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A BSTRAC T

BACKGROUND: Chronic low back pain (CLBP) is a major health concern characterized by paraspinal muscle fatigability. This can be im-proved following a functional restoration program. Muscle fatigability can be related to impairment in aerobic metabolism responses. In this study, we investigated paraspinal muscles aerobic metabolism in CLBP patients before and after a functional restoration program, in order to determine if the enhancement in patients' condition following the program is associated to changes in metabolism responses.

METHODS: Twenty-two CLBP patients (11 women, 11 men; 41.6±1.8 years; 73.7±3.1 kg; 1.74±0.02 m) were evaluated before and after a 4-week functional restoration program, with exercise therapy as the main component. Three months later, 12 patients were seen for a follow-up visit. During each testing session, patients performed a five-minute isokinetic trunk extension exercise in measuring pulmonary gas exchanges and paraspinal muscle oxygenation. Mechanical efficiency and onset $\dot{V}$ O2 kinetics were also calculated, in addition to usual questionnaires and exercises designed to evaluate psychosocial and physical factors.

RESULTS: At the end of the program, paraspinal muscle oxygenation, mechanical efficiency, and the $\dot{V}$ O2 onset kinetics were improved ($P<0.05$). All measures remained stable during the three-month follow-up except for paraspinal muscle oxygenation, which deteriorated ($P<0.05$). Return-to-work was associated with the level of workday physical activities and to a decrease in fear-avoidance beliefs.

CONCLUSIONS: At the end of the program, aerobic metabolism responses were improved in paraspinal muscles in patients. These improve-ments were not associated with return-to-work, which was primarily influenced by socio-psychological factors.

KEY WORDS: Low back pain; Physical therapy modalities; Rehabilitation; Oxygen consumption; Spectroscopy, near-infrared.

Chronic low back pain (CLBP) is a major health concern in industrial country, which leads to physical and psychological limitations, resulting notably of high level of paraspinal muscle fatigability in patients.[1, 2] CLBP-induced muscle fatigability could be associated with an alteration in aerobic metabolism during paraspinal muscle contractions, in an attempt to satisfy muscular energy requirements for spine mobilization and stabilization.[3] An imbalance between muscle O_2 needs and utilization could limit aerobic metabolism and induce high level of paraspinal muscle fatigability.

Functional restoration programs for CLBP patients, described by Mayer and Gatchell,[4] have been recognized as being more effective than the traditional medical interventions to improve patients' condition. These restoration programs consist of multidisciplinary biopsychosocial care, with exercise therapy as the main component. These programs notably improve paraspinal muscle fatigability during exercise,[5] which may partly result from enhanced aerobic metabolism contribution. Indeed, aerobic metabolism contribution during exercise is a major factor in muscle endurance and can be improved by physical training.[6] However, the benefits permit by the programs on muscle endurance and functional capacities are not always preserved following the return home. It is unclear if the maintain of benefits is mainly associated with psychosocial (*i.e.* anxiety, kinesiophobia) or physical factors (*i.e.* physical inactivity, aerobic metabolism responses deterioration).[7, 8]

The contribution of aerobic metabolism to exercise can be assessed by measurement of pulmonary gas exchanges in order to calculate onset $\dot{V}O_2$ kinetics and oxygen cost. Muscle oxygenation can also be investigated using near infrared spectroscopy technique (NIRS).[9] Surprisingly, pulmonary gas exchanges in CLBP during prolonged trunk extension exercise have never been reported in the literature, nor during a functional restoration program. Only one study has described paraspinal muscle oxygenation before and after a functional restoration program. It has demonstrated improvement during functional tasks following the program.[10] However, it was unclear if the muscle oxygenation changes identified in this study were associated with changes in metabolic responses or in muscle activation because of the freedom of motion during exercise. A trunk extension exercise using an isokinetic dynamometer may be one method to limit this freedom of motion and to focus the mechanical work on paraspinal muscles, due to the high degree of movement standardization.[11]

The effects of a functional restoration program on paraspinal muscle metabolism in CLBP are still unclear, whereas it could be an important factor in rate of the patients' rehabilitation. Then, the aim of this study was to investigate paraspinal aerobic metabolism during an isokinetic trunk extension exercise before and after a four-week functional restoration program in CLBP patients. Additionally, a three-month follow-up has been set to determine if any potential benefits were preserved after returning to home, and if these benefits were related to returning to work.

Materials and methods

Participants

All participants were referred by their physician to join a four-week multidisciplinary functional restoration program in a rehabilitation inpatient department. A baseline visit was made by an orthopedist to check the inclusion and exclusion criteria. The included patients were suffering from back pain for at least three months, and in a work stoppage because of the disease. Exclusion criteria included the following: overweight and any antecedent of metabolic, cardiovascular, respiratory or neurologic diseases. Also, patients suffering from persistent and very intense pain exacerbated during exercise were excluded from the study, to avoid improper exercise execution, and a potential deterioration of the patients' condition due to prolonged trunk extension exercise. Last, we did not include sedentary individuals with chronic low back pain because the aim of the study was to assess physiological impairment in these patients, irrespective of the deterioration caused by inactivity.

Twenty-nine patients were invited to participate in the study. All accepted and completed a written informed consent form. However, six of them were excluded (two overweight patients, one patient suffering from very intense pain when exercising, one patient was not able to perform the exercise because of muscle weakness, one patient missed the appointment, two patients were excluded because of unrecorded data due to technical issues). Finally, participants included subjects aged between 26 and 55 years old, suffering from non-specific chronic low back pain for at least three months (11 women, 11 men; 41.6±1.8 years; 73.7±3.1 kg; 1.74±0.02 cm). Among them, only twelve participants (6 women, 6 men; 40.7±2.6 years; 68.7±2.9 kg; 1.71±0.02 cm) performed the 3-month follow-up session. The other twelve did not perform the last session, due to time constraints or missed appointments, and for one patient, because of severe low back pain.

The multidisciplinary functional restoration program consisted of five days of hospitalization per week, for four weeks. Professional care was administered about 15 hours per week. These cares were composed of physical exercises, therapeutic education, and manipulations supervised by physicians, physiotherapists, occupational therapists, and adapted physical activity professionals. Additionally, patients were required to independently perform prescribed physical exercises each day. The protocol was set in accordance with the Helsinki Declaration and received the approval of the local Committee for the Protection of Persons (N. ID: 2016-A01151-50).

Study design

Participants performed three testing sessions to evaluate physical and psychosocial factors (Figure 1). The first ses-

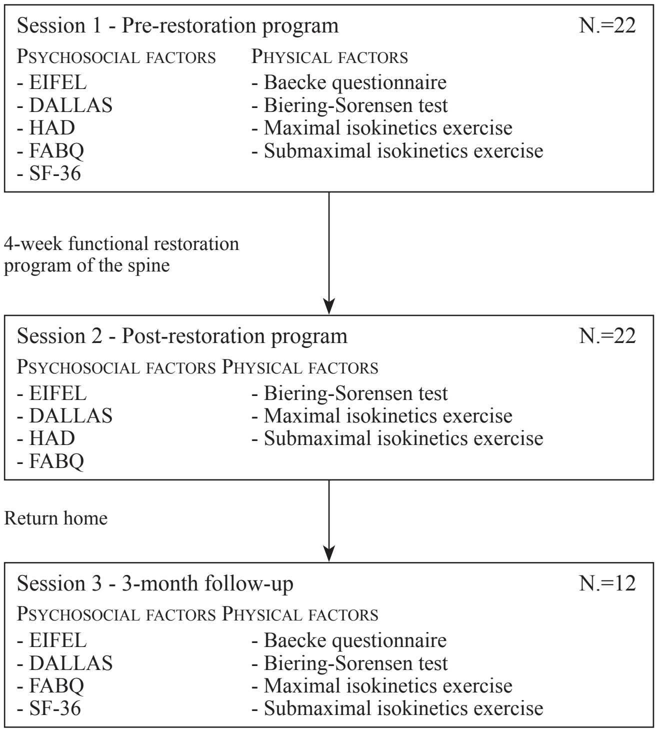

Figure 1.—Study design.

sion (S1) was performed during the first week of hospitalization, and the second session (S2) was performed during the last week of hospitalization. Three months after returning home, all study patients were invited to perform a half-day follow-up session. This session (S3) was designed to assay physical and psychosocial measures taken during S1 and S2. Patients were also asked about their professional activities since returning home.

Psychosocial factors

The perceived disabilities were evaluated using the EIFEL questionnaire at S1, S2, and S3.[12] CLBP incidence was assessed at S1, S2, and S3 using the Dallas questionnaire, focusing on four items: daily activities, work and leisure activities, anxiety and depression, and sociability.[13] Anxiety disorders and depression during hospitalization were evaluated using the Hospital Anxiety Depression questionnaire (HAD) at S1 and S2.[14] Pain-related fear was evaluated using the Fear-Avoidance Beliefs Questionnaire (FABQ) at S1, S2, and S3, focusing on two items: the beliefs about professional activity (FABQ-Work) and those about physical activities (FABQ-PA).[15] Quality of life at home was evaluated using the MOS 36-item Short-Form Health Survey (SF-36) at S1 and S3.[16]

Physical factors

Level of physical activity during daily life was evaluated using the Baecke questionnaire at S1 and S3, focusing on three items: physical activities at work, during sport activities, and during the leisure time.[17] Paraspinal muscle fatigability was determined using the Sorensen test at S1, S2, and S3.[18] Paraspinal muscle strength was evaluated at S1, S2, and S3 using an isokinetic dynamometer (Con-trex® TP-1000, CMV AG, Switzerland) associated to a specific trunk module in continuous passive motion. All isokinetic exercises used in this study consisted of trunk extensions with passive flexions. The flexions exercise velocity was fixed at $30°.s^{-1}$ against $60°.s^{-1}$ during the extensions. The range of motion was set at 70° (from 5° of extension to 65° of flexion from the neutral position for each individual). After a familiarization and a warmup period, three maximal trunk extensions were performed to determine maximal peak torque as a maximal trunk extensor muscle strength measurement.

Aerobic metabolism responses to isokinetic trunk extension exercise

A 20-minute rest period occurred after paraspinal muscle strength measurement. Participants were then equipped with a pulmonary gas exchange analyzer, a heart rate monitor, and one near-infrared spectroscopy probe positioned in regard to paraspinal muscles: 3 cm to the painful side of the third lumbar vertebra, or to the dominant side if the pain was bilateral. Patients then performed a five-minute isokinetic submaximal trunk extension exercise, corresponding to a constant setting torque of 80 Nm, as described previously.[19] It has been established that five minutes were sufficient to permit a fully aerobic metabolic contribution, and that 80 Nm corresponds to a performable and submaximal exercise level for CLBP patients (unpublished data). During this exercise, a biofeedback diagram was displayed in real time, showing the produced torque. On the same screen, a green band represented the desired intensity; patients were asked to perform the trunk extensions while staying inside this green band. At the end of the five-minute exercise, the total performed work (W_{tot}) was recorded by the Con-trex software (Human kinetics® 1.7.5).

During this trunk extension exercise several parameters were recorded and analyzed.

Pulmonary gas exchanges and heart rate were assessed using a portable metabolic system (MetaMax® 3B, Cortex, Germany) coupled with a heart rate (HR) monitor (Polar Electro T31®, Finland). Oxygen uptake ($\dot{V}O_2$), carbon dioxide production ($\dot{V}CO_2$), and ventilation ($\dot{V}E$) were measured breath-by-breath. Before each test, the gas analyzer and volume transducer were calibrated. Any value visually considered as outliers were removed before data analysis.

Breath-by-breath data for $\dot{V}O_2$ were interpolated to 1-s values in order to analyze the onset kinetics adjustment for $\dot{V}O_2$ from the mono-exponential form: $\dot{V}O_{2(t)}=\dot{V}O_{2(0)}+A(1-e^{-(t-TD)/\tau})$.

$\dot{V}O_{2(t)}$ represents the oxygen uptake at any moment of the exercise and $\dot{V}O_{2(0)}$ represents the value of $\dot{V}O_2$ at rest. A represents the difference between $\dot{V}O_{2(0)}$ and $\dot{V}O_2$ value at the steady state of the exercise. TD represents the time delay, while τ is the time constant, which is the time required for $\dot{V}O_{2(0)}$ to achieve 63% of the steady state.

Breath-by-breath $\dot{V}O_2$, $\dot{V}CO_2$, $\dot{V}E$, and HR were averaged on the last minute of exercise for data analyses. $\dot{V}O_2$ and $\dot{V}CO_2$ averages were also used to calculate the energy expenditure (EE) during the last minute of exercise. Mechanical efficiency (ME) was calculated from the total work (W_{tot}) and EE, as described by Moseley and Jeukendrup:[20] EE ($J.s^{-1}$)=[(3.869×$\dot{V}O_2$)+(1.195×$\dot{V}CO_2$)]×(4.186/60)×1000, and ME (%)=[(W_{tot}/300)/EE-exercise]×100.

Paraspinal muscle oxygenation was assessed using a probe emitting near-infrared light[9] (Portamon, Artinis Medical Systems®, the Netherlands). The wavelengths emitted were 760 Nm and 850 Nm, which represented the near-infrared light absorbed by deoxygenated hemoglobin (Hb) or myoglobin (Mb) and oxygenated Hb-Mb, respectively. Emitted light is scattered or absorbed, with the scattered light returning to the receptor permitting identification of changes in deoxygenated Hb-Mb (ΔHHb) and oxygenated Hb-Mb (ΔHbO_2). The sum of the changes in oxy- and deoxygenated Hb-Mb represents the total Hb-Mb (ΔTHb), which is an indicator of the total blood volume under the investigated zone. The differential pathlength factor used was 4. Data were sampled at 10 Hz, averaged minute per minute, and normalized by rest values in order to identify changes produced by exercises.

Perceived pain in the low back was evaluated before and after the five-minute exercise using a visual analogue scale of pain. The scale ranged from zero (corresponding to "no pain at all") to 10 (corresponding to "worst pain imaginable").[21]

Statistical analysis

Data are presented as mean (SEM) or median (25th, 75th percentile) when the distribution was non-normal. Because of the difference in sample size between S1 and S3, analyses were primarily performed between S1 and S2 (N.=22), followed by a comparison of S2 and S3 (N.=12). To compare the questionnaires' responses, time holding during Sorensen test, maximal peak torque, $\dot{V}O_2$, $\dot{V}E$, HR, A, TD, τ and ME between two periods (S1 *vs.* S2 or S2 *vs.* S3), paired *t*-tests were used if the normality test was successful. Wilcoxon tests were used if the normality test failed. Two-way analysis of variance (ANOVA) with repeated measures were used to compare perceived pain in the low back, ΔHbO_2, ΔHHb and ΔTHb (moment of exercise × testing session). When differences were detected, Bonferroni's *post-hoc* analysis were used to isolate the differences. Student's *t*-tests were used to analyze the factors associated with return to work at S3 (W: workers *vs.* NW: non-workers). Statistically significant differences were declared if $P<0.05$.

Results

Effects of a four-week functional restoration program

Psychosocial factors

The outcomes of the EIFEL, Dallas, HAD-Anxiety, and FABQ questionnaires were improved at S2 compared with S1 ($P<0.05$). The HAD-depression score was not statically different between S1 and S2 (Table I).

Physical factors

Holding time during the Sorensen test was improved at S2 compared with S1 ($P<0.05$). Maximal peak torque developed during maximal trunk extension was unchanged (Table I).

Responses to 5-minute isokinetic trunk extension exercise

At S1, perceived pain in the low back was higher after exercise ($P<0.001$), whereas there was no increase in pain following exercise at S2. At the end of the exercise, perceived pain was higher at S1 than S2 ($P=0.012$) (Figure 2).

At S1, there was a significant decrease in ΔHbO_2 and ΔTHb during the five-minute exercise compared to resting level ($P<0.05$). At S2, ΔHbO_2 was also reduced during exercise ($P<0.05$), whereas ΔTHb was unchanged compared to resting level. ΔHHb was significantly higher at S2 compared with S1 from the third minute of exercise ($P<0.05$) (Figure 3).

Analysis of the onset $\dot{V}O_2$ kinetic revealed that τ was lower at S2 *versus* S1 ($P=0.036$). TD and A were unchanged (Table I). In the last minute of exercise, HR, and $\dot{V}E$ were unchanged between S1 and S2. The mechanical efficiency was improved at S2 compared with S1 ($P=0.008$).

Table I.—*Psychosocial and physical factors measured before (S1) and after the program (S2).*

Factors	N.	S1	S2	P value	95% CI
Psychosocial factors					
Dallas-DA[a]	20	67.20 (2.58)	40.35 (4.96)	<0.001	18.93–34.77
Dallas-W/L[a]	20	67.30 (4.41)	39.25 (5.74)	<0.001	18.02–38.08
Dallas-PSY[a]	20	52.50 (5.87)	28.75 (5.09)	<0.001	15.65–31.85
Dallas-SOCIAL[a]	20	43.00 (4.27)	27.25 (4.27)	<0.001	8.07–23.43
FABQ-Work[a]	20	13.60 (1.35)	7.45 (1.39)	<0.001	3.13–9.17
FABQ-PA[a]	20	21.60 (2.43)	17.10 (3.05)	0.03	0.48–8.43
HAD-Anxiety[a]	21	9.24 (0.72)	7.38 (0.76)	0.01	0.55–3.16
HAD-Depression[a]	21	6.48 (0.81)	5.57 (0.96)	0.21	-0.55–2.36
Physical factors					
Maximal peak torque (N.·m)[a]	22	234.19 (14.67)	233.95 (14.57)	0.98	-22.89–23.37
Biering-Sorensen test (s)[a]	21	79.33 (9.42)	117.24 (6.90)	<0.001	-53.19– -22.62
Responses to submaximal exercise					
Mechanical efficiency (%)[a]	20	4.31 (0.13)	4.89 (0.20)	0.01	-0.95– -0.16
$\dot{V}O_2$ amplitude ($L.min^{-1}$)[b]	20	1.01 (0.84, 1.13)	0.89 (0.81, 1.05)	0.35	
$\dot{V}O_2$ onset time delay (s)[a]	20	21.22 (2.15)	17.56 (1.51)	0.05	-0.05–8.88
$\dot{V}O_2$ onset time constant (s)[b]	20	28.27 (25.57, 32.96)	25.53 (22.82, 28.68)	0.04	
Heart rate ($beats.min^{-1}$)[a]	19	133.06 (4.48)	129.63 (4.01)	0.39	-3.58–8.60
Ventilation ($L.min^{-1}$)[a]	21	45.91 (2.61)	45.14 (2.66)	0.54	-1.79–3.34

Values are [a]mean (SEM) or [b]median (25th, 75th percentile) when the distribution was non-normal.
DA: Daily activities; W/L: work and leisure time; PSY: psychological condition; SOCIAL: sociability; PA: physical activity.

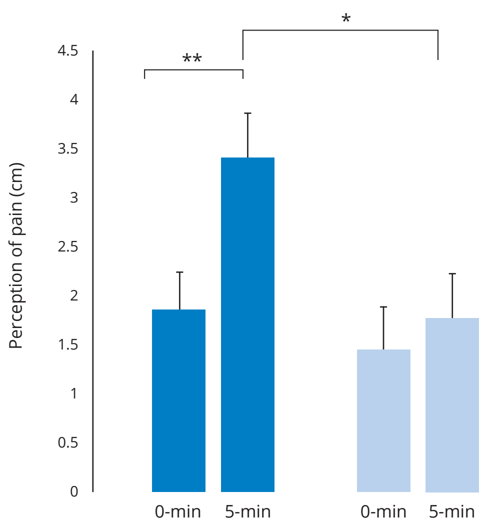

Figure 2.—Level of pain perceived before (0-min) and after (5-min) the five-minute exercise, before (■) and after (■) the program (N.=22).
Values are mean±SEM.
Significant difference: *P<0.05; **P<0.001.

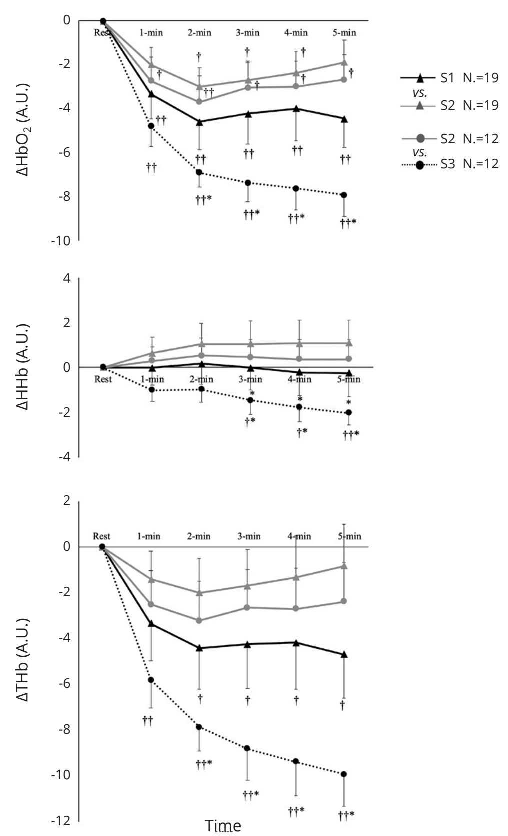

Figure 3.—Changes in HbO_2, HHb, and THb during the 5-minute exercise before (S1), after (S2), and at three months after the program (S3).
Values are mean±SEM.
Significant difference with rest values: †P<0.05, ††P<0.001; significant difference with S2: *P<0.05.

Table II.—*Psychosocial factors, physical factors, and cardiorespiratory and metabolic responses to exercise measured after the program (S2), and at the 3-month follow-up (S3).*

Factors	N.	S2	S3	P value	95% CI
Psychosocial factors					
Dallas-DA[a]	11	40.91 (7.58)	40.18 (6.22)	0.91	-13.13–14.58
Dallas-W/L[a]	11	45.45 (8.32)	41.82 (5.59)	0.68	-13.13–14.58
Dallas-PSY[a]	11	32.27 (7.64)	33.64 (8.29)	0.87	-15.25–22.52
Dallas-SOCIAL[a]	11	31.36 (6.11)	28.64 (6.03)	0.67	-11.89–16.16
FABQ-Work[a]	11	21.18 (4.49)	22.36 (4.03)	0.69	-7.55–5.18
FABQ-PA[b]	11	5.00 (2.50, 12.25)	6.00 (1.25, 6.00)	0.63	
Physical factors					
Maximal peak torque (N.·m)[a]	12	244.43 (21.30)	231.61 (22.03)	0.25	-10.59–36.23
Biering-Sorensen test (s)[a]	9	107.56 (12.02)	95.78 (9.11)	0.37	-17.01–40.57
Responses to submaximal exercise					
Mechanical efficiency (%)[a]	10	4.86 (0.20)	4.89 (0.26)	0.19	-0.47–0.39
$\dot{V}O_2$ amplitude (L.min^{-1})[a]	11	0.94 (0.05)	0.91 (0.05)	0.35	-0.05–0.13
$\dot{V}O_2$ onset time delay (s)[a]	11	14.10 (2.09)	18.79 (1.31)	0.07	-9.76–0.37
$\dot{V}O_2$ onset time constant (s)[a]	11	25.55 (1.66)	26.81 (0.94)	0.39	-4.39–1.86
Heart rate (beats.min^{-1}) [a]	10	133.03 (4.35)	128.16 (5.76)	0.34	-6.56–11.39
Ventilation (L.min^{-1})[a]	11	45.34 (3.81)	42.17 (3.03)	0.04	0.59–5.89

Values are [a]mean (SEM) or [b]median (25th, 75th percentile) when the distribution was non-normal.
DA: Daily activities; W/L: work and leisure time; PSY: psychological condition; SOCIAL: sociability; PA: physical activity.

Three-month follow-up

Psychosocial factors

There was no significant change in questionnaire outcomes between S2 and S3 (Table II). The SF-36 outcomes were improved at S3 compared with S1 (43.81±3.31 *vs.* 68.23±4.71%; P<0.001).

Physical factors

There was no difference in maximal peak torque or holding time during the Sorensen test between S2 and S3 (Table II). According to the Baecke questionnaire, the level of sport activity was increased at S3 compared with S1 (2.29±0.25 *vs.* 2.84±0.23; P=0.039).

Responses to five-minute isokinetic trunk extension exercise

There was no significant change between S2 and S3 in perceived pain in the low back, mechanical efficiency, or the onset $\dot{V}O_2$ kinetics during the five-minute trunk extension exercise (Table II). However, ΔHbO_2, ΔHHb, and ΔTHb were significantly lower at S3 than S2 (P<0.05) (Figure 3).

Return to work

Among the twelve patients evaluated during the three-month follow-up, six returned to work (W), whereas the six others were waiting for work-adjustment or reconversion (NW). According to the Baecke questionnaire completed during S1, return to work was associated with a lower level of physical activity at work (W: 1.92±0.44 *vs.* NW: 3.76±0.16; P=0.003). It was also associated with a lower FABQ-Work outcome at S2 (W: 11.80±3.01 *vs.* NW: 29.00±6.41; P=0.05).

Discussion

The aim of this study was to investigate paraspinal muscle aerobic metabolism responses to exercise in CLBP patients before and after a four-week functional restoration program, followed by an evaluation at three months post-program. Aerobic metabolism responses to prolonged trunk exercise were improved after the program. However, the benefits of paraspinal muscle oxygenation to exercise were deteriorated three months after returning home.

Pre- and postintervention

The multidisciplinary program resulted in decreased paraspinal muscle fatigability and improved psychosocial condition of the patients after the program. All of these benefits contributed to rehabilitate patients to daily tasks and normal activity.[22]

At the end of the program, $\dot{V}O_2$ onset kinetics were faster than before the program, and the mechanical efficiency, paraspinal muscle deoxygenation (ΔHHb), and blood volume (ΔTHb) were increased, suggesting benefits in the oxidative metabolism responses to exercise.

Oxidative metabolism response changes may be explained by an increase in exercise blood supply between S1 and S2.[23] The results of this study support this hypothesis. At S1, the drop in ΔTHb during exercise suggests a restriction of blood volume to the muscle, likely due to high intramuscular pressure in the paraspinal muscles.[24, 25] At S2, the drop in ΔTHb was not present, indicating that paraspinal blood volume was stable between rest and trunk extension exercise. This result suggests greater vasodilation or capillary recruitment during exercise after the program.[23] These effects would result in an increase in paraspinal muscle blood volume during exercise and may raise the exchange area between blood and muscle. This could induce greater muscle O_2 availability and extraction during exercise;[26] this is supported by the increase in ΔHHb at S2. Hemodynamic improvement may also explain the faster $\dot{V}O_2$ onset kinetics, which can be influenced by both O_2 supply and O_2 utilization.[27]

Also, this study demonstrated an increase in mechanical efficiency at S2 compared to S1. This increased efficiency may also be explained by an improvement in the muscle aerobic pathway. In our study, THb decreased at S1, suggesting a limitation in blood volume during trunk extension, which could result in a restriction in muscle blood flow. Previous works have demonstrated than, in healthy individuals during exercise, blood flow restriction may increase the aerobic and anaerobic metabolic contributions, leading to a greater energy expenditure and thus a decrease in mechanical efficiency.[28, 29] In these studies, the greater energy expenditure induced by blood flow restriction was associated with a greater solicitation of the cardiorespiratory system. In our study, at S2, ΔTHb did not decrease anymore during exercise. This could potentially be a result of improved muscle blood flow, removing effects of blood flow restriction on mechanical efficiency. However, we observed no difference in HR or V_E between the two testing periods. Thus, the improvement in mechanical efficiency must be associated to other factors. Another explanation to consider is the potential changes in muscle activation, which can also be increased with blood flow restriction.[30] Removal of blood flow restrictions at S2 could induce lower muscle implication and diminished O_2 needs, increasing motor efficiency. In other words, the muscle involvement would be more effective at S2.

Our results demonstrated that a four-week functional restoration program alleviated low back pain induced by prolonged trunk extension exercise. Prior to the program, low back pain was exacerbated after exercise, whereas pain was not increased after exercise at the end of the 4-week program. This could be as a result of greater aerobic metabolism contribution which will limit the production of metabolites such as lactate or H^+ to exercise.[31, 32] Indeed, the literature has reported that a decrease in pH and an increase in lactate concentration would induce a sensation of pain.[33] If a four-week functional restoration program reduces muscle metabolite production, it can also limit low back pain in response to exercise.

Three-month follow-up

Three months after the restoration program, the quality of life was improved compared with S1. Most of the program benefits were preserved at S3 except for paraspinal muscle oxygenation in response to exercise; this was demonstrated by the reduction of ΔHbO_2, ΔHHb and ΔTHb at S3 compared with S2. This could be a precursor of progressive deterioration of the benefits conferred by the program. Muscle oxygenation in response to exercise may be influenced prior to other variables after returning home following the restoration program. The level of patients' physical activity following the program could be insufficient to preserve the program benefits. This is in contrast with other studies, where the level of activity was higher, and the benefits were preserved.[34] Moreover, in this study, patients declared practicing low intensity exercise following the program, essentially at home and unregularly during their free time. Adhering to regular and structured activity may be a way to make post-program rehabilitation more effective and to avoid the loss of benefits following the return home.

At the three-month follow-up, 50% of patients returned to work. Return to work was related to the work conditions. The individuals with the lower level of physical activity during their workdays, as measured by the Baecke questionnaire at S1, returned to work. This result could support ergonomic interventions or work adjustments for patients with a higher score for the Professional Activity entry on Baecke questionnaire. This could reduce the amount of time of patients' inactivity following the restoration program. Our results confirm that psychosocial approaches to patient care, notably with a focus in reducing pain-related fear, are effective as these factors have been shown to influence the ability to return to work.[22]

Limitations of the study

There are major limitations in this study which may influence the results. First, only twelve patients were evaluated 3 months after the program in this study. Also, the lack of a control group of chronic low back pain patients receiving no intervention is a limitation. Some results should be considered carefully.

Conclusions

A four-week functional restoration program improves the contribution of muscular aerobic metabolism to trunk extension exercise in CLBP patients, but this benefit is only partially preserved three months after the return home. We expected that this improvement in the aerobic pathway would be a determinant of returning to work, but psychosocial factors and the level of physical activity related to the profession seem to also be important factors. This underlines the importance of a multidisciplinary approach to care chronic low back pain patients.

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