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ORIGINAL REPORT

PHYSICAL DECONDITIONING IN CHRONIC LOW BACK PAIN

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Objective: **To establish the level of cardiorespiratory fitness and the rate of decrease in maximal aerobic capacity according to age in patients with chronic low back pain and compare these with normative data.**
Design: **Prospective case series with historical controls.**
Subjects/patients: **Seventy patients with chronic low back pain.**
Methods: **A maximal cycle ergometer protocol was used to measure VO_2max, heart rate, respiratory exchange ratio and blood lactate levels.**
Results: **Seventy patients achieved absolute and normalized for weight VO_2max values of 2.17 (standard deviation (SD) 0.65) l/min and 30.79 (SD 7.77) ml/kg/min, respectively. Absolute VO_2max was poorly related to age in both men and women with chronic low back pain (r=–0.22 and r=–0.28, respectively). VO_2max normalized for weight was also inversely related to age in both men and women (r=–0.36 and r=–0.42, respectively). The rate of VO_2max decline between 20 and 59 years was –3.3 ml/kg/min/decade for the entire population and –1.2 and –5.4 ml/kg/min/decade in men and women, respectively.**
Conclusion: **The level of physical fitness of patients with chronic low back pain is comparable to the physical fitness of healthy, but poorly conditioned subjects. Patients with chronic low back pain show a VO_2max decline with ageing that is slower than of active subjects.**

Key words: aerobic capacity, ageing, chronic low back pain, deconditioning, fitness.

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INTRODUCTION

Chronic low back pain (CLBP) is one of the most disabling and costly problems that affects modern society; nevertheless, in a lot of patients an underlying pathology cannot be identified. In developing countries its prevalence is much lower in rural populations that are continually exposed to greater physical effort; however, the values observed in urban populations are quite close to those found in industrialized countries (1).

There is evidence that bed-rest can harm patients with back pain (2, 3). In patients with CLBP it has been hypothesized that a progressive diminution of physical activity has a negative impact on maximal aerobic capacity, creating a vicious circle in which inactivity leads to even more deconditioning and further inactivity (4). It is, however, not proven that patients with chronic pain have a lower physical activity level than healthy individuals (5, 6). Maximal aerobic capacity, as assessed by maximal aerobic uptake (VO_2max), is closely related to the level of exertion during physical activities that involve repetitive use of large muscles, as in activities such as walking, jogging and cycling. Nowadays this physiological variable can be considered a reliable parameter for measuring a subject's functional reserve. High aerobic capacity in physically active subjects ensures adequate function in activities of daily living, while the highest values of VO_2 are measured in endurance-trained subjects. A high level of VO_2max has also been considered an important factor in successful ageing (7). VO_2max decreases approximately 7 ml/kg/min/decade between the ages of 20 and 60 years, with a possible acceleration thereafter (8). It is uncertain what proportion of this loss is inevitable, and to what extent this decline is due to a progressive reduction in daily physical activity. At the age of 60 years, the VO_2max decreases to approximately 50% of the value observed in young adults (8). However, some reports state that individuals who remain vigorously active with ageing maintain their VO_2max for many years (9). Åstrand (8) has proposed poor, moderate and good categories of aerobic capacity for gender and age, based on maximal exercise testing in healthy subjects, the VO_2max in women representing approximately 85% of that for men. Its variation with inactivity represents a good index of the metabolic and cardiorespiratory consequences of a deconditioning process.

Using different methods of estimation, some authors have determined the level of aerobic capacity in patients with CLBP, ranging from deconditioned patients to healthy active subjects. Lower VO_2max values, compared with those of healthy controls, were measured using extrapolated values from a submaximal test by Smeets et al. (4) and Robert et al. (10). Lower values in women were also reported by Hoch et al. (11) using a graded continuous maximal exercise test. On the other hand, Wittink et al. (12), using symptom-limited test, Rasmussen et al. (13) using a submaximal test and Nielens & Plaghki (14) establishing the physical working capacity index and the physical activity level scores, found that aerobic fitness

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levels in patients with CLBP are comparable to those of healthy subjects. However, maximal exertion is important for measuring VO_2max accurately. In the present study patients performed the test until exhaustion and, additionally, the physiological criteria of achievement of VO_2max were considered.

The aim of this study is two-fold; first, to establish the maximal oxygen uptake and its rate of decline with ageing in patients with CLBP and secondly, to compare it with reference data involving healthy subjects.

METHODS

A total of 101 patients were referred by rehabilitation physicians from the functional restoration programme for disabled patients with CLBP of the rheumatology service of Cochin University Hospital, Paris, France. All the patients volunteered to perform a bicycle exercise test until exhaustion. Thirty-one (30.7%) patients failed to perform a maximal test and achieved a VO_2peak value. Only 70 subjects achieved VO_2max criteria during the test and were included in the study. These patients met the following criteria: (*i*) low back pain for at least 6 months; (*ii*) at least 4 months of continuous sick-leave from work because of back pain; (*iii*) no obvious medically or surgically treatable lesion; and (*iv*) absence of cardiorespiratory contraindications for heavy exercise. All subjects were apparently healthy and free of obvious coronary artery disease as assessed by medical history questionnaire.

Before participation, each patient was informed of test procedures and their potential risks and signed an informed consent to participate in the investigation. All procedures were approved by the University Institutional Review Board for Human Subjects. Patients were asked to report to the laboratory 2 h post-prandial and to wear loose, comfortable clothing. Demographic data, body weight and height were recorded. Body mass was measured with a physician's balance scale (Detecto, Webb City, MO, USA) to the nearest 0.1 kg. Pain severity was measured using a 100-mm visual analogue scale (VAS) as proposed by Carlsson (15). Physical strenuousness at work was measured using the Baecke total physical activity score (16). For the assessment of severity of back pain, functional and psychological aspects were measured using the Main and Waddell's functional index (17) and the Hamilton's Anxiety Score (18), respectively.

Exercise consisted of a discontinuous incremental test with an initial stage at 30 watts, followed by a 30 watt increase at each 3 min stage. Between each stage there was a 1 min rest period. A Bosch ERG 55O® (Bosch, Barlin, Germany) cycle ergometer, equipped with an electromagnetic brake was utilized. The pedal rate was maintained at 60 rpm. Standard instructions were given for obtaining a maximal effort during the test. Respiratory gas exchanges were measured breath by breath, using, a Medical Graphics® Cardiopulmonary Exercise System CPX/D (Medical Graphics, St Paul, MN, USA) equipped with a zirconium cell and carbonic infra-red gas. The gas analysers were calibrated immediately prior to each test session using calibration gases. Metabolic data were updated every 30 sec. Electrical heart activity was monitored continuously during the test with a Schiller® A.G Cardiovit CS-200 (Schiller, Baar, Switzerland) 12 -lead electrocardiograph. Maximal heart rate was defined as the highest value recorded during the test and was divided by the predicted maximal heart rate (220 minus age in years) to calculate the percentage of maximal heart rate achieved. Blood lactate concentration was measured using the enzymatic method proposed by Guttman & Wahlefeld (19). Blood samples were obtained from the ear lobe after 5 min rest in a recumbent position prior to the test, at the end of each stage during the test and following 5 min recovery.

Based on the review by Howley et al. (20) concerning VO_2max achievement criteria, the test was considered maximal if the subject reached the primary criterion (variation ≤ 2 ml/kg/min with respect to the VO_2 from the last test charge increment), or 2 of the 3 secondary criteria (blood lactate ≥ 6.7 mmol/l, respiratory exchange ratio ≥ 1.13 or maximal heart rate ≥ 90% of the theoretical maximum). Normalized values of VO_2 are the absolute values in ml O_2 per min divided by body weight in kg. The VO_2max values obtained were compared with the aerobic fitness norms proposed by Åstrand (8) based on maximal exercise testing in healthy subjects.

Data analysis

For the descriptive analysis, results are expressed as percentage and mean (standard deviation (SD)). A proportion test was used to obtain percentage comparisons. One-way analysis of variance was used to determine differences between dependent variables when subjects were classified according to age groups by decades. Univariate correlations and regression analyses were performed to determine the correlations among the dependent variables and the proportion of variance in VO_2max explained by selected predictor variables. Changes in VO_2max with ageing were calculated from the mean values of the upper and lower age ranges. Stepwise multiple-regression analysis was used to identify significant, independent determinants for the age-related declines in VO_2max. Differences were considered to be significant when $p<0.05$.

RESULTS

A total of 101 patients with CLBP accepted to participate in the study. Seventy (69.3%) subjects who achieved VO_2max

Table I. *Characteristics of patients and comparison between men and women*

Variable	Total sample $n=70$	Men $n=37$ (52.9%)	Women $n=33$ (47.1%)	p-value
Age, years, mean (SD)	39.2 (7.1)	38.9 (7.5)	39.7 (6.8)	NS
Height, cm, mean (SD)	167.3 (7.8)	172.2 (6.5)	161.9 (5.2)	<0.001
Body weight, kg, mean (SD)	70.5 (12.8)	76.3 (11.6)	64.0 (11.1)	<0.001
Body mass index, kg/m², mean (SD)	25.2 (4.4)	25.8 (3.9)	24.5 (4.9)	NS
LBP duration, months, mean (SD)	69.4 (57.2)	63.4(49.0)	76.2 (64.6)	NS
Pain at rest, VAS 100 mm, mean (SD)	51.7 (23.8)	44.6 (21.1)	59.3 (24.6)	<0.05
Radicular pain, %	63.3	58.4	41.6	NS
Physical strenuousness at work, %,				
Light	5.5	3.7	8.1	NS
Medium	28.5	14.8	48.6	<0.05
Heavy	66.0	81.5	43.2	<0.001
Months off work, months, mean (SD)	12.0 (8.6)	13.1 (8.7)	10.9 (8.6)	NS
Previous back surgery, %	21.7	11.9	9.9	NS
Main and Waddell's functional index (0–9), mean (SD)	3.9 (2.3)	3.5 (2.2)	4.3 (2.4)	NS
Hamilton's Anxiety score (0–56), mean (SD)	8.5 (8.4)	5.9 (9.2)	11.1 (7.6)	NS

LBP: low back pain; VAS: visual analogue scale; NS: not significant; SD: standard deviation.

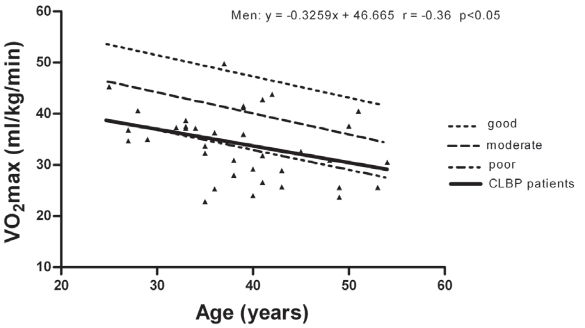

Fig. 1. Comparison in men of values normalized for weight VO_2max values between patients with chronic low back pain (CLBP) and normative data (modified from Åstrand (8)) (n=37).

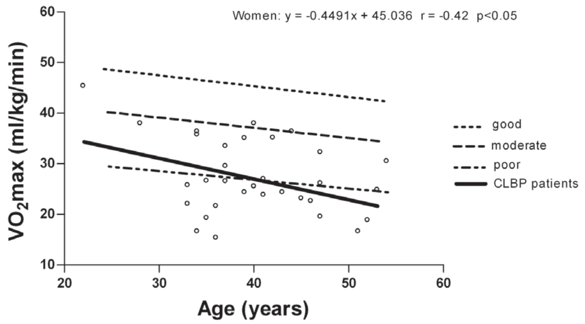

Fig. 2. Comparison in women of normalized for weight VO_2max values between patients with chronic low back pain (CLBP) and normative data (modified from Åstrand (8)) (n=33).

criteria during a maximal cycle ergometer protocol were included in the study and none had to interrupt the test prematurely because of electrocardiographic modifications and/or signs of cardiovascular abnormalities. The remaining 31 subjects were excluded from the study. Comparison between those who did not and those who did participate showed no significant difference regarding anthropometric parameters, severity of back pain and level of disability. Table I presents percentages and mean values (SD) of demographic and anthropometric characteristics of the population and assessment of severity of back pain. The p-values for comparison between men and women are presented. Body weight and height were significantly greater in men ($p<0.05$). Heavy level of physical strenuousness at work was significantly more frequent in men ($p<0.05$). Medium level of physical strenuousness at work was significantly more frequent in women ($p<0.05$). Pain intensity was significantly greater in women ($p<0.05$).

In our study, we measured a mean absolute VO_2max value of 2.17 (SD 0.65) l/min. The mean absolute values for men and women were 2.58 (SD 0.56) and 1.72 (SD 0.41) l/min respectively, representing a highly significant difference between sexes ($p<0.001$). The mean measured value of VO_2max normalized for weight was 30.8 (SD 7.77) ml/kg/min. There was also a highly significant difference between mean values for men (33.9 (SD 6.75) ml/kg/min) and women (27.2 (SD 7.27) ml/kg/min) ($p<0.001$)).

In subjects as a whole and in men and women independently, a linear regression analysis demonstrated that absolute VO_2max was inversely and poorly related to age (p=NS). VO_2max normalized for weight was inversely and modestly related to ageing in patients with CLBP ($r=-0.037$, $p<0.05$). Values for men and women were: $r=-0.36$ ($p=0.02$) and $r=-0.42$ ($p=0.01$), respectively (Figs. 1 and 2).

When compared with normative categories of VO_2max, men and women showed a decrease trend line with ageing similar to that proposed by Åstrand (8). The trend line was situated both, in men and women, between the moderate and poor categories. Compared with absolute values of VO_2max, normalized for weight values were lower in the lower age ranges.

The rate of decline of VO_2max between 20 and 59 years for the whole population was –3.3 ml/kg/min/decade, and –1.2 and –5.4 ml/kg/min/decade for men and women, respectively. The comparison of our findings with healthy sedentary and endurance-trained subjects is shown in Figs 3 and 4.

DISCUSSION

To date, most articles concerning aerobic capacity in patients with CLBP present results based on submaximal testing and none has focused on measuring maximal oxygen uptake during a graded maximal exercise. In our study, the measurement of VO_2max during a graded exercise until exhaustion supports

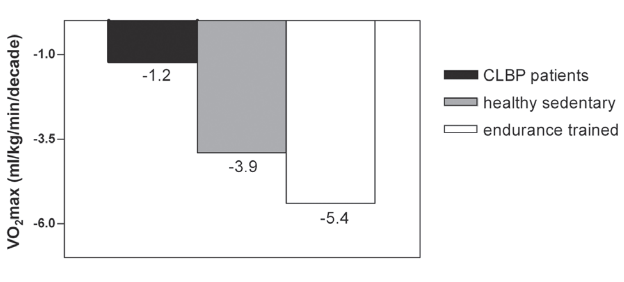

Fig. 3. Comparison in men of rates of decline in VO_2max with increasing age between patients with chronic low back pain (CLBP) (our study) and healthy sedentary and endurance-trained subjects (modified from Pimentel et al. (33)).

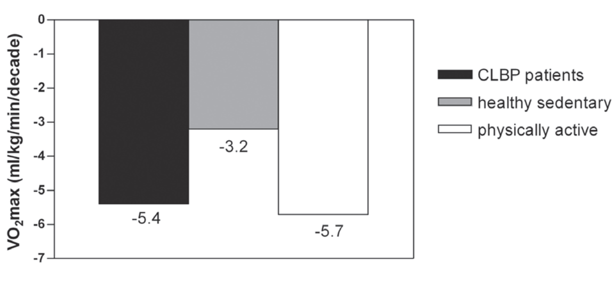

Fig. 4. Comparison in women of rates of decline in VO_2max with increasing age between patients with chronic low back pain (CLBP) (our study) and healthy sedentary and physically active subjects (modified from Tanaka et al. (34)).

the validity of the assessment. A value higher than 3 in the Waddell's somatization score for our patients demonstrates, accordingly to that proposed in the literature (17), a strong component of magnification of symptoms or possible illness behaviour. The comparison of absolute and normalized for weight VO_2max values with normative data of Åstrand (8) confirmed the low levels of cardiovascular fitness found by most of the authors. For all age ranges our values are situated between the moderately and poorly conditioned categories proposed by Åstrand (8). In a relatively large population ($n=70$), we found absolute and normalized VO_2max values close to those found by other authors in patients with low back pain: 2.17 l/min in our study, vs 2.00 l/min in the study by Poiraudeau et al. (21); 30.8 ml/kg/min in our study, vs 30.5 ml/kg/min in the study by Robert et al. (10) and 35.8 ml/kg/min in the study by Hoch et al. (11). Smeets et al. (4) also reported mean lower values of VO_2max in ml/kg lean body mass (LBM)/min of 10 ml/kg LBM/min and 5.6 ml/kg LBM/min for men and women, respectively. These results suggest that the progressive decrease in physical activity in patients with CLBP has a negative impact on their aerobic capacity. In fact, in our population, which had a mean of 12 (SD 8.6) months out of work before the test, the presence of persistent low back pain could cause those patients to avoid physical activities at work and during their leisure time, causing deconditioning as has been described previously by others (14, 22–24). This physical deconditioning, in turn, may result in even more pain, loss of function and disability and so contribute to the chronicity of low back pain (25, 26).

For the analysis of the VO_2max related to sex, a highly significant difference in favour of men, both in absolute and normalized for weight values, confirms the findings of various authors in healthy subjects (8, 27, 28). The VO_2max in patients with CLBP is slightly lower in women than in men of equal size and weight. After puberty, VO_2max in women represents 70–75% of that of men (28) and in our study it represented 80.2%. This difference could be explained, at least partially, by higher physical workloads among men compared with women. In our study men were significantly more exposed to heavy physical strenuousness at work than were women. Moreover, men tend to have larger VO_2max values even when the values are expressed relative to body size. The reasons for this difference could be, at least in part, the fact that women generally have more body fat, which consumes virtually no oxygen (29); the presence of lower haemoglobin values (30); and a lower systolic volume (31, 32).

Taking into account the rate of VO_2max decline with ageing, the men with CLBP in this study showed a lower rate of decline than active subjects when compared with the findings of Pimentel et al. (33)) and Tanaka et al. (34). The rate of decline in maximal aerobic capacity during middle and older age is greater in endurance-trained men than in their sedentary peers and is associated with a marked decline in O_2 pulse (33). The results of our study are also consistent with those reported in longitudinal studies in men (35, 36). We found a rate of VO_2max decline with ageing of –1.2 ml/kg/min/decade in men with CLBP. Our value is lower than for the sedentary healthy subjects and even lower than Pimentel's (33) endurance-trained population (3.9 and 5.4 ml/kg/min/decade, respectively) (33) (Fig. 3). However, in our study women showed a rate of VO_2max decline similar to Tanaka's physically active women (34) (–5.4 and –5.7 ml/kg/min/decade, respectively) (Fig. 4). The reason for the negative correlation between VO_2max decline with ageing and physical fitness level has not been completely established. It is clear that changes in body composition with advancing age play an important role in the diminution of the VO_2max normalized for weight (37–39). Our population revealed a slightly positive correlation between weight and age ($r=0.19$). For Pimentel et al. (33) and Tanaka et al. (34), the highest rate of VO_2max decline with ageing in well-conditioned men and women may be due to a baseline effect. Consistent with the results of Pimentel et al. (33), men with CLBP, who for all age ranges had the lowest VO_2max values, showed a rate of decline lower than that of sedentary subjects and even lower than that of endurance-trained athletes. In women with CLBP the rate of decline of VO_2max is closer to Tanaka's physically active subjects than to sedentary ones (34). This could not be explained by the baseline effect, if one considers that, like men, they had lower VO_2max values for all age groups. However, this could be explained by the increased weight and body fat content with ageing and the sedentary lifestyle observed in patients with CLBP. Because we expressed VO_2max normalized for body weight, increases in body mass would directly reduce VO_2max. According to this reasoning, the baseline effect should not be interpreted in our population of women in the same way as in men.

A limitation of our study is its cross-sectional design, which cannot determine definitively the rate of decline of VO_2max with age. However, Jackson et al. (39) found similar rates of decline of VO_2max using cross-sectional studies and longitudinal analysis in a single study. Longitudinal studies are necessary to confirm the present cross-sectional findings.

In conclusion, patients with CLBP are comparable in terms of physical fitness to healthy but poorly conditioned subjects; a lower level to that observed in sedentary subjects. Differences in work situations might still be the reason for the lower level of fitness. In our study, men showed a rate of decline of VO_2max lower than that of endurance-trained and sedentary subjects. In women with CLBP, the rate of decline is closer to that observed in physically active women.

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