

# Practical and Simple Method in Measurement of Forearm Muscle Fatigue in Computer Operator

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## ABSTRACT

Fatigue is a problem experienced by every worker, especially computer operators that until now cannot be overcome. Various methods used in analyzing the occurrence of muscle fatigue under the computer operator, such as handgrip and lactic acid blood plasma levels. This study aimed to find a method of measuring muscle fatigue in computer operators that can be applied in the field or workplace with the principle of simple, fast and cheap without ignoring the level of accuracy. The results showed that there was a correlation between the measurement of handgrip method with a lactic acid concentration of blood plasma to muscle fatigue, where  $p = 0.000 < 0.05$  with  $r_s = 0.667$ . Furthermore, it can be concluded that measurement of handgrip method and lactic acid blood plasma level as a fast, simple and cheap method can be used as a parameter to determine the fatigue of the forearm muscle of computer operator after working in the computer.

**Keywords:** *Fatigue, Handgrip, Lactic acid level*

## INTRODUCTION

Fatigue is a protective mechanism for the body to avoid further damage. Fatigue usually indicate different conditions in each individual, but it all leads to loss of efficiency and decreased work capacity and body resistance<sup>(1)</sup>. The problem of fatigue in the world of work is a common problem that can lead to occupational diseases, but until now the problem of fatigue has not been fully addressed by the world. Workers with fatigue have low productivity, with a higher risk of accidents in the workplace, which can affect workers' health<sup>(2)</sup>. Muscle fatigue has been studied using a variety of exercise models, protocols and assessment methods<sup>(3)</sup>. Research on fatigue aims to find methods to prevent or reduce the occurrence of fatigue at work. Many ways to know the fatigue in muscle or body, both local fatigue, and general fatigue. A variety of methods can be used in determining fatigue, ranging from the most complicated

and expensive methods to simple and inexpensive methods with relatively inexpensive results<sup>(4)</sup>.

This study compared the presence of muscle fatigue in the lower arm of the computer operator after working in front of the computer for more than 4 hours. Fatigue is known by looking at blood lactic acid levels of blood plasma and muscular contraction ability of the forearm through the handgrip before and after work. There are differences in lactic acid levels of blood plasma and contraction ability of the fingers and arms before and after working in front of the computer for 4 hours<sup>(5)</sup>

The above description shows that blood plasma lactic acid levels and muscle contraction ability with handgrip can be used as a parameter of muscle fatigue in the forearm of computer operator after doing work activity. The above problem can be used as a measurement method because it can be done quickly, easily and at a cheaper cost.

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## MATERIAL AND METHOD

This study aimed to recommend a simple method in a fast way as the parameters determine the fatigue of the forearm muscles of the computer operator after

working for 4 hours. The research was conducted in 2017 at the regional office of the Directorate General of Taxes of South Sulawesi. The main sources required in this study were: 1) handgrip to measure the ability of muscle contraction, 2) accutrend to measure blood plasma lactate acid level, 3) research subjects are male employees aged between 25-40 years, have no history of disease with physician recommendations, free from musculoskeletal disorders and working on the computer at least 4 hours, so a large sample 175 people.

Evidence of the effectiveness of this simple method was implemented with several steps: 1) validation of measuring instruments by comparing the results of standard laboratory tests to determine the accuracy and accuracy of the measuring tool to be used, 2) measure muscular contraction muscle capability of computer operator by using handgrip before and after work in computer for 4 hours, 3) measure blood lactate acid level by taking blood + 0.5 ml, before and after work on computer 4 hours, 4) compare result of measurement of both method to know the increase of lactic acid level of blood plasma and decreased ability of muscle contraction.

### FINDINGS

The selection of measurement methods as parameters of muscular arms fatigue is based on the theory that functional ability of the forearm grip is influenced by fatigue<sup>(6)</sup>. Muscle strength is an important component in assessing muscle activity, which increases or decreases muscle strength can affect muscle performance<sup>(6,7)</sup>.

Therefore, the measurement of grip strength allows in determining the parameters of the ability of arm muscle activity<sup>(8)</sup>. At lactic acid levels showed that there was a correlation between elevated lactic acid levels of blood plasma with the decreased ability of muscle contraction<sup>(9)</sup>. Increased levels of lactic acid in the muscle will affect the ability of muscle contractility, but the increase in lactate in extracellular level indirectly affects the ability of muscle contraction. A decrease in blood pH will affect muscle contraction ability<sup>(10,11)</sup>. Thus the method of handgrip and lactic acid blood plasma levels method can be used as a parameter of muscle fatigue in the forearm of the computer operator.

In the various literature described various methods used in determining the presence or absence of fatigue of a muscle or muscle group. Good measurements using electrical, chemical, mechanical methods and questionnaires<sup>(2,4)</sup>. The method is used based on the purpose and type of fatigue that occurs. Muscle fatigue can generally be used with electrical, chemical and mechanical methods<sup>(2)</sup>. In field research, the measurement of muscle fatigue determination should be used as a simple method, fast and cheap by not ignoring the level of accuracy in the measurement<sup>(1)</sup>. Based on the analysis of objectives and benefits, the researchers choose the parameter method in determining fatigue, the method handgrip, and lactic acid blood plasma levels. Both methods show the difference between measurement results before and after doing work on the computer for four hours<sup>(1)</sup>. For more details can be seen table 1.

**Table 1. Relationship Analysis of Measurement Result of Muscle Fatigue and Lower Arms Computer Operator Based on Measurement Handgrip and Lactic Acid Level of Blood Plasma**

Variable	Mean	SD	Min	Max	R <sub>s</sub> p	p-value
Changes in muscle contraction ability /handgrip (kg)	-4.33	2.15	-11.00	0.00	0.667	0.000
Change in lactic acid Level (mmol/L)	0.51	0,31	0.11	1.50		

Spearman test results on the relationship of muscle contraction ability change (handgrip) with changes in blood plasma lactate acid levels before and after work for four hours on the computer showed a relationship with significant value 0.000 <0.05, where the change in the ability of contraction of the muscles of the finger

and forearm operator computer at -4.33 + 2.15 kg with the lowest change -11.00 kg and the highest 0.00 kg.Changes in blood plasma lactic acid level of 0.51 + 0.31 mmol / L with the lowest change of 0.11 mmol / L and the highest 1.50 mmol / L. If muscle fatigue occurs, the handgrip examination will show a decrease in the

ability of muscle contraction, whereas in the lactic acid level of blood plasma is increased.

The results of the analysis concluded that there is a correlation between the change of muscle contraction ability with the change of lactic acid level of blood plasma of computer operator, meaning the higher the decreasing ability of muscle contraction, the higher the lactic acid blood plasma level increase in fatigue of finger muscle and forearm of computer operator. Muscle fatigue occurs, then the handgrip show the decreased ability of muscle contraction, while the lactic acid level of blood plasma is increased. It is recommended that the measurement of muscle fatigue rate quickly, simple and cheap in the field can be used handgrip method and lactic acid blood plasma level. But both methods can not know whether the muscle fatigue as a result of local or general muscle fatigue.

## DISCUSSION

This study presents an effective method used in the field in determining muscle fatigue of the forearm of the computer operator after work. The handgrip method is used for the reason that grip strength is an indicator of muscle strength as a parameter that is easily measured<sup>(12)</sup>. Strength grip with handgrip as one of the characteristics of the sensation of fatigue<sup>(13)</sup>. The handgrip method is used as a parameter, since the use of handgrip may indicate a decrease in the ability of muscle contraction as a sign of fatigue, as a result of decreased blood supply to the muscle associated with decreased muscle electrical activity<sup>(14)</sup>. Muscle fatigue occurs as a result of reducing the coupling of excitation contractions caused by the decreased number of active cross bridges due to decreased release of  $Ca^{2+}$ , decreased myofibril sensitivity in  $Ca^{2+}$  and reduced strength produced by a cross bridge<sup>(15)</sup>. The handgrip method can measure the ability of muscle contraction throughout the range of motion of the joints because the mechanism occurs because of the long relationship of muscle tension, arm and activity moment and muscle mass<sup>(16)</sup>. Lactic acid method of blood plasma is done to determine the relationship of muscle fatigue with chemical changes in the blood<sup>(17,18)</sup>. The mechanism of increased lactic acid levels after work can occur because the work causes the muscles to contract continuously both statically and dynamically to the load given. The continuous contraction in the muscle causes a reduced muscle response which is shown in progressively decreasing the motor unit's potential

amplitude, resulting in a gradual decrease in the strength capacity produced by the neuromuscular system. This is due to a combination of factors, i.e., interference with the mechanism of muscle contraction due to decreased energy storage, obstacles to the influence of the central nervous system and decreased impulse conduction in the myoneural distortion, especially in fast fibers<sup>(6)</sup>. There is a relationship between decreased strength or fatigue with decreased ATP, increased inorganic phosphate (Pi), increased ADP and PCr depletion which in turn increases the accumulation of lactic acid in the blood<sup>(10,19)</sup>. Maximum exercise voluntarily increases lactate concentration as a parameter of fatigue as evidenced by measurement results using a rating of perceived exertion (RPE) <sup>(1,6,9,14)</sup>. Blood lactate concentration reflects the anaerobic capacity of the muscle, lactate or  $H^+$  ion is a potential factor causing fatigue<sup>(10,20)</sup>. Muscle fatigue can occur through the process of the phosphagen system and anaerobic glycolysis, where the phosphagen system can only provide energy with a short span of time, so anaerobic glycolysis becomes the main metabolic pathway that eventually produces lactic acid<sup>(21)</sup>. Thus muscle contraction due to computer work can lead to decreased ability of muscle contraction and increase lactic acid blood plasma level. This means there is a relationship between changes in muscle contraction strength with changes in lactic acid levels of blood plasma in computer operator after working on the computer. Handgrip method and lactic acid levels can be used to assess the fatigue that occurs in the forearm muscles of computer operators after doing work on the computer.

## CONCLUSION

This research has recommended a simple, fast and cheap method of measuring muscle fatigue that can be done in the field without reducing the accuracy of the measurements. This method can be used one or a combination of both to see muscle fatigue after work. These findings are expected to contribute positively to improve the quality of field measurements that require fast, simple and inexpensive measurement results and can be developed on other types of conditions and workers.

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## REFERENCES

- Hendrik, Tjipto Suwandi, Harjanto JM, Hari Basuki Notobroto. Comparison of Results of Measurement Hand Dynamometer with Lactat Acid Blood Plasma for Muscle Fatigue Level Indicator Hand Computer Operator. *International Journal of Sciences: Basic and Applied Research (IJSBAR)*. 2016;27(2):53–62.
- Cotelez LA, Serra MVGB, Ramos E, Zaia JE, Toledo FO, Quemelo PRV. Handgrip strength and muscle fatigue among footwear industry workers. *Fisioterapia em Movimento*. 2016 Jun;29(2):317–24.
- Nina KVøllestad. Measurement of human muscle fatigue. *Journal of Neuroscience Methods*. 1997 Jun 27;74(2):219–27.
- Suma'mur PK. *Company hygiene and Work Safety (Higiene Perusahaan dan Kesehatan Kerja) (Hiperkes)*. Jakarta, Indonesia: Sagung Seto; 2009. 570 p.
- Hendrik, Tjipto Suwandi, Harjanto JM, Hari Basuki Notobroto. The Effect of Work Position on Fatigue on the Arm Muscles of Computer Operator. *Dama International Journal of Researchers (DIJR)*. 2016 Oct;1(10):33–7.
- Carolyn Kisner, Lynn Allen Colby. *Therapeutic Exercise: Foundations and Techniques*. 6th ed. Philadelphia: FA. Davis Company; 2012. 928 p.
- Hanon C, Savarino J, Thomas C. Blood Lactate and Acid-Base Balance of World-Class Amateur Boxers After Three 3-Minute Rounds in International Competition: *Journal of Strength and Conditioning Research*. 2015 Apr;29(4):942–6.
- Franassis Barbosa de Oliveira<sup>1</sup>, Demóstenes Moreira. Handgrip Strength and Diabetes Mellitus. *Rev Bras Clin Med*. 2009;7:251–5.
- Bonitch-Góngora JG, Bonitch-Domínguez JG, Padiál P, Feriche B. The Effect of Lactate Concentration on the Handgrip Strength During Judo Bouts: *Journal of Strength and Conditioning Research*. 2012 Jul;26(7):1863–71.
- Cairns SP. Lactic Acid and Exercise Performance: Culprit or Friend? *Sports Medicine*. 2006;36(4):279–91.
- Indriana T. The Effect of Muscle Fatigue on Work Accuracy (Pengaruh Kelelahan Otot Terhadap Ketelitian Kerja). 2010;7(3):4.
- Bautmans I, Gorus E, Njemini R, Mets T. Handgrip Performance in Relation to Self-Perceived Fatigue, Physical Functioning and Circulating IL-6 in Elderly Persons without Inflammation. *BMC Geriatrics* [Internet]. 2007 Dec [cited 2018 Jul 5];7(1). Available from: <http://bmcgeriatr.biomedcentral.com/articles/10.1186/1471-2318-7-5>
- Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, Gottdiener J, et al. Frailty in Older Adults: Evidence for a Phenotype. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*. 2001 Mar 1;56(3): M146–57.
- Currier DP. Measurement of Muscle Fatigue. *Physical Therapy*. 1969 Jul 1;49(7):724–30.
- Place N, Bruton JD, Westerblad H. Mechanisms of Fatigue Induced by Isometric Contractions in Exercising Humans and in Isolated Mouse Single Muscle Fibres. 2008;8.
- Mookerjee S, Ratamesh N. Comparison of Strength Differences and Joint Action Durations Between Full and Partial Range-of-Motion Bench Press Exercise. :6.
- WF Ganong. *Review of Medical Physiology*. 23rd ed. New York: McGraw-Hill Companies, Inc.; 2010. 714 p.
- Stuart Fox. *Human Physiology*. 8th ed. New York: Mc Graw Hill; 2011. 726 p.
- Gladden LB. Lactate Metabolism: A New Paradigm for The Third Millennium: Lactate Metabolism. *The Journal of Physiology*. 2004 Jul;558(1):5–30.
- Hasanli M, Nikooie R, Aveseh M, Mohammad F. Prediction of Aerobic and Anaerobic Capacities of Elite Cyclists From Changes in Lactate During Isocapnic Buffering Phase: *Journal of Strength and Conditioning Research*. 2015 Feb;29(2):321–9.
- Fanny Septiani F, Ermita I. Ilyas, Mohamad Sadikin. The Role of H<sup>+</sup> in Emerging Muscle Fatigue: It Influence in Skeletal - Muscle of Rana Sp. *Majalah Kedokteran Indonesia*. 2010 Apr;60(4):178–80.