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Low intensity physical training in older subjects

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Background. **This study was designed to evaluate the effects of a low intensity general training program (<50 % of heart rate reserve) on physical fitness of healthy older subjects, by comparing maximal and submaximal indices of training response.**

Methods. **Twenty-two volunteers over 60 years of age participated in the present study. The sample was randomly divided in an experimental group of 13 older subjects (3 men and 10 women, mean age 63.5±3 years) while the remaining 9 subjects (3 men and 6 women, mean age 64.2±4 years) served as inactive control group. After medical screening all participants were evaluated before and after 12 weeks in which the experimental subjects underwent a low intensity training.**

Each subjects — either inactive or active — performed two treadmill tests at two-days interval, to measure maximal and submaximal responses to exercise, respectively. Heart rate (HR), oxygen uptake ($\dot{V}O_2$) and pulmonary ventilation (VE) were measured using a telemetric apparatus.

Results. **The major finding of the study was the significant improvement in submaximal response to exercise of experimental subjects, expressed by the reduction in HR, $\dot{V}O_2$ VE while $\dot{V}O_2$max did not change.**

Conclusions. **Thus, it appears that a low intensity general training similar to that followed in the present study may represent a good means to improve physical fitness in healthy elderly people. Similarly, this study supports the effectiveness of evaluation tests based on submaximal responses to exercise in this population.**

KEY WORDS: Submaximal test - Aged - Exercise test - Exercise, physiology.

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There is increasing evidence that the practice of regular physical exercise is effective in slowing the age-related progressive deterioration of all biological functions. Several studies have been conducted in order to examine the physiological effects of exercise training in the elderly.[1-4] Maximal oxygen uptake ($\dot{V}O_2$max), anaerobic threshold (AT), either ventilatory or lactate, and heart rate (HR) response to submaximal exercise, were the criteria most frequently adopted to evaluate training response in the elderly. Various authors reported improvements in $\dot{V}O_2$max and AT, following different kinds of training, but their results are not consistent.[2 5 6] This variability seems to depend on the intensity and the duration of the proposed exercise programmes. It is generally accepted that, to obtain significant improvements in $\dot{V}O_2$max and AT it is necessary to exercise at intensities corresponding to 50-85% of $\dot{V}O_2$max.[7] However, such intensities are often not appropriate for the elderly due to the health status of the subjects and the lack of familiarity with heavy physical exercise.

When designing training programmes for the elderly, the main concern regards the selection of

TABLE I.—*Physical characteristics and age of participants. Values are mean±SD.*

Parameters	Experimental group	Control group
Variable	(N=11; 3m-8f)	(N=5; 2m-3f)
Age (yrs)	63.5±3	64.2±4
Stature (m)	1.57±0.08	1.59±0.1
Body mass (kg)	74.0±8.5	75.5±7

m= males; f= females.

the convenient intensity both for effectiveness and safety.

Similarly, the choice of a valid test to demonstrate the training response is necessary. In fact, some changes in cardiorespiratory fitness following training are not easily detected using parameters such as $\dot{V}O_2$max and AT. Furthermore, in the elderly it could be more important to detect improvements in submaximal response to exercise which are more related to the accomplishment of daily activities, and thus to independence. Therefore, especially in the elderly, it seems more practical to evaluate the individual work capacity by means of a submaximal effort.

Submaximal response has been previously evaluated as effort economy, which has been reported to increase after conditioning.[1 8 9] Others researchers[10] reported an improvement in $\dot{V}O_2$max of about 10% after 9 weeks of aerobic training. The same authors observed an increase in submaximal exercise capacity expressed as time to fatigue by 180%.

To our knowledge, most of the studies on the effects of low intensity training have adopted extremely controlled training methods, such as cycling or walking at fixed and controlled pace, while no attention has been devoted to studying the effects of non specific general training programs.

Consequently, the purposes of the present study were: a) to evaluate the effectiveness of a low intensity aspecific training programme on physical fitness in sedentary healthy subjects over 60 years of age, and b) to compare maximal and submaximal indices of training responses.

Materials and methods

Subjects and experimental design

Twenty-two older subjects (6 men and 16 women), over 60 years of age, recruited from the surrounding community participated in the present study. The physical characteristics and the age of subjects were reported in Table I.

Criteria for selection included the following: absence of cardiac, pulmonary or metabolic diseases, absence of osteoarthritis, and inactivity for the previous 2 years. Subjects enrolled in the study gave their written consent and underwent a clinical evaluation including: medical history, physical examination, resting electrocardiogram and a maximal graded exercise test using the Bruce protocol.

Aiming at the minimisation of bias effects due to improvement of motor skill, prior to laboratory test, each subject practised with treadmill walking. This practice was long enough to allow the subject to reach a uniform walking pattern. At the same time, particular care was taken to avoid any training conditioning on the subject.

Two/three practice sessions, including the above mentioned Bruce protocol, were needed to make the subject self-confident with the ergometer.

Of the 22 subjects, 13 were randomly assigned to an exercise group while the remaining 9 served as inactive control group. The selected subjects were tested, with the same protocol, before and after 12 weeks of low intensity aspecific training. Each laboratory session included two treadmill tests, the second being performed two days after.

Measurement of $\dot{V}O_2$max and submaximal capacity

Subjects were advised to eat at least two hours before testing. The first test was maximal and performed to measure $\dot{V}O_2$max. The test started with 2 min warm-up at 1 $m \cdot s^{-1}$ and 0% grade. The speed and the grade were then increased to 1.1 $m \cdot s^{-1}$ and 2.5% respectively. The slope was increased by 2.5% each minute thereafter. When a 10% grade was reached, the speed was set at 1.4 $m \cdot s^{-1}$ and the test was conducted until volitional exhaustion, increasing the slope by 2.5% each minute (Table II).

The criteria of $\dot{V}O_2$max attainment were: 1) plateau in oxygen uptake despite an increase in treadmill speed and/or grade; 2) HR within 10 beats min^{-1} of age predicted maximal (220-age).

For the second laboratory test, a constant-load submaximal treadmill test, the individual work intensity was established using the pretraining $\dot{V}O_2$max measured during the maximal treadmill test. The test protocol speed and grade ranged respectively from

TABLE II.—*Graded maximal exercise test protocol for elderly subjects adopted in the study. Speed in m s^{-1}, grade in % elevation, and time in minutes.*

Stage	Speed	Grade	Time
1	1	0	2
2	1.1	2.5	1
3	1.1	5	1
4	1.1	7.5	1
5	1.1	10	1
6	1.4	10	1
7	1.4	12.5	1
8	1.4	15	1
9	1.4	17.5	1
10	1.4	20	1

1.1 to 1.4 $m \cdot s^{-1}$, and 5 to 10%, to elicit about 70% of $\dot{V}O_2$max.

In order to reach a steady-state condition the duration of the submaximal test was six minutes, and the data from the last minute were averaged for the evaluation of submaximal endurance.

During both tests, maximal and submaximal, oxygen uptake ($\dot{V}O_2$), pulmonary ventilation (VE) and HR were measured every 30 s by means of a telemetric device (Cosmed mod. K2, Italy). The validity and reliability of this apparatus has been evaluated elsewhere.[11] Furthermore, electrocardiogram and arterial blood pressure were continuously monitored during the tests.

Training programme

The training programme consisted of three sessions per week for 12 weeks. At the beginning of the study the instructor taught to the subjects how to measure the correct HR through pulse-palpation for a period of ten seconds.

Exercise classes were designed to improve all fitness components, keeping training intensity below 50% of the HR reserve (HRR). Each exercise class was divided as following:

— warm-up 5-10 minutes. Mobility of all major joints, callisthenics exercises and stretching of the major muscular groups;

— aerobic exercises 15-30 minutes. Walking, very light jogging, for no more than five minutes alternated with active recovery;

— standing exercises 10 minutes. In this phase of the class, subjects cooled-down actively, performing general flexibility and strengthening exercises;

TABLE III.—*Cardiorespiratory values obtained in the two maximal treadmill test, performed before and after training. Data are referred only to the exercise group. Also the significance of differences (p) is reported.*

Parameters	1st	2nd	p
$\dot{V}O_2$ ($l \cdot min^{-1}$)	1.71±0.2	1.80±0.3	NS
$\dot{V}O_2$ ($ml \cdot kg^{-1} \cdot min^{-1}$)	24.3±3	25.0±2	NS
HR ($beats \cdot min^{-1}$)	152±11	155±12	0.02
VE ($l \cdot min^{-1}$)	50.0±10	56.5±13	NS

— relaxation 10 minutes. Muscular relaxation alternated with breathing exercises.

Exercise intensity was self monitored using HR measurements. The instructor ensured that correct measurements were taken.

Statistical analysis

During the training period two women developed orthopaedic problems and did not complete the study, therefore the statistical analyses will concern only 11 subjects (8 women and 3 men). Furthermore, only 5 out 9 control group subjects (2 men and 3 women) completed all the phases of the study. Paired Student's "t"-test was used to evaluate differences between pre-training and post-training condition.

Considering the small number of samples of the control group, we further tested these differences using the non parametric U-test of Wilcoxon, Mann and Whitney.

As indicated by Sachs,[12] this test may be applied as a "check of highly significant "t"-test results in which one does not have real confidence, Pearson's correlation coefficient was used to verify the relationship between $\dot{V}O_2$max measured in the pre-training condition, and the change in $\dot{V}O_2$ (Δ%) observed between the two submaximal tests. Differences were considered significant at $p<0.05$. All values reported are means ±SD.

Results

Table III shows the data of the maximal treadmill test obtained before and after training in the experimental group. Nine out of eleven experimental subjects reached both criteria for the $\dot{V}O_2$max attainment, while the remaining two reached

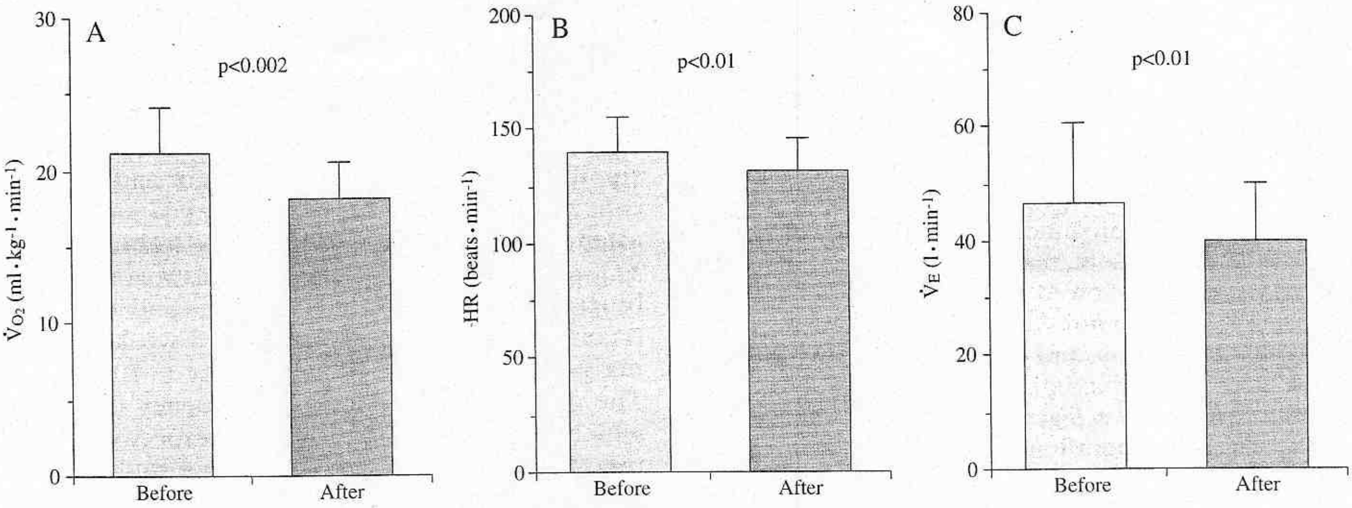

Fig. 1.—Values (mean±SD) of $\dot{V}O_2$ (A), HR (B) and VE (C), obtained in the two submaximal treadmill tests, performed before and after training by the experimental subjects. Also the significance of differences (p) is showed.

TABLE IV.—*Cardiorespiratory values obtained in the two maximal and submaximal treadmill test, performed before and after training. Data are referred only to the control group. Also the significance of differences (p) is reported.*

	1st	2nd	p
Maximal			
$\dot{V}O_2$ (l·min-1)	1.65±0.2	1.67±0.2	NS
$\dot{V}O_2$ (ml·kg-1·min-1)	23.4±2.5	23.2±2	NS
HR (beats·min-1)	155±4	156±3	NS
VE (l·min-1)	53.8±6	53.0±5	NS
Submaximal			
$\dot{V}O_2$ (l·min-1)	1.35±0.1	1.39±0.2	NS
$\dot{V}O_2$ (ml·kg-1·min-1)	20.0±2	20.2±2	NS
HR (beats·min-1)	135±13	134±12	NS
VE (l·min-1)	39.4±9	38.2±8	NS

only one criteria (plateau in oxygen uptake). Training produced no significant change in $\dot{V}O_2$max either when expressed in absolute (l·min-1) or in relative (ml·kg-1·min-1) values. Among the maximal parameters measured only HR showed a significant improvement ($p<0.05$), changing from 152±11 to 155±12 beats·min-1 (Δ%+2).

In Figure 1, are showed the submaximal parameters. As mentioned above the submaximal test was performed at constant workload, and the same protocol was applied before and after the period of training. The energy cost of the exercise, performed at the same work intensity of the pretraining test, was reduced after training.

This reduction is expressed by the significant ($p<0.002$) decrease in oxygen uptake 21.2±3 before and 18.2±2.4 ml·kg-1·min-1 following training (Δ%-14).

Furthermore, a significant reduction ($p<0.01$) in post-training HR compared to the pre-training value (140±15 *versus*, 132±14 beats·min-1;Δ% -6) was found, together with a significant ($p<0.01$) reduction in pulmonary ventilation (46.5±14 *versus* 40±10 l·min-1; Δ% -14). The pretraining $\dot{V}O_2$max not significantly related with the reduction (Δ%) in $\dot{V}O_2$ observed in submaximal post-training test. Thus, no significant influence of the pretraining fitness status on the submaximal response to training is assumed. In Table IV are showed the data of the control group, these subjects did not show any statistical difference between pre and post training testing values. Concerning the $\dot{V}O_2$max attainment all the control group subjects reached the two considered criteria.

Discussion and conclusions

This study demonstrates that 12 weeks of low intensity aspecific training can improve some important aspects of the physical fitness of healthy older subjects. These results show that even a training programme conducted at intensities considered minimal for improvements in cardiovascular fitness,[7] can result in a significant increase in submaximal capacity. In fact, in spite of the lack of modification in $\dot{V}O_2max$ it is necessary to consider the acute reduction in all considered parameters observed during submaximal constant treadmill test performed after the training period.

Testing submaximal capacity is of paramount importance in this population due to its relation with the accomplishment of daily activities. Concerning the present results, the evaluation of the training effects showed that in the elderly, the usual parameters could not describe the real gain in terms of both efficiency and cardiovascular fitness. The reduction in submaximal $\dot{V}O_2$ has been attributed by many authors to a learning effect, especially when subjects are not familiarised with the ergometer.[13,14] A reduction in oxygen uptake is generally observed after two or three tests as consequence of an improved economy of motion. When cardiac work and myocardial oxygen uptake are less for any given work load, muscles are more efficient and relative oxygen requirements are less. In simple activities such as walking, there is a slight difference in mechanical efficiency between individuals, however in older subjects the variability is greater compared to younger counterparts.[15] As above mentioned, the subjects involved in this investigation were all familiarised with treadmill ergometer. Thus, present results should have not biased by a learning effect such as proposed by Astrand and Rodahl[13] and by Wilmore and Costill.[14]

The mean values for directly measured $\dot{V}O_2max$ are similar to those reported in other studies on elderly subjects.[1,6,8] These values range from 21.1 to 26.4 ml·kg^{-1}·min^{-1}. As regards the training effects, the lack of elevation in $\dot{V}O_2max$ found in this study (from 24.3±3 to 25.0±2 ml·kg^{-1}·min^{-1}) suggests that the proposed exercise was specific for improving submaximal fitness such as effort economy. On the other hand, the literature reports several investigations which have demonstrated significant improvements in $\dot{V}O_2max$ after low intensity exercise programs.[1,2,4] It has been suggested that the degree of improvement in aerobic power following training is inversely related to pretraining $\dot{V}O_2max$.[16] In the present research, in order to evaluate the importance of the pretraining fitness condition on the improvements in submaximal aerobic capacity, the initial $\dot{V}O_2max$ has been compared to the degree of reduction in oxygen uptake (Δ%) during the submaximal test. The results showed no correlation between the two variables suggesting that the improvement could be attributed to exercise only.

The literature concerning the effects of low intensity training is not unanimous. Seals *et al.*[2] found a significant improvement in $\dot{V}O_2max$ and a significant reduction in HR during submaximal exercise after six months of low intensity training, while $\dot{V}O_2$ at the same absolute work rates was unaffected by training. In contrast, Belman and Gaesser[6] reported similar results after only 8 weeks of training performed at similar intensity (~40% HRR). The only difference was the frequency of training which was 3 and 4 times weekly respectively in the two studies. On the contrary, another study[1] showed a significant reduction in the $\dot{V}O_2max$ during a submaximal exercise test after 9 weeks of training.

In the present study, the major finding is the improvements in submaximal efficiency, while $\dot{V}O_2max$ did not change. These results could be explained on the basis of the differences in intensity, frequency and duration of the present training programme with the previously mentioned studies.

Regarding the intensity of exercise, previous investigations[1,2,4] adopted values of HRR ranging from 35 to 50% then similar to those of the present study.

The duration of the proposed training programme (12 weeks) is comparable to other studies which adopted period from 6 to 2 months.[6,17] Furthermore, Rogers *et al.*,[18] demonstrated a significant reduction in HR, systolic blood pressure, blood lactate and respiratory exchange ratio during submaximal constant load exercise, in a group of middle aged men after only six consecutive days of moderate exercise training. These results could indicate that the mechanisms underlying the submaximal adaptations are characterised by a short-term response. Further, Forte *et al.*[19] found in two groups of middle-aged women, which trained once and twice a week respectively, a significant decrease in submaximal $\dot{V}O_2max$ being this change greater in the group who trained twice a week thus showing a dependence of performance improvement on the frequency of training.

In summary, it was found a consistent improvement in submaximal efficiency following exercise training of low intensity and relatively short duration.

Furthermore, it is important to stress that the physical training adopted in the present investigation was aspecific and more varied than the training programmes adopted in similar previous studies. Thus, it appears that general aspecific low intensity training represents a good mean to improve physical fitness in elderly people. In addition, this study supports the effectiveness of submaximal fitness evaluation in this population and it also complies with the needs of the elderly population.

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