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Original Research

Assessment of four-week exercise re-training programme in chronic low back pain patients in Sub-Saharan Africa : a case series study at the university hospital of Bogodogo

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ABSTRACT

Background: Exercise training is recommended for patients with chronic low back pain. The aim of this study was to evaluate exercise training in patients with chronic low back pain.

Patients and methods: This was a case series study involving 92 patients with chronic low back pain over a two-month period from 5 December 2023 to 5 February 2024. The patients underwent a four-week exercise training programme.

Results: The mean age of the patients was 49.37±12.72 years, with extremes of 26 and 70 years. There was a significant improvement in VAS pain intensity (m before=66.6 ± 1.4 ; m after =12 ± 10.9 p=0.0000) and also a significant improvement in VO2 max (m before=25.87 ± 10.15 m after = 28.25 ± 10.64 p= 0.000). The risk factors associated with low VO2max were age over 60 (p=0.000; RR=3), obesity (p=0.0002; RR=2.41) and sedentary lifestyle (p=0.0008; RR=8.39).

Conclusion: Indirect measurement of VO2max is effective for evaluating exercise training in patients with chronic low back pain. Our experimental exercise training protocol resulted in a significant improvement in patients' pain and VO2max.

Key words: *chronic low back pain; re-training; exercise; six-minute walk test; VO2max*

INTRODUCTION

Chronic low back pain is defined as pain between the thoracolumbar hinge and the lower gluteal fold, lasting for more than three months. It may be associated with radiculalgia, corresponding to pain in one or both lower limbs at the level of one or more dermatomes (1,2). In sub-Saharan Africa, hospital studies have found a frequency of between 35% and 56%(3-5). Patients suffering from chronic low back pain may have kinesiophobia due to the intensity of the pain, the presence of certain comorbidities and the chronic course of the symptoms (6,7). Taken together, these factors can sometimes lead to exertional deconditioning syndrome. Exercise deconditioning syndrome is responsible for limiting the activity of patients suffering from chronic low back pain. This situation can lead the patient to stop doing physical activities for fear of aggravating the pain. This syndrome is partly responsible for the poor exercise tolerance, the maintenance of pain and the progressive decline in physical and cardiorespiratory capacity in chronic low back pain patients (8-11). As a result, these patients may experience a gradual reduction in, or even cessation of, physical activity, which has an impact on maximum oxygen consumption (VO2max). The alteration in VO2max will create a vicious circle known as the 'deconditioning spiral' (12). In this spiral, inactivity leads to aerobic deconditioning, which in turn leads to a reduction in physical activity. This deconditioning syndrome is responsible for the aggravation and chronicisation of pain and disability in patients suffering from chronic low back pain. Current recommendations on the management of patients with chronic low back pain are based on a 'bio-psycho-social' model. These recommendations primarily advocate maintaining physical activity outside the usual rehabilitation sessions for patients with chronic low back pain (10,13-15). Exercise training is an integral part of certain rehabilitation programmes for chronic low back pain patients, but does not always seem to be systematic, depending on the availability of technical facilities, particularly in sub-Saharan Africa. When an exercise training programme is administered to patients suffering from chronic pathologies, its efficacy and follow-up are assessed through instrumental measurement of VO2max by ergo spirometry coupled with electrocardiogram. VO2 max is the main criterion for assessing cardiorespiratory fitness. It is defined as the maximum volume of gaseous oxygen that the body can absorb per unit of time during maximal aerobic exercise. It can be measured directly by the cardiopulmonary exercise test, which is considered to be the absolute reference, or indirectly by sub-maximal exercise tests (16). In sub-Saharan Africa, rehabilitation services have more and more equipment for exercise training, particularly for chronic low back pain patients. Data on the evaluation of exercise training in patients with chronic low back pain are scarce, due to the inaccessibility of devices for the instrumental measurement of VO2max. To compensate for this lack of data, the aim of this study was to evaluate exercise training in patients with low back pain who had benefited from a training protocol in the Physical Medicine and Rehabilitation (PRM) department of the Bogodogo University Hospital, by in-direct measurement of VO2max.

METHODS

Study design: This was a case series study involving 92 patients with low back pain over a 2-month period.

Setting: The study took place from 5 December 2023 to 5 February 2024 at the Centre Hospitalier Universitaire de Bogodogo (CHU-B) in the city of Ouagadougou (Burkina Faso).

Participants: Our study included all patients admitted to the PRM department of CHU-B for chronic low back pain. We created a case series of patients by systematically recruiting all patients with chronic low back pain who had given informed consent.

Inclusion criteria: We included patients suffering from chronic low back pain, aged over 18 years, whose low back pain had progressed for more than 3 months and who had undergone a standard X-ray of the lumbar spine and a minimum biological work-up consisting of a blood count, sedimentation rate and C-reactive protein.

Non-inclusion criteria: We did not include in the study patients with chronic low back pain who had a chronic cardiac or respiratory condition, or those with reduced mobility (walking with technical or human assistance).

Exclusion criteria: we excluded from the study all patients with chronic low back pain who had a follow-up of less than 4 weeks and a number of re-training sessions of less than 12 (patients who had dropped out or incompletely completed the protocol).

Follow-up method: the patients included in the study were followed for 4 weeks. At the first week (S0), each patient received a clinical assessment and an indirect measurement of VO2max. The exercise training protocol was then administered to each patient 3 times a week from S0 to the fourth week (S4), i.e. a total of 12 sessions. At the end of the 12 sessions (S4), a new indirect VO2max measurement was taken for each patient. VO2max was measured by the department's PRM doctor. These measurements always took place in the mornings under identical conditions (closed room).

Variables: the dependent variables in the study were VO2max (16),distance covered in the six-minute walk test (6MWT) (17) and pain intensity on the visual analogue scale (VAS) (18). The independent variables were represented by: socio-demographic variables: age, gender and sedentary lifestyle; clinical variables: co-morbidities, , body mass index (BMI), finger-ground distance (FGD) and Schöber index (SI).

Data sources: VO2max was measured indirectly by calculation, after a six-minute walking test. VO2max was calculated using Peter SAGAT's formula (19). V02 max = 59.44 - 3.83 x sex (1= male and 2= female) - 0.56 x age (years) -0.48 x BMI (kg/m2) + 0.04 x 6 MWT (m) with 6MWT= distance covered in six minutes. VO2max was measured before the start of the experimental exercise-training protocol (S0) and at the end of the protocol (S4).

Maximum oxygen consumption or VO2 max(16): this is the maximum amount of oxygen a person can absorb and the value does not change despite an increase in workload over time. It is expressed in litres/min as an absolute value or in millilitres/kg/min as a relative VO2 max. This is the maximum capacity of an individual's body to transport and use oxygen during progressive exercise. A value of VO2 max < 17ml/min/kg is said to be low level, between 17 and 25 medium level and > 25 ml/min/kg high level.

Bias: bias in the measurement of VO2max after the six-minute walk test was minimised by strict adherence to the instructions given to the patients: participants should fast on the day of the test and not eat for at least 4 hours. They should hydrate with 500ml of water at least 3 hours before the 6WMT and empty the bladder before the start of the test if the need arose. Participants were asked to stretch their ankle, knee and hip joints for 5 minutes. The evaluating doctor checked the heart and respiratory rates, pulse, peripheral oxygen saturation and blood pressure to detect any abnormalities in the vital parameters that would contraindicate the test. Other instructions before the start of the test were to explain the aim of the test to the participant: 'The aim of this test is to cover the longest distance possible in six minutes. You will have to run back and forth between two cones ten metres apart, going around them. You may be tired or out of breath by the end of the test. You are therefore allowed to slow down and even stop to rest if necessary. You are allowed to lean against a wall or sit in a chair to rest, but you should resume walking as far as possible. Bear in mind that the aim of this test is to walk as far as possible in six minutes, without running. Do you have any questions? Are you ready? Go for it.

Study size: Exercise training for patients with chronic low back pain is recommended but not always systematic. We systematically recruited all voluntary patients who had given informed consent and who met the inclusion criteria.

Processing quantitative variables: we calculated the mean and standard deviation of the quantitative variables.

Treatment of qualitative variables: we calculated the proportions of the different qualitative variables and presented them in a table.

Data analysis: Data analysis was performed using SPSS Statistics and Epi info 7.2.6.0 statistical software. The paired Student's t-test was used to compare means, with a significance level of $P \leq 0.05$. Multivariate logistic regression was used to identify the factors associated with normal VO2max before the start of the experimental protocol and at the end of the protocol. Linear regression was used to assess changes in VO2max. A bivariate analysis was used to determine the risk factors associated with a low VO2max after the experimental protocol with a 95% confidence interval.

exercise re-training protocol : After giving their informed consent, the participants were assessed twice during the study. Initially on the first day of their consultation with the PRM doctor, and then after the 4-week exercise training protocol. The exercise training sessions were administered to the participants under the supervision of 4 physiotherapists (the department's referents for adapted physical activity). The training sessions were given to the participants 3 times a week; each session lasted 45 minutes. The first two sessions consisted of: overall muscle strengthening (15 minutes), joint stretching (15 minutes), and cycloergometer training (15 minutes) with a resistance level of 15 and a pedalling speed maintained at 60 rotations per minute. The 3rd and 4th sessions consisted of: overall muscle strengthening (10 minutes), joint stretching (15 minutes), and cycloergometer re-training (20 minutes) with a resistance level of 15 and a pedalling speed maintained at 60 rotations per minute. The 5th to 12th sessions consisted of: overall muscle strengthening (10 minutes), joint stretching (10 minutes), and cycloergometer re-training (25 minutes) with a resistance level of 15 and a pedalling speed maintained at 60 rotations per minute. At the end of each cycloergometer session, patients were advised to dismount and walk slowly to recover.

Ethical and deontological considerations

The research protocol was approved by the CHU-B institutional ethics committee. Free verbal informed consent was obtained from each participant before the start of the study. Participant anonymity and data confidentiality were respected. There was no financial and/or material compensation for participation in our study.

Results

Participants : a total of 107 patients with chronic low back pain were seen during the study period. Ninety-two (92) patients were included and 15 patients excluded (5 lost to follow-up and 10 for insufficient number of sessions) **Figure 1**.

There were 57 women and 35 men, giving a sex ratio of 0.6. The mean age of the patients was 49.37±12.72 years, with extremes of 26 and 70 years.

Descriptive data : the patients' comorbidities were represented by arterial hypertension (23%), diabetes (6%) and overweight and obesity (40.22%) **Table I**.

Outcome data : pain intensity assessed by VAS showed a mean VAS equal to 66.6 ± 14 mm before re-training and 12 ± 10.9 mm after re-training. The difference between the two averages was statistically significant, with a p-value of 0.000.

The mean distance covered in the six-minute walk test (TDM6) by the participants was 309.11 ± 92.37 m at S0 and 367.15 ± 101.99 m at S4. The difference between the two means was statistically significant, with a p-value of 0.000.

The patients' mean finger-to-ground distance (FGD) before re-training was 2.55 ± 7.98 cm and 0.2 ± 1.2 cm after re-training. The difference between the two averages was statistically significant, with a p-value of 0.002.

The patients' mean VO2 max was 25.87 ± 10.15 ml/kg/min at S0 and 28.25 ± 10.64 ml/kg/min. The difference between the two means was statistically significant with a p-value of 0.000. The explanatory variables in logistic regression of a normal VO2max before and after the experimental protocol were age (p=0.008), BMI (p=0.011), hypertension (p=0.008) and coffee consumption (p=0.046) **Table II**.

At the end of the experimental protocol, there was a good progression in VO2max correlated with young age (r=0.84) **Figure 2** and normal BMI (r=0.17) **Figure 3**.

A bi-variate analysis identified age ≥ 60 years (p=0.00002; RR=3), obesity (p=0.002; RR=2.41) and a sedentary lifestyle (p=0.008; RR=8.39) as factors associated with a low VO2max at the end of the protocol **Table III**.

DISCUSSION

Limitations in this study concerned the sample size, which did not allow VO2max to be stratified by age and gender for better analysis. In any case, this study led to some interesting observations. In our study, we observed that the mean age of the patients was 49.37±12.72 years. We found that the most common age group was between 41 and 45, which could be attributed to the fact that low back pain is mainly a condition affecting young adults in sub-Saharan Africa (3-5). The same observations have been made in several African studies (3,5,9). In our cohort, the female gender was the most represented at 62%, with a sex ratio equal to 0.6. This female representation is in line with the general demographics of Burkina Faso, where the population is predominantly female. This trend is consistent with epidemiological observations showing a high prevalence of chronic low back pain among women in Sub-Saharan Africa, who are often subjected to demanding domestic tasks such as laundry, housework and carrying heavy loads. In addition, the physiological hyperlordosis of African women could be a contributing factor in the onset of low back pain. Comorbidities were dominated by hypertension (23%), diabetes (6%) and obesity (10%). A sedentary lifestyle accounted for 79.35% of our chronic low-back pain patients. The presence of these comorbidities in patients with low back pain can be explained by their frequency of onset with age, but also by the sedentary lifestyle in Sub-Saharan populations due to the emergence of means of transport (11,20-23). Indeed, the urban lifestyle adopted by Sub-Saharan populations leaves little room for physical activities such as walking, which is replaced by public transport and many motorcycles. In sub-Saharan Africa, and in Burkina Faso in particular, most people travel by motorcycle or car. Added to this, daily occupation times and the lack of spaces dedicated to sporting activities are a hindrance to the practice and maintenance of adapted physical activity. All this limits the implementation of scientific recommendations on the management of chronic low-back pain, but above all the prevention of cardiovascular co-morbidities by maintaining regular physical activity, as emphasized by the WHO (23). Sub-Saharan African countries should put in place policies that encourage walking activities in urban areas, to limit the need for motorcycles or vehicles, and also create more spaces next to workplaces and homes for group physical activity. However, the high prevalence of a sedentary lifestyle could also be explained by the fact that kinesiophobia is common among chronic low-back pain sufferers in Sub-Saharan Africa(7). The mean VAS score was 66.6± 14 mm before the exercise retraining program, indicating that pain was intense in patients with low back pain. This could be explained by cognitive and behavioural changes during chronic pain, as in the case of chronic low back pain. These changes can alter the actual perception of pain, but they can also be the cause of kinesiophobia, putting patients with low back pain in a spiral of overall physical deconditioning. One of the aims of rehabilitation treatment for patients with chronic low back pain is to manage chronic pain and re-train them for exercise. Patients with chronic low back pain must be put at the centre of their pain management through education in the neurophysiology of pain and back hygiene measures (24). The spiral of physical deconditioning in these patients necessitates a training programme in a rehabilitation environment and the subsequent maintenance of adapted physical activity.

We experimented with a 4-week training protocol that resulted in a significant improvement in pain (p=0.000), spinal mobility (p=0.002), CT6 (p=0.000) and VO2max (p=0.000). These results suggest that our protocol for re-training chronic low back pain patients is effective in our context. This study is one of the first in sub-Saharan Africa to be able to evaluate an exercise training programme using indirect measurement of VO2max. Re-training programmes need to be evaluated in order to improve their effectiveness. In developed countries, laboratories for the instrumental measurement of VO2max exist and make it possible to monitor changes in people undergoing physical training. In our African context, as the technical facilities are not available, indirect measurement of VO2max may be an effective alternative for monitoring our chronic low-back pain patients. This indirect measurement can provide additional motivation for patients, who can monitor their own progress. After exercise re-training, there was a good progression in VO2max with younger age (r=0.84) and normal BMI (r=0.17). In logistic regression, normal VO2max in chronic low back pain patients was influenced by age (p=0.008), BMI (p=0.011), hypertension (p=0.008) and coffee consumption (p=0.046). The literature indicates a decrease in VO2max values averaging 10% per decade in men and women aged between 45 and 70(16). This could explain the fact that re-training results in a better progression of VO2max in the younger patients in our study. In bivariate analysis, the factors associated with lower VO2max after exercise training were age ≥ 60 years (p=0.00002; RR=3), obesity (p=0.002; RR=2.41) and sedentary lifestyle (p=0.008; RR=8.39). In our view, these results suggest that patients with these factors could benefit from exercise re-training protocols lasting longer than 4 weeks in order to achieve a good progression in their VO2max. Our experimental protocol demonstrated its effectiveness in 4 weeks for the majority of chronic low-back pain patients. Our protocol could serve as a starting point for African recommendations on exercise re-training for chronic low back pain sufferers.

CONCLUSION

Exercise training for chronic low back pain patients in sub-Saharan Africa is effective and measurable. A four-week training protocol resulted in a significant improvement in pain and VO2max values. Advanced age and the presence of co-morbidities in chronic low back pain patients appear to be limiting factors in the development of cardiorespiratory fitness after re-training.

State of knowledge on the subject

Deconditioning syndrome is common in patients with chronic low back pain;

Exercise re-training and the maintenance of appropriate physical activity are recommended for patients with chronic low back pain;

Instrumental measurement of VO2max is used to assess exercise re-training.

Contribution of our study to knowledge

This is the first African study to show that indirect measurement of VO2max is possible, especially in our developing countries; VO2max is low in patients with chronic low back pain.

Our 4-week experimental protocol resulted in a significant increase in VO2max and an improvement in pain;

The increase in VO2max was correlated with age and BMI;

The factors limiting the increase in VO2max even after 4 weeks' re-training were age, obesity and a sedentary lifestyle.

Conflicts of interest

The authors declare that they have no conflict of interest.

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Authors' contributions

Study design and plan: TY, GS, and TB. Data collection: TY, TB. Data analysis, interpretation and drafting of the manuscript: TY, SC, KF, NG. Manuscript revision: GS, NG, WJSTZ and OD. Study guarantor: TY. All authors approved the final version of the manuscript.

References

1. Wu A, March L, Zheng X, Huang J, Wang X, Zhao J, et al. Global low back pain prevalence and years lived with disability from 1990 to 2017: estimates from the Global Burden of Disease Study 2017. Ann Transl Med. mars 2020;8(6):299-299.

2. Knezevic NN, Candido KD, Vlaeyen JWS, Van Zundert J, Cohen SP. Low back pain. The Lancet. juill 2021;398(10294):78-92.

3. Morris LD, Daniels KJ, Ganguli B, Louw QA. An update on the prevalence of low back pain in Africa: a systematic review and meta-analyses. BMC Musculoskelet Disord. déc 2018;19(1):196.

4. Kahere M, Hlongwa M, Ginindza TG. A Scoping Review on the Epidemiology of Chronic Low Back Pain among Adults in Sub-Saharan Africa. Int J Environ Res Public Health. 3 mars 2022;19(5):2964.

5. Ouédraogo DD, Ouédraogo V, Ouédraogo LT, Kinda M, Tiéno H, Zoungrana EI, et al. Prévalence et facteurs de risque associés à la lombalgie chez le personnel hospitalier à Ouagadougou (Burkina Faso). Médecine Trop Rev Corps Santé Colon. 2010;70(3):277-80.

6. Vaegter HB, Madsen AB, Handberg G, Graven-Nielsen T. Kinesiophobia is associated with pain intensity but not pain sensitivity before and after exercise: an explorative analysis. Physiotherapy. juin 2018;104(2):187-93.

7. Tiaho Y, Tiendrebeogo WJSZ, Sougue C, Kabore F, Savadogo JE, Gandema S, et al. Kinesiophobia: frequency, associated factors and impact on the life quality of participants with chronic low back pain in sub-saharan africa. Wiad Lek. déc 2021;74(12):3179-83.

8. Grabovac I, Dorner TE. Association between low back pain and various everyday performances: Activities of daily living, ability to work and sexual function. Wien Klin Wochenschr. nov 2019;131(21-22):541-9.

9. Tesfaye AH, Abere G, Mekonnen TH, Jara AG, Aragaw FM. A systematic review and meta-analysis of low back pain and its associated factors among school teachers in Africa. BMC Musculoskelet Disord. 17 juin 2023;24(1):499.

10. Ranganathan H, Singh DKA. A Review of Clinical Practice Guidelines for Physiotherapy Management of Patients with Non-Specific Low Back Pain. Natl J Community Med. 1 mai 2024;15(05):405-15.

11. Mendonça CR, Noll M, Rodrigues APDS, Vitorino PVDO, Mendes MDA, Silveira EA. Association of Pain, Severe Pain, and Multisite Pain with the Level of Physical Activity and Sedentary Behavior in Severely Obese Adults: Baseline Data from the DieTBra Trial. Int J Environ Res Public Health. 22 juin 2020;17(12):4478.

12. Doury-Panchout F, Métivier JC, Fouquet B. VO2max in patients with chronic pain: The effect of a 4-week rehabilitation program. Ann Phys Rehabil Med. févr 2014;57(1):1-10.

13. Boutevillain L, Blay GL, Chaleat-Valayer E. Quoi de neuf dans le réentraînement à l'effort ? Actual En Médecine Phys Réadapt. 2020;27-9.

14. Dupeyron A, Fabre S, Tavares I, Foltz V, Ribinik P, Isner-Horobeti ME, et al. Éducation thérapeutique pour les patients lombalgiques chroniques : élaboration d'un guide destiné aux équipes. Principes méthodologiques et principaux résultats. Lett Médecine Phys Réadapt. sept 2013;29(3):163-8.

15. Dupeyron A, Ribinik P, Gélis A, Genty M, Claus D, Hérisson C, et al. Education in the management of low back pain. Literature review and recall of key recommendations for practice. Ann Phys Rehabil Med. juill 2011;54(5):319-35.

16. Karampreet KB, Neha S, Sudhanshu kacker. A review: Maximal oxygen uptake (VO2 max) and its estimation methods. Int J Phys Educ Sports Health. 2019;6(6):24-32.

17. Guinet AL, Desailly E. Test de marche de six minutes (6MWT) aux enfants atteints de paralysie cérébrale. Revue de littérature et proposition d'une version adaptée. Mot Cérébrale. nov 2018;39(4):119-26.

18. Haute autorité de la Santé (HAS). IQSS 2019 - HAD : Outils de l'expérimentation de l'indicateur « Evaluation et prise en charge de la douleur » en HAD [Internet]. 2019 [cité 8 juin 2024]. Disponible sur: https://www.has-sante.fr/jcms/c_2905713/fr/iqss-2019-had

19. Sagat P. Associations Between Gait Speed and Fat Mass in Older Adults. Clin Interv Aging. mai 2024;Volume 19:737-44.

20. Organisation Mondiale de la Santé. Activité physique [Internet]. 2022 [cité 7 juill 2022]. Disponible sur: https://www.who.int/fr

21. Zhuo Q, Yang W, Chen J, Wang Y. Metabolic syndrome meets osteoarthritis. Nat Rev Rheumatol. déc 2012;8(12):729-37.

22. Gay C, Chabaud A, Guilley E, Coudeyre E. Educating patients about the benefits of physical activity and exercise for their hip and knee osteoarthritis. Systematic literature review. Ann Phys Rehabil Med. juin 2016;59(3):174-83.

23. Chaput JP, Willumsen J, Bull F, Chou R, Ekelund U, Firth J, et al. 2020 WHO guidelines on physical activity and sedentary behaviour for children and adolescents aged 5–17 years: summary of the evidence. Int J Behav Nutr Phys Act. déc 2020;17(1):141.

24. Tegner H, Frederiksen P, Esbensen BA, Juhl C. Neurophysiological Pain Education for Patients With Chronic Low Back Pain: A Systematic Review and Meta-Analysis. Clin J Pain. août 2018;34(8):778-86.

Table I : Clinical and functional characteristics of the study population.

Characteristics		**Before**		**After**	
		workforce	**percentage**	**effectifs**	**percentage**
ATCD	**Hypertension**	21	23	-	-
	Diabete	6	6	-	-
	Others	65	71	-	-
BMI	**skinny**	7	7,6	-	-
	normal	37	40,2	-	-
	overweight	38	41,3	-	-
	obesity	10	10,9	-	-
VAS* (mm)	**<3**	4	4,3	10	11
	[3-6]	29	31,6	81	89
	> 6	59	64,1	0	0
FGD(cm)**	**pathological**	20	21,7	3	3,3
	normal	72	78,3	89	96,7
SI (cm)	**pathological**	92	100	81	88
	normal	0	0	11	12
6MWT* (meters)**	**<180**	8	8,70	1	1,1
	[180-350]	53	58	35	38
	> 180	31	34	56	60,9
VO2max** (ml/min/kg)**	**< 17**	22	23,9	17	18,4
	[17-25]	22	23,9	18	19,6
	> 25	48	52,2	57	62

VAS(mm)* : *mean before* =66,6 ± 1,4 *mean after* =12 ± 10,9 *p*=0,000 *r*= 0.81

FGD(cm)** : *mean before* =2,55 ± 7,98 *mean after* =0,2 ± 1,2 *p*=0,002 *r*=0,90

6MWT (m)*** : *mean before* =309,11 ± 92,37 *mean after* =367,15 ± 101,21 *p*= 0,000 *r*=0,97

VO2max (ml/min/kg) **** : *mean before* =25,87 ± 10,15 *mean after* = 28,25 ± 10,64 *p*= 0,000 *r*=0,99

Table II: Explanatory variables in logistic regression of normal VO2max.

Explanatory variables for normal VO2max	**Coef**	**Std.Err**	**P**	**[95% Conf. Interval]**	
Gender	.8025023	.7418751	0.279	-.6515461	2.256551
Age	3.254048	1.234933	**0.008**	.8336243	5.674472
BMI	-1.712729	.6717048	**0.011**	-3.029246	-.3962116
Diabete	-2.742745	1.801921	0.128	-6.274444	.7889552
Hypertension	5.01392	1.883589	**0.008**	1.322153	8.705687
alcohol consumption	.6128436	.5961776	0.304	-.5556431	1.78133
smoking	1.224867	1.607901	0.446	-1.926561	4.376295
coffee consumption	-2.149976	1.077393	**0.046**	-4.261628	-.0383246

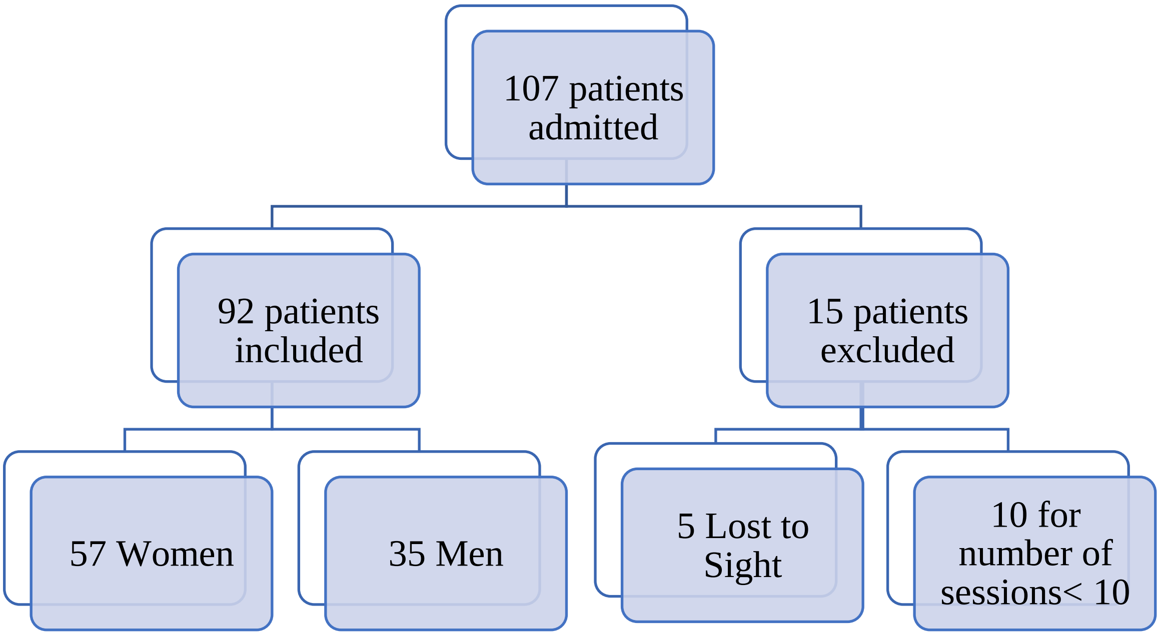
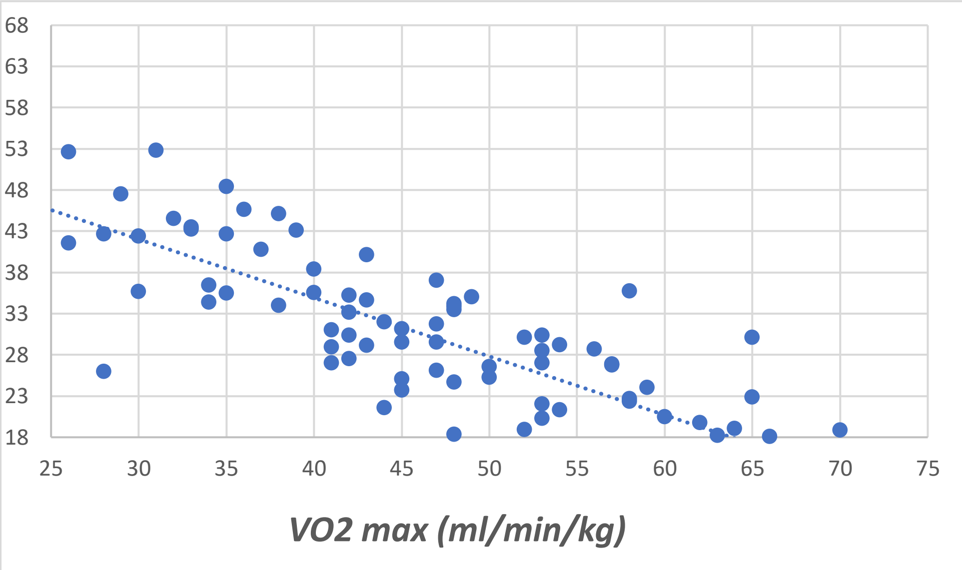


Figure 1: flow diagram.

Age (years)



(r=0.84)

Figure 2 : progression of VO2max correlated with younger age.

BMI (Kg/m²) (r= 0,17)

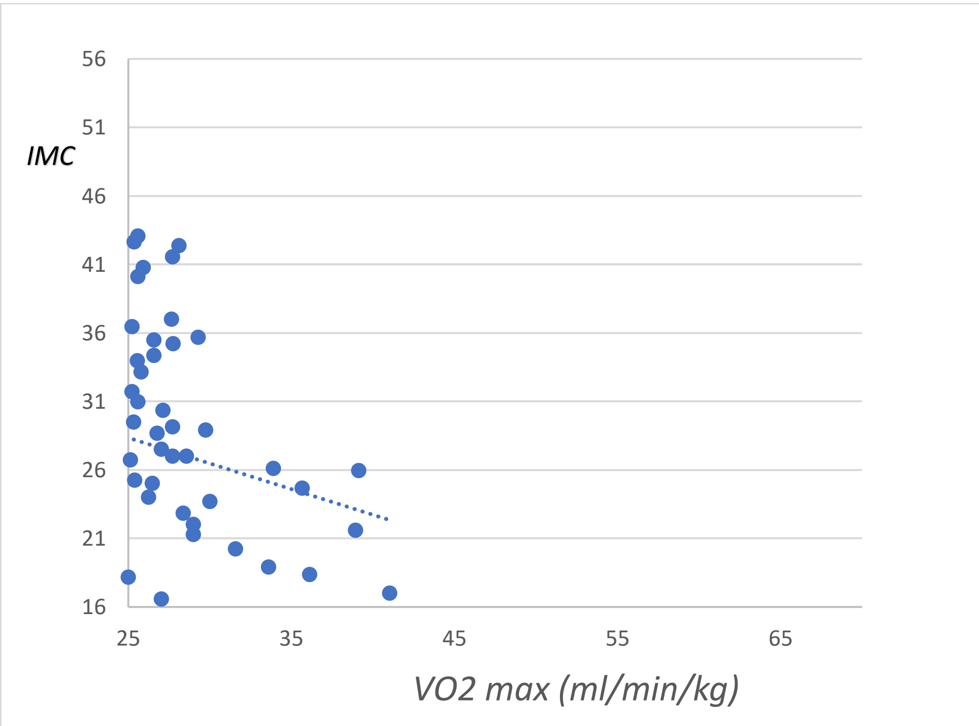


Figure 3 : progression of VO2max correlated with a normal BMI.

Table III: Factors associated with a low level of VO2max in the population studied after the re-training programme, using a bi-variate analysis.

Associated factors	**VO2 max**		**P-value**	**RR**	**confidence interval**
	Low n (%)	**Normal n (%)**			
Age			**0,00000002**	**3**	**2,10-4,28**
< 60 ans	22 (50,0)	47 (97,91)			
≥ 60 ans	22 (50,0)	1 (2,09)			
Total	44 (100)	48 (100)			
Obesity			**0,0002**	**2,41**	**1,86-3,11**
Oui	10 (22,72)	0 (0,0)			
Non	34 (77,28)	48 (100,0)			
Total	44 (100)	48 (100)			
Sedentary lifestyle			**0,0008**	**8,39**	**2,80-25,06**
Oui	41 (93,18)	16 (33,33)			
Non	3 (6,82)	32 (66,67)			
Total	44 (100)	48 (100)			