.92. Moreover, the validation value from expert 3 is r = 0.83. Based on the assessments of the three experts, the PUC is very high valid and eligible as a measuring tool for arm muscle strength (triceps).

Furthermore, as shown in Table 3, which describes the results of the overall Cronbach Alpha value for the reliability of this instrument is r = 0.41. Compared with the value of r table = 0.36, the Cornbach Alpha value is greater than the r table. It can be defined that the PUC is reliable as a tool for measuring arm muscle strength (triceps). Therefore, based on the the value of validity and reliability, it can be stated that the PUC is acceptable and reliable to be used for measuring arm muscle strength, especially the triceps muscles of athletes and students. The PUC design can be seen in Figure 1 and how the PUC (ping sensor) works can be seen in Figure 2.

Table 2. The Analysis of Three Experts for the Validity of the PUC

Expert	Instructions	Component	Safety	Usage	Average of Value	r Value
Expert 1	.89	.84	.92	.88	.88	
Expert 2	.95	.89	.94	.89	.92	r = .88
Expert 3	.86	.79	.88	.80	.83	

Table 3. Cronbach Alpha Reliability Coefficient Value Analysis of the Use of PUC

Reliability	Trial 1	Trial 2	Trial 3
N	30	30	30
Mean	31.500	32.367	31.200
SD	3.149	3.337	3.708
Cronbach's Alpha Based on Standardized Items	0.429		
Cronbach's Alpha	0.411*		
r table	0.361		

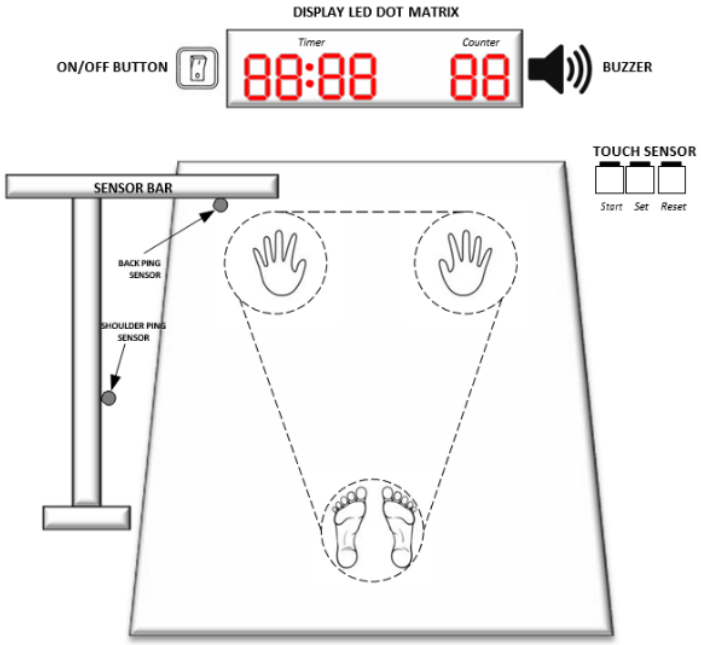

Figure 1. PUC Design

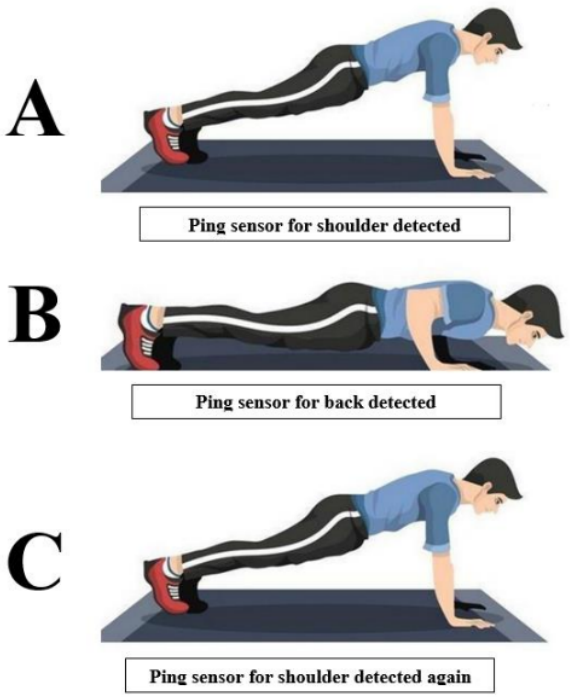

Figure 2. The PUC (Ping Sensor) Works

The aim of this research is to develop PUC as an innovation to minimize human error in the manual implementation of the 30-second push-up test. So the current development step is to reveal the level of validity and reliability of this innovative measuring instrument as one of the contributions of technology in sports. One of the physical measurement is the arm muscle strength (triceps) by using a manual push-up test. On the other hand, aside from being a method of training in gaining strength and muscle endurance in the upper body, push-up is also used as an instrument to measure the strength of arm muscle for both in the military and civilians (Hartono et al., 2019). The basic concept of the push up test movement is that the testee's body must be perpendicular, when the body position goes down and up alternately (Odierno & Morro, 2013; Cureton et al., 2013). As stated in the study by Putranta and Supahar (2019), that the weakness of the manual push-up test is that the scores shown by the testers are mostly not identical, due to the different perceptions of each tester. In avoiding or minimizing that weakness, the use of digital technology can be conducted as one of the solution.

An instrument should has a level of validity and reliability in order to produce an objective and accurate final value. In line with what were conveyed by (Teixeira et al., 2014; Hachana et al., 2014; Kellner et al., 2021) that scientific instruments must be valid, reliable, and objective. The purpose of the objective value is that an instrument should not based on the subjectivity of the tester (Gwet, 2014). Based on the result of this study, it can be shown that the PUC has met the validity and reliability requirements as a mesurement of arm muscle strength (triceps) for athletes. Valid states that a credible test is used to measure what it is supposed to measure (Sireci, 2016). A device that is declared reliable means that is has a probability level in the device system that does not experience failure or problems at one time when the system is working (Afonso et al., 2013). Although, there were sensor-based push-up instrument has been developed previously (Rosadi et al., 2018; Ramdhon & Sumarni, 2020). However, there are some developments in aspects that differenciate the previous findings (product) from this product. As stated by the validator who was an expert (sport test and measurement expert) that this tool has been equiped with operating instructions for the device

until the operating instruction for implementing push-up test. The instruction is in the form of audio that has clear sound and in the form of guideline book. Another advantage is in the component aspect of the device. According to the validator team, the device gives a sound signal if the movement when the body is up and down properly carried out. The timer can be set from 30 to 60 seconds and the score for the movement made by the testee can be clearly seen. PUC form which is portable is also an added value of this measuring instrument. This is line with previous findings which state that tools used with portable, cheap and valid system will provide many benefits to the users of a tool (Xu et al., 2021; Artanayasa et al., 2023; Villalon-Gasch et al., 2023).

Furthermore, the validity and reliability of this device can be used as a solution for the problem in measuring the manual push-up test. An accurate measurement have an impact to the accuracy of final result (Arifin et al., 2020). The use of technology or creating products through technology is one of the effort of a nation that wants their sport to achieve global achievements (Bäckström et al., 2013). If you want more accurate results on test results, it is appropriate for coaches and athletes to choose test kits that have a high level of validity and reliability (Beato et al., 2021). This PUC also follows the principle of being easy and safe to be used. This is obviously in accordance with the findings that there are still many trainers who are looking for affordable, easily accessible and reliable measuring device that can be used to measure muscle strength in young athletes as a result of a training process (Bergeron et al., 2015; Lloyd et al., 2016). The limitation of the current findings is that PUC has not been integrated into smartphones, both Android and IoS based. Therefore, the opportunity for connectivity using a remote control or Android-based application in the PUC operation process can also be carried out in the future.

CONCLUSION

Based on the result of this study, it can be concluded that the PUC has demonstrated both validity and reliability. The instrument's validity is supported by its adherence to established instructions, components, safety standards, and ease of use. Furthermore, extensive testing with athletes has confirmed its reliability, making it suitable for assessing and measuring arm muscle strength (specifically triceps) across various levels of athletes, from grassroots (PPLP) to Provincial Sports Week (PORPROV) and even National Sports Week (PON).

The PUC represents a significant advancement in addressing the limitations and weaknesses associated with manual push-up tests in both the military and civilian sectors. Manual triceps strength tests often suffer from high bias due to human errors on the part of testers and variations in testee understanding of the correct push-up movement. The inclusion of sensors that detect the testee's body position (extensor or flexor arm) greatly enhances the precision of arm muscle strength (triceps) measurement. Additionally, the diverse range of sports included in this study, all requiring arm muscle strength or power, provides a valuable reference for future researchers seeking to develop innovative measurement tools.

While the PUC shows promise, there are some limitations to consider. Further research opportunities lie in exploring the use of secondary (lithium-ion) batteries in the PUC and the potential for operating the system with light-emitting diode (LED) technology. These developments could pave the way for more eco-friendly products based on green energy sources, such as solar power conversion. Additionally, integrating the system with smartphones could enhance practicality and usability. In conclusion, this research contributes by introducing the PUC as a valid and reliable instrument for measuring arm muscle strength, filling a critical gap in the field. It offers a solution to the challenges posed by manual triceps strength tests and provides valuable insights for future research in the development of innovative measurement tools. The exploration of eco-friendly power sources and smartphone integration represents exciting directions for further research, promising enhanced practicality and sustainability in sports science and measurement.

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CONFLICT OF INTEREST

The author believes that all forms of writing and the contents of this article do not contain a conflict of interest.

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