

A Functional Study of Oxidative Muscle Efficiency in Older People

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Abstract

To assess, in vivo, muscle oxidative efficiency in older people we studied haematic lactate in blood samples obtained from 34 older and 10 young subjects before and after an incremental exercise performed on a treadmill, in order to identify a possible defect as a factor determining motor performance impairment.

The exercise protocol consisted of 11 steps of 2 minutes of duration, at a constant speed of 3 km/h; the grade was 0 at the beginning and was incremented of 2.5% each step. Lactate was evaluated at rest and during recovery (at 1', 5', 10' and 30' after the end of the exercise).

We found that lactate resting values didn't show a significant difference between older and young people. During recovery, older people showed significantly higher values at any time. The analysis of results permitted to distinguish a subgroup of 11 out of 34 subjects with a behaviour similar to young's one.

In conclusion the abnormal lactate increase observed in this study points out a reduced oxidative muscle function in older people. Interestingly, the test employed allowed to identify two subgroups: with normal levels and with altered levels of lactate. The latter could due to a different individual mt-DNA damage susceptibility.

Key words: aerobic capacity, ageing process, serum lactate, skeletal muscle function.

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During ageing processes neuromuscular apparatus undergoes structural and functional modifications involving both nervous system and muscle and this causes a reduction in motor performance.

These modifications have been assessed on experimental animals and humans through histological, biomechanical and functional analysis.

Many authors showed important structural changes in the aged muscle. Tomlison et al. (1969) [29], Larsson et al. (1978) [17] and Scelsi et al. (1980) [25] noticed a modified distribution of the two types of fibres in the senile muscle. They described a progressive reduction in number and size of the fast-twitch (type II) and an increase of the percentage of the slow-twitch (type I).

Hicks et al. (1992) [12] described a reduced M-wave amplitude in the aged muscle which they ascribed to a decreased sarcolemmal excitability.

Moreover, a reduction in muscle strength with ageing has been demonstrated [15, 13].

Finally, an age-dependent decline in aerobic power has been shown on the basis of the evaluation of cardiorespiratory parameters [2, 5, 6, 14, 24, 26].

In this study we evaluated in vivo the oxidative muscle function in older people analysing changes in serum lactate concentration in subjects undergoing a predominantly aerobic exercise.

Patients and Methods

34 subjects aged between 60 and 75 years and classified as older people group (OP), were studied and compared to 10 subjects aged between 24 and 33 years (young's group) (Y).

All the subjects had been previously clinically examined at our Unit. They had not previous history of neuromuscular disorders or major cardiorespiratory problems. All the subjects referred they led a predominantly sedentary life.

All the subjects were advised to wear comfortable clothes and shoes with a low heel or trainers and to eat a light meal no less than two hours before the exercise. After careful explanation of the procedure informed consent was obtained from all the subjects.

Each subjects performed an incremental test on a calibrated, electronically braked treadmill (Runrace HC 1200, TechnoGym, Forli, Italy).

The exercise protocol consisted of 11 steps of 2 minutes of duration, at a constant speed of 3 km/h. The grade was 0 at the beginning and was incremented of 2.5% at each step.

If the subjects reached the 75% of maximum hearth rate theoretically calculated (220- age), the test was stopped. In this way the work was kept in a predomi-

Muscle oxidative capacity in older people

nantly aerobic condition. All the subjects were informed that exercise could be stopped at any time.

Haematic lactate was evaluated by venous blood samples collected at rest, and at 1', 5', 10' and 30' from the end of exercise.

Blood was collected in EDTA tubes. Samples were withdrawn from the antecubital vein by venepuncture. Lactate was rapidly analysed through an enzymatic assay. The method is based on the conversion of lactate to piruvate and H_2O_2 by lactate oxidase. In the presence of the formed H_2O_2 , peroxidase catalyses the oxidative condensation of chromogen precursor to produce a coloured dye with adsorption maximum at 520 nm. The increase in absorbency at 520 nm is directly proportional to lactate concentration in the sample.

Standard statistical methods were used to calculated means and standard deviation (SD). The evaluation of the differences in mean values among the groups was done using the Mann-Whitney test. Statistical significance was set at $p < 0.05$.

Results

Values are expressed as mean $\pm$ standard deviation (SD). The normal serum lactate range is 0.63-2.44 mmol/L.

All young subjects (Y) completed the exercise (11 steps) while the older people (OP) performed a mean number of 8.3 steps.

On the basis of the results obtained it has been possible to identify a subgroup of 11 out of 34 older people with a trend similar to Y one: they will be called subgroup 1 (OP1) (mean age $\pm$ SD: 66.3 $\pm$ 4.9 years). The remaining 23 subjects will defined subgroup 2 (OP2) (mean age $\pm$ SD: 66.5 $\pm$ 3.8 years).

The mean number of steps performed by OP1 and OP2 was 9.4 and 7.7 respectively. Lactate resting levels were not significantly different in OP, OP1, OP2 and Y.

No difference in lactate values was found after exercise (recovery) between OP1 and Y. Lactate values were significantly higher in OP than in Y, in OP2 than in Y and in OP2 than in OP1 at any time during recovery (Table 1 and Figg. 1 and 2).

Discussion

The first datum arising from our study is a precocious fatigability of the older people (OP) respect to young (Y): the latter completed the exercise while the former performed a mean number of 8 step. The analysis of lac-

Table 1. Absolute lactate values before and after the exercise (mmol/L).

	Rest	1'	5'	10'	30'
Y	1.20 $\pm$ 0.31	1.82 $\pm$ 0.59	1.47 $\pm$ 0.50	1.34 $\pm$ 0.53	1.04 $\pm$ 0.33
OP	1.61 $\pm$ 0.69	3.49 $\pm$ 1.86 [^]	3.22 $\pm$ 1.60 [*]	2.61 $\pm$ 1.18 [*]	1.92 $\pm$ 1.10 [^]
OP1	1.42 $\pm$ 0.40	1.83 $\pm$ 0.45	1.65 $\pm$ 0.42	1.58 $\pm$ 0.48	1.18 $\pm$ 0.41
OP2	1.69 $\pm$ 0.79	4.28 $\pm$ 1.76 ^{^§}	3.96 $\pm$ 1.40 ^{*§}	3.10 $\pm$ 1.10 ^{*§}	2.27 $\pm$ 1.16 ^{^§}

[^] $p < 0.01$ and ^{*} $p < 0.0001$ (vs Y);
[§] $p < 0.0001$ (vs OP1).

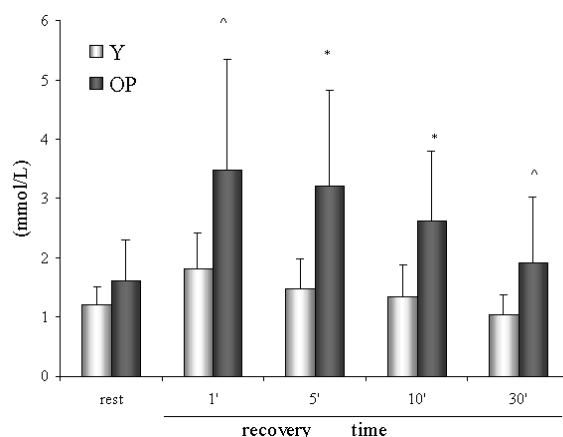


Figure 1. Lactate absolute values (+ or - SD) before and after the exercise in young's group (Y) and in older people group (OP). [^] $p < 0.01$; ^{*} $p < 0.0001$.

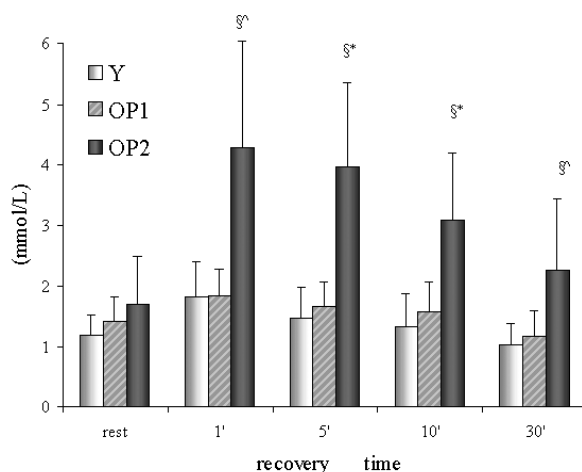


Figure 2. Lactate absolute values (+ or - SD) before and after the exercise in young's group (Y) and in older people subgroups (OP1 and OP2). [§] $p < 0.0001$ (vs OP1); [^] $p < 0.01$, ^{*} $p < 0.0001$ (vs Y).

tate values shows a significant increment after the exercise in the older people group (OP) respect to young's (Y). The resting levels are not significantly different.

The finding of a significant increase of lactate in OP after a prolonged exercise suggests a reduced oxidative muscle function and a precocious resort to anaerobic metabolism.

In fact, it's well established that, during exercise, under aerobic conditions, lactate concentration lightly in-

Muscle oxidative capacity in older people

creases in blood due to the fact that the extra lactate produced in some muscle fibers is oxidized in other muscle fibers [1]. But when aerobic metabolism becomes insufficient, the energy output is guaranteed by anaerobic metabolism supplementation: in these conditions lactate accumulates in the blood.

Recently, Prioux et al. (2000) [21] observed a significantly higher haematic lactate concentration in elderly subjects with respect to young during an incremental exercise on cycle ergometer. They ascribed their finding to an higher catecholamine production during exercise and/or either to a lower skeletal muscle oxidative capacity and to a reduced oxygen extraction capacity.

Our results are in agreement with those of Prioux et al., but the larger number of subjects examined permitted us to distinguish in OP group a subgroup of 11 out of 34 subjects (OP1) that shows a lactate trend similar to young's one. Interestingly, their mean age and their life style didn't substantially differ compared with the remaining subjects (OP2). So, we can exclude that the finding is due to differences in age or in training conditions between the two subgroups. The hypothesis of a reduced oxidative muscle function in older people agrees with findings of an age-dependent decline in aerobic power that several authors showed on the basis of the evaluation of cardiorespiratory parameters. In particular a decrease in maximal oxygen uptake (VO_2max) [2, 14, 24, 26].

Decrease in VO_2max has been attributed to a reduced O_2 delivery and a reduced capacity to use O_2 [12], to a reduced cardiac output [9], to a reduced muscle oxidative capacity [27].

On the other hand, Rifai et al. (1994) [23] studied the frequency of "ragged red fibers" in muscle biopsy specimens obtained from old and young healthy subjects. They found a significantly higher frequency in old compared to young subjects and they suggested that this could be an age-related phenomenon. Moreover the number of COX-deficient myofibers has been found to increase with age in limb muscle, diaphragm and cardiac muscle [19, 20]. Ragged red fibers and COX activity deficient fibers are important markers for mitochondrial disease and are often present in large number in skeletal muscle of subjects with mitochondrial myopathy and encephalomyopathy [7]. It would be a reasonable assumption that in ageing skeletal muscle there is a fall in mitochondrial oxidative metabolism.

An age-related decline in muscle oxidative function would provide a possible biochemical basis for the reduced exercise capacity associate with ageing.

It results interesting to relate the lactate increase to the reduced motor performance and to the precocious fatigability observed in older people.

In fact, lactate, besides heat production, as byproducts of muscle activity, is thought one of the main factors in-

ducing fatigue during long lasting exercise, through reduction in pH (accumulation of hydrogen ions) [8].

On the other hand, lactate accumulation at rest and during exercise is a characteristic laboratory finding in mitochondrial myopathy, where muscle weakness and fatigue represent the main symptoms [7]. It seems very important to underline that, also in this muscle primary pathology, oxidative efficiency can be improved by aerobic training as shown by Taivassalo et al. (1998) [28]. In their study, subjects with mitochondrial myopathy were submitted to an aerobic training. After the training period they found an increase of aerobic capacity with a 30% decrease of lactate concentrations at rest and after exercise, while the patients referred improvement of fatigue and of tolerance to daily activities. Then, the study of muscular oxidative function in older people results important for the indication of eventual specific rehabilitative treatments.

Recent biochemical and molecular studies have indicated that the respiratory enzymes activities of complex I and IV decline progressively with age in human skeletal muscle [30]. Moreover a series of studies in stable tissues of older individuals support an age-related susceptibility for mt-DNA mutations [4, 11, 18, 30]. Spontaneous mutations are frequent in mt-DNA because it has no repair system, and it is constantly exposed to oxygen free radicals leaked from the electron transport chain [18].

Then, a reduced mitochondrial oxidative function can contribute to explain the abnormal increase of lactate blood levels after the exercise observed in older people. In our study we found a subgroup of older people with normal and a subgroup with altered lactate levels. We could hypothesize that there is a different individual mt-DNA damage susceptibility to the responsible factors (i.e. oxygen radicals, etc.).

In conclusion, we think that the test employed represents a specific, reproducible and easy to administrate tool to in vivo evaluate muscle aerobic efficiency in older people. This in order to establish the eventual indication for an appropriate training program. The maintenance of a good level of physical fitness allows a better performance of daily physical activities which is at the basis of a good quality of life for older people.

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Muscle oxidative capacity in older people

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