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REVIEW ARTICLE

Comparison product of muscle contraction strength measuring device based on specifications and its uses

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ABSTRACT

Currently, technological developments have been used in several health cases. One technology used for health is a tool to measure the strength of muscle contractions. So far, measuring muscle contractions still uses manual methods, namely the measurement muscle strength test method. Apart from that, health workers also measure manually by feeling the muscles to be measured. The need for tools to measure muscle contractions in the medical world is quite large because these tools can be used for various needs of doctors and nurses. There are many commercialized products on the market. The first aim of this article is to review four products that are available on the market. The second aim is to provide an overview of the use of the four products that have been carried out by previous researchers and the results. This article also discusses various aspects of product specifications. The research results show that each product has its own advantages. When we compare these products, it is better for us to return to the kind of product we are looking for. For example, if we want a product with high-class features that is equipped with several games, then we can choose MyoBoy. Myo armband and Trigno™ are used to identify several movement force conditions that are influenced by muscle strength, which has been equipped with an Inertial Measurement Unit (IMU) sensor. MyoWare is used to make bionic hands or bionic legs that can be controlled using electromyography (EMG) and has a relatively economical price.

***Keywords*:** muscle contraction; surface electro myograph; non-invasive measurement; medical device

1. Introduction

Today, many companies produce innovations in muscle contraction measurement with a wide range of variations in shape, function, and features at an economical price. Products that are produced will compete with products that are already on the market. Various efforts have been made by companies; there are companies that are still in the research stage until companies that already have products are ready to market and are already ready to compete. Muscle contraction measuring tools are much needed by the medical world because their function can be used for various medical needs. One of the main components used to make this product is the use of electromyography (EMG) sensors. Research regarding various devices for measuring

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muscle contraction strength and their use is still rare. Therefore, this article will discuss the various types of muscle contraction strength measuring devices on the market and their various uses in various fields.

EMG is an extensively utilized biological signal for predicting human motor work. EMG becomes an integral component of the human-robotic collaboration system[1]. EMG signals are derived from bio-electric signals produced by muscle cells and have numerous applications, including rehabilitation, auxiliary devices, ergonomics, clinical diagnosis, and sports science[2]. EMG can work at times when the muscles are in a state of contraction and relaxation. The muscles move every part of our body. As for lifting objects with different weights, the power that is removed is also different. So, the diagnosis of muscle strength is an important factor. Therefore, muscle contraction measurements have become an important device for researchers and doctors. By using this tool, doctors can know the strength of the muscle and compare it to normal and tired muscles.

In general, there are two types of EMG that are already widely used, namely intramuscular electromiography (using a needle or electrode wire) and surface EMG. The electrical potential generated by muscle cells is either recorded using surface EMG or intramuscular EMG[3,4]. The difference between intramuscular EMG and sEMG is the way in which the electrical activity of the muscles is recorded. The working principle of intramuscular EMG is to insert an electrode needle into the muscle (invasively) to record the electrical activity of the muscle. Meanwhile, the working principle of sEMG is to stick electrodes over the muscles to record the electrical activity of the muscles. EMG sensors are primarily used for diagnosing clinical applications and could potentially be used for manufacturing enhancements to robots[5,6].

Surface EMG is used to record muscle shifts and to estimate muscle strength at the time of contracting, as well as its impact on body comfort, and is suitable for designs that come into direct contact with humans[7]. As a diagnostic instrument, clinical neurophysiology utilizes EMG recordings during activity, primarily in patients with neuromuscular disorders. In the beginning, intramuscular EMG was used to record muscle signals, but because of the way it works, which injures the body, it is now rarely used and replaced with sEMG[8]. In this study, the type of EMG sought was a tool for muscle contraction using surface EMG.

Currently, the development of sensor technology has made robot-human interaction more effective. Thus, humans and robots are able to collaborate or communicate in various ways to complete assigned duties. Although the terms collaboration and cooperation are frequently interchanged in the study of human-robot interactions, they have distinct meanings. During collaborative duties, robots and human partners interact without needing to be aware of one another's actions. During the collaborative endeavor, however, both partners must communicate and comprehend one another, necessitating a high level of interaction[9–11].

EMG signals can be utilized in a variety of medicinal and robotic applications. EMG can be used for robotics and rehabilitation tools[12,13], ergonomics[14], diagnostic and clinical applications[15], sports science and motion analysis[16,17], telerobots[18], military tasks[19], etc. According to previous studies, EMG is a simple device but has many benefits. From this, it can be concluded that EMG is an important device for medical staff or doctors.

2. Review of muscleon contracti measurements in the market

It is important to do a review and comparison of the products available on the market. The purpose of this review and comparison is to know the functions of each product and to find out the advantages and disadvantages of each. In this review article, there are four products measuring muscle contraction strength that will be discussed. The products to be discussed are Myo armband, MyoWare, Trigno, and MyoBoy. **Table 1** discusses the product description comparison. **Table 2** discusses the comparison of product specifications for a tool measuring muscle contraction strength. **Table 3** discusses the comparison of the use of muscle contraction strength measurement products that have been carried out by previous researchers.

Table 1. Comparison of four products for measuring muscle contraction strength.

Product name	Product description
Myo armband by Thalmic Labs, Canada	The Myo armband is a data collection device equipped with IMU and sEMG sensors. The IMU sensor measures three types of signals at a sample rate of 50 Hz. A total of 8 sEMG sensors are attached to the skin at a sample rate of 200 Hz, which is used to measure muscle contractions. IMU and sEMG signals on these channels are transmitted via Bluetooth to the computer[20].
MyoWare by SparkFun Electronics, USA	MyoWare is a type of muscle sensor that works based on the principle of EMG. MyoWare muscle sensors can be connected to Arduino boards and Bluetooth modules to send readings via analog signals and receive readings on a smartphone or computer[21,22].
MyoBoy by Ottobock Healthcare, Germany	MyoBoy is a commercial product aimed at training upper extremity muscles in patients and controlling prosthetic hands[23]. MyoBoy is also equipped with several supporting components, namely a grounding cable, a jinjing bag, two electrodes, a USB cable, an electrode cable, a crane, and a short instruction guide.
Trigno by Delsys Inc, US	Trigno EMG is a wireless EMG system designed to simplify EMG signal detection. It is used for various studies of human movement and can be used alone or in combination with software[24,25].

Table 2. Comparison of product specifications.

Comparison	Product			
	Myo armband	**MyoWare**	**MyoBoy**	**Trigno**
Dimension	11.9 cm × 7.4 cm × 10.4 cm	5.2 cm × 2.1 cm × 0.5 cm	15 cm × 8.3 cm × 3.5 cm	2.7 cm × 4.6 cm × 1.3 cm
Weight	255 gr	28 gr	250 gr	14 gr
Sensor	sEMG, IMU	sEMG	sEMG	sEMG, IMU
Frequency	sEMG 200 Hz, IMU 50 Hz	10–500 Hz	1000 Hz	sEMG 20–450 Hz, IMU 24 Hz–360 Hz
Supply voltage	+1.7 V to +3.3 V	+2.9 V to +5.7V	9 V	+/– 5 V
Connection	Bluetooth	Bluetooth, micro USB	Software PAULA, USB	Bluetooth
Power supply	Battery	Battery	Battery	Battery
References	Tao et al.[20], Amazon[26]	SparkFun[27], MyoWare[28]	Ottobock[23], Manualzz[29], Prahm et al.[30]	Delsys[31], Delsys Incorporated[32]

Table 3. Comparison of products used by previous researchers.

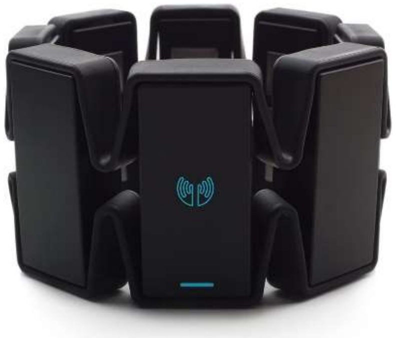
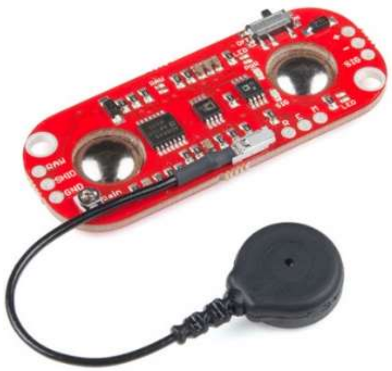
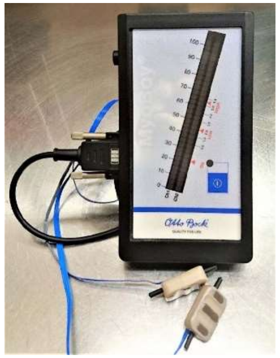
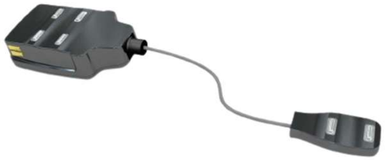
Product name	**Product use**		
	Ref	**Research purposes**	**Research result**
Myo armband 	Fu et al.[7]	Identify the physical factors that affect the comfort of rest in the stretched position in the office chair using the Myo armband sensor.	There are ten body regions that significantly influence comfort, with the right and left sides of the neck having the greatest impact.
	Tao et al.[20]	Develop a CNN model for the identification of worker activity using IMU and sEMG signals obtained from the Myo armband.	The study involved eight subjects that contained six common activities in assembly tasks. The CNN model developed was evaluated with a recognition accuracy of 98%.
	Bangaru et al.[33]	Identification of the activity of ANN-based automated construction workers who can recognize complex construction activities	The proposed model can recognize fifteen scaffold-building activities with an accuracy of 94%.
	Tepe and Erdim[34]	Determine the effect of character selection and classification scheme on the accuracy of figure gesture classification with the Myo armband.	Using the ANN method, the optimal performance of the sEMG data was 94.40%. The highest performance of sEMG and gyroscopic data with the ANN method is 96.30%.
	Tepe and Demir[35]	Determine the effect of the number of channels and the selection of features on the classification accuracy of the 8-channel EMG Myo armband signal.	Using all EMG channels, the maximum accuracy is 98.38%. When the number of channels is reduced to three, accuracy surpasses 90%.
	Tepe and Demir[36]	Identify SVM performance to classify EMG signals in non-real time and real time.	The highest accuracy for non-real-time and real-time classifications on one subject was 96.38% and 99.05%.
MyoWare 	Ali Hashim et al.[21]	Design a fall detection system, or WFDS, that can be used for Parkinson's disease patients based on WSN MyoWare.	The results of experiments indicate that WFDS achieves 100% accuracy, sensitivity, and specificity in detecting fall patients.
	Heywood et al.[37]	During muscle contractions, compare the validity of a low-cost EMG (MyoWare) to that of a commercial system (TeleMyo).	For evaluating muscle activation, low-cost EMG systems are comparable to commercial systems, and the use of TKEO improves the reliability of time-related variables.
	Widhiada et al.[38]	Create bionic foot innovation products equipped with MyoWare sensors.	MyoWare can be used to read the movement of the DC motor angle between 0–60° and vice versa, following the concept of the gate cycle.
	Martins et al.[39]	Design of a MyoWare-based robot hand orthosis prototype to help people with neuromuscular disorders.	In real-time testing with three commonplace objects, system accuracy reached 90%. The prototype includes an orthosis that meets the requirements.
	Hassan et al.[40]	Monitor epileptic behavioral signals and prevent them in the early stages of the disease using ECG, MyoWare, accelerometers, and Dallas sensors.	The accuracy of the prototype epilepsy monitoring system is 98.90%, 95.49%, 83%, and 87.21% for monitoring body temperature, pulse rate, muscle seizures, and fall detection, respectively.
	Chaparro-Cárdenas et al.[41]	Utilize walking fatigue detection, an instrumented orthosis using MyoWare, and a treadmill to detect muscle fatigue.	A decrease in the amplitude and frequency of the sEMG signal, as well as the position of the corner of the lower extremities, are indicative of muscle fatigue.

Table 3. (*Continued*).

Product name	**Product use**		
	Ref	**Research purposes**	**Research result**
MyoBoy 	Prahm et al.[30]	MyoBoy was used to assess the impact of game-based rehabilitation in the short term.	Game-based interventions are advantageous for training and can improve clinical outcome measurements.
	Prahm et al.[42]	Analyze the effect and benefit of video games on patients' effort, performance, and motivation. The EMG control used is MyoBoy.	This control can be effectively trained through the incorporation of engaging video games into the rehabilitation process. The patient tries harder while doing it.
	de Boer et al.[43]	Determining the effect of intermanual transfer with a prosthesis in a patient a below-elbow amputation.	There was no intermanual transfer effect on force control, and there was no laterality effect.
	Sturma et al.[44]	Presented a structured rehabilitation protocol for two different groups of patients with upper limb nerve injuries.	Using MyoBoy makes patients feel more competent in controlling EMG signals.
	Prahm et al.[45]	Examine the usability of MyoBoy-based game systems, their functionality, and their subjective qualities.	Significant improvement in all parameters assessed. Game-based applications can train EMG signals on prosthetic controls.
	Bouwsema et al.[46]	Described changes in the performance of upper limb myoelectric prostheses during exercise.	Control of grip force is more difficult to master than positioning the prosthesis.
Trigno 	Pauk et al.[24]	Bicluster algorithm method for grouping steps showing homogeneous EMG activation intervals.	Bicluster depicts the actual difference between the subject's stride parameters, namely stride length, stride time, and walking speed.
	Reeves et al.[47]	Determines PL sEMG reliability in running. EMG was recorded with Trigno electrodes at 2000 Hz.	The peak amplitude SEMs were 4% and 3% for barefoot and shoes. Low SEM indicates good PL EMG reliability during running.
	Lee et al.[25]	Utilizes machine learning techniques to recognize IMU data indicative of a physically fatigued or sluggish gait.	Normal gait, physical fatigue, or simulated cadence without muscle fatigue can be recognized using LSTM machine learning techniques with one or more IMUs.
	Lynch et al.[48]	Determine the influence of the general TMS waveform on RMT, AMT, and MEP amplitudes in the biceps and FDI.	The effect of TMS waveforms on motor thresholds in the proximal and distal upper limb muscles is identical. The effect of the waveform is sensitive to the target muscle.
	Zaluski et al.[49]	Know the magnitude and peak activation times for the supraspinatus and infraspinatus during general rehabilitation exercises.	Supraspinatus posterior and infraspinatus superior activation levels were comparable between elastic band exercises, but their maximal activation times were specific to each exercise.
	George et al.[50]	Determine the optimal cut-off frequency for low-frequency noise attenuation on the sEMG signal from TB and BF from 20 horses during trot and canter.	The HPF cut-off frequency between 30 Hz and 40 Hz is the optimal setting for the equine sEMG signals collected from TB and BF during trot and canter.

Notes: AMT = Active Motor Threshold, ANN = Artificial Neural Network, ARM = Augmented Reality Myoelectric, BF = Biceps Femoris, CNN = Convolutional Neural Network, FDI = First Dorsal Interosseous, HPF = High-Pass Filtering, IMU = Inertial Measurement Unit, MEP = Motor Evoked Potential, PL = Peroneus Longus, RMT = Resting Motor Threshold, SEM = Standard Error of Measurement, sEMG = Surface Electromyography, SVM = Support Vector Machine, TB = Triceps Brachii, TKEO = Teager-Kaiser Energy Operator, TMS = Transcranial Magnetic Stimulation, WFDS = Wearable Fall-Detection System, WSN = Wireless Sensor Network.

Table 1 presents the name of the product, the manufacturing company, the place of production, and a short description of the products. Thalmic Labs currently does not manufacture Myo armband, so it is rather difficult to find Myo armband products on the market. However, the MyoWare, MyoBoy, and Trigno products are still mass-produced, so they are easily obtained on the market.

Table 2 presents a comparison of the four products, ranging from price to size, weight, sensors used, working frequency, supply voltage, connections, and power supply used. MyoBoy has the highest selling price of $2716.56, and Trigno has the lowest selling value of $40.00. In terms of size, Myo armband has the largest size of 11.9 cm × 7.4 cm × 10.4 cm, and MyoWare has the smallest size of 5.2 cm × 2.1 cm × 0.5 cm. In terms of weight, the Myo armband has the largest weight of 255 g, and the Trigno has the lightest weight of 14 g. In terms of the sensors used, Myo armband and Trigno have two main sensors, namely surface EMG and IMU, while MyoWare and MyoBoy products only have a sEMG sensor. In terms of frequency, each product has a variation in frequency. The frequency can be adjusted according to the measurement. In terms of voltage, Myo armband and Trigno have a small working voltage compared to the other two products. MyoBoy has a different connection with three other products, namely using PAULA and USB software. All four products use batteries as a working power supply.

Table 3 presents an overview of the products of previous researchers, research objectives, and research results. The Myo armband is used to identify muscles based on surface EMG signals and types of muscle movement based on IMU signals. The Myo armband is mostly used for construction work and sports because there are additional features that can be used to identify the type of movement[7,20,33–36]. MyoWare is used to identify muscles based on the recordings from the sEMG sensor. MyoWare has been used in the health sector for such purposes as detecting Parkinson's patients, making bionic legs, monitoring epilepsy symptoms, and identifying muscle fatigue[21,37–41]. MyoBoy is used to identify muscles based on the recordings from the surface EMG sensor. MyoBoy has been used in the health sector, especially in the upper extremities. For example, game-based rehabilitation, the influence of games on rehabilitation motivation, and the use of prosthetics on the upper limb[30,42–46]. Using the Trigno is almost the same as using the Myo armband because it has a surface EMG and IMU sensor. However, Trigno has also been carried out in health research, namely rehabilitation and recognition of gait[24,25,47–50].

3. Discussion

In Indonesia, there also a development of surface electromyograph (EMG) device to measure the muscle contraction, developed by CBIOM3S, a Centre of Excellent on Medical Device and Health Technology in Diponegoro University, Semarang Indonesia. Ismail[51] reported his research on the device of muscle contraction strength measurement by analysing electrical signal from voltage potential in micro-volt units. This device (EMG) could be used to measure and record the muscle acquisition data when patient conduct the rehabilitation program in some period. The surface EMG was designed to produce amplification level to maintain the readability of signal data and filter it to minimize noise. The surface EMG has been used to record data development of muscle power at a certain time. The EMG device was called as MyoMES.

The MyoMES was also used to measure muscle contraction on a foot during walking gait cycle[52]. The machine learning method was applied to multiclassification of human walking gait based on the signal measure in the muscle contraction using EMG signals. The EMG sensor was set to the bicep femoris longus and gastrocnemius lateral head to measure the micro voltage using EMG signal. The experiment was conducted by volunteers during normal walking activity at various speeds and the movements. The initiated as initial contact, was labelled as initial gait; loading response to the terminal stance, which was labelled as mid-gait; and pre-swing to terminal swing, which was labelled as final gait. The machine learning, as reported in the paper show a good classification for the three classes of human walking gait with an overall accuracy (training, testing, and validation).

The expansion of the use of measuring instruments for measuring the strength of muscle contractions still needs to be developed because there are quite a lot of market needs regarding cases of muscle diagnosis. Future research is expected to measure the strength of muscle contractions to be used to identify or diagnose the growth of stunted children. It is hoped that a measuring instrument for the strength of muscle contractions can be used to diagnose the time of delivery for women giving birth.

4. Conclusion

Myo armband, MyoWare, MyoBoy, and Trigno are muscle contraction measurement tools that have been commercialized in the market. We can get these products by visiting the official store, either offline or online. Each product certainly has advantages and disadvantages, and each product also has superior features. When we compare these products, it is better for us to come back to the kind of product we are looking for. For example, if we want a product that has high-class features and is equipped with several games, we can choose MyoBoy. If we want to identify several movement style conditions that are affected by muscle strength, then we can choose Myo armband or Trigno products, which are equipped with IMU sensors. If we want to make bionic arms or bionic legs that can be controlled using EMG, then we can choose MyoWare products at relatively economical prices. Choosing which product is the best depends on the specifications we need.

Conflict of interest

The authors declare no conflict of interest.

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