ORIGINAL RESEARCH PAPER

MUSCLE BLOOD SUPPLY DURING PROLONGED STATIC VOLUNTARY CONTRACTIONS

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Abstract

It is known that metabolic activity of muscle cells even in one separate muscle differs. If VO_2 rate differs between muscle`s motor units, then blood flow through capillaries supplying muscle cells must be regulated according to their metabolic activity. The aim of this study was to evaluate muscle blood flow and compare it with active muscle cell metabolic activity during muscle prolonged static voluntary contraction with different contraction forces. In this study participated 37 healthy untrained people in age 24 – 36. Investigations were performed on the forearm muscles using hand grip exercises with 10% and 15% of maximal voluntary contraction (MVC) Volume blood flow in the forearm segment (I) and capillary filtration coefficient (CFC) were measured using venous occlusion plethysmographic device "KPOBOTOK- 4". VO_2 and lactate delivery (La) were calculated from pO_2 and lactate concentration arterio-venous differences and I in every controlled moment. pH and pO_2 was measured using bioanaliser ABC-1"RADIOMETER". Lactate concentration was measured using BIOSEN C-line "EKF diagnostic" device. During 10% MVC it was shown that I, VO_2, La and CFC till the cessation of exercise caused by exhaustion which takes 42±1,1min stabilize on appropriate level not reaching maximal possible values. Increasing contraction force only for 5% it is to 15% MVC all examined parameters during exercise till exhaustion which takes 12±0,8 min, increases and at moment of cessation of exercise reaches their maximal values. Increasing of blood supply and VO_2 during 15% MVC did not provide prolonged forearm contraction and exhaustion occurs more than 3 times quicker neither during 10% MVC .

Key words: Muscle energetic; prolonged static contraction; exhaustion.

Introduction

The important role for muscle energetic supply plays oxygen transport to muscle cells. For whole organism it is well known as oxygen consumption – VO_2 – a main parameter characterising activity of aerobic metabolism of the body. For characterising muscle metabolism are used parameters indicating activity of oxidative phosphorilation in muscle cells. In literature it is known that different muscle cells have different activity of oxidative phosphorilatin and it is known that during light till sub maximal muscle contractions there are active only definite part of all muscle motor units. Simultaneous activity of all motor units is described in literature during maximal voluntary contractions. In addition, it is known that during muscle contraction increases intramuscular pressure which reduce muscle`s blood supply. It means that metabolic activity of muscle cells even in one separate muscle differs. If $VO_2$ rate differs between muscle`s motor units, then blood flow through capillaries supplying muscle cells must be regulated according to their metabolic activity.

The aim of this study was to evaluate muscle blood flow and compare it with active muscle cell metabolic activity during muscle`s prolonged static voluntary contraction with different contraction forces.

Material and methods

In this study participated 37 healthy untrained people in age 24 – 36. Investigations were performed on the forearm muscles using hand grip exercises. We evaluate forearm muscle maximal voluntary contraction tacking in account the best of three attempts and investigate forearm muscle energetic supply during prolonged exercises till exhaustion with 10% and 15% of maximal voluntary contraction (MVC)

Volume blood flow in the forearm segment (I) and capillary filtration coefficient (CFC) were measured using venous occlusion plethysmographic device "KPOBOTOK- 4" constructed in Latvian cardiology institute. VO_2 and lactate delivery (La) were calculated from arterio-venous differences of pO_2 and lactate concentration and I in every controlled moment pH and pO_2 was measured using bioanaliser ABC-1 "RADIOMETER". Lactate concentration was measured using BIOSEN C-line "EKF diagnostic" device. The MVC was measured every time before starting exercise.

Results

At first was organised an experiment where was measured actual MVC after selected time of maintaining 10% of MVC and 15% MVC. It shows decrease of MVC during increase of fatigue. In second part of this

investigation I, VO_2, La and CFC during prolonged static contraction of forearm muscles with 10% MVC till exhaustion was calculated in every second minute, but with 15%MVC – every minute. The values of measured and calculated parameters were analysed as group means with standard mathematic statistics. Dispersion of the results around the mean in every case not exceeded 8% and on the figures these dispersions where not presented.

The results of the first part of experiment are shown in Fig. 1.

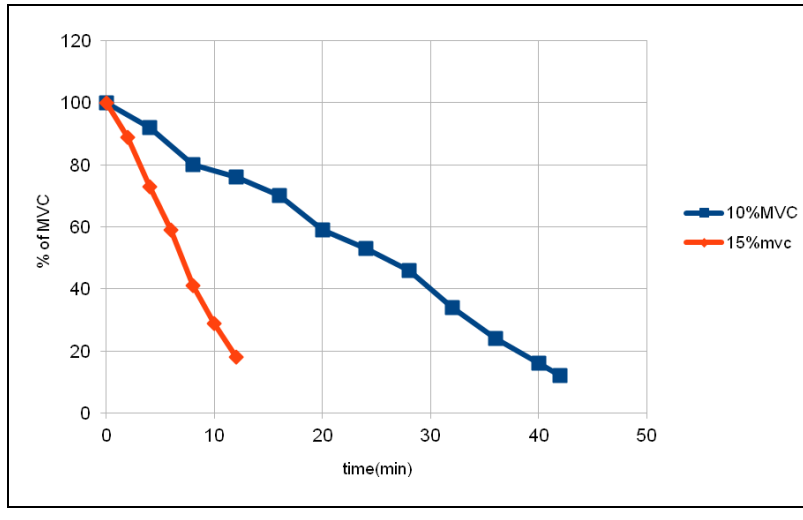

Figure 1. Decrease of MVC during prolonged static contraction of forearm muscles maintaining 10% MVC and 15%MVC till exhaustion

From these results it is evident that MVC decreases with increasing fatigue and reaching full exhaustion it is not possible voluntary increase contraction force above maintined ctatic contraction. It is known that during MVC there are activated all motor units and from the results of this experiment it can be stated that maintaining 10% MVC or 15% MVC till exhaustion there are fatigued all motor units of the forearm. In the same time it is knwn that during muscle contraction with low forces there are activated only appropriate part of all motor units. It could be concluded that during prolonged static contraction till exhaustion there are fatiguet sequensly all motor units and once fatiqued part of motor units till ceasetion of contraction are not again activated. From obtained results it is evident that only 5% MVC increase – from 10% MVC to 15% MVC more than 3 times decreases contraction time till exhaustion. It could be speculated that there exist two different mechanisms of development of fatigue.

For clarifying this question was done next part of experiment. In this part of experiment it was evaluated dynamics of I, VO_2, La and CFC during forearm handgrip with 10% MVC and 15% MVC till exhaustion These results are shown in Fig. 2.

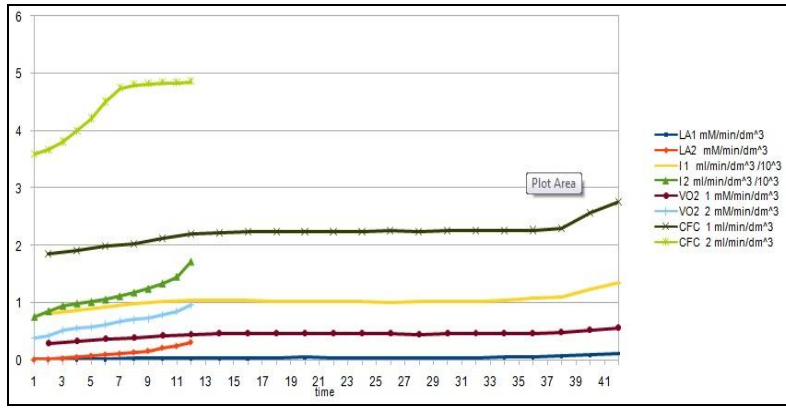

Figure 2. Blood flow, oxygen consumption, lactate delivery and capillary filtration coefficient during forearm muscle static voluntary contraction till exhaustion with contraction forces 10% MVC and 15% MVC

Discusions

During 10% MVC it was shown that I, VO_2, La and CFC till the cessation of exercise caused by exhaustion which takes 42±1,1min stabilize on appropriate level not reaching maximal possible values. Tacking in account results of the first part of experiment it could be stated that during prolonged contraction with 10% MVC where contraction force was maintained by appropriate amount of motor units which during contraction changes recruiting new not fatigued motor units blood flow also was distributed not through all the muscle, but through capillaries feeding active muscle fibres. It is obvious also from dynamics of CFC which characterises the number of opened capillaries and which level during prolonged contraction stays on steady state level not reaching maximal values. Increasing contraction force only for 5% it is to 15% MVC all examined parameters during exercise till exhaustion which takes 12±0,8min, increases and at moment of cessation of exercise reaches their maximal values. It means that during fatiguing one portion of motor units and switching them off and recruiting next portion of motor units the blood flow feeding this part of motor unit's remains and are opened new capillaries feeding newly recruited motor units. In the end of contraction there are opened all capillaries and blood flow through the muscle reaches its maximal values. In

spite of increasing VO_2 there is activated anaerobic glycolisis which characterises with increasing delivery of La. Increasing of blood supply and VO_2 during 15% MVC did not provide prolonged forearm contraction and exhaustion occurs more than 3 times quicker neither during 10% MVC.

Conclusion

During fatiguing one portion of motor units and switching them off and recruiting next portion of motor units the blood flow feeding this part of motor units remains and are opened new capillaries feeding newly recruited motor units. In the end of contraction there are opened all capillaries and blood flow through the muscle reaches its maximal values.

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