Effects over one year of low-intensity endurance exercise targeted at the level of maximal lipid oxidation

Effets à un an de l'activité physique ciblée au LIPOX_{max} dans l'obésité

M. Guiraudou, C. Fédou, A.-J. Romain, A. Sferlazza, E. Calas, J.-F. Brun*

Inserm U1046 « physiologie et médecine expérimentale du cœur et du muscle », équipe d'exploration métabolique (CERAMM), département de physiologie clinique, hôpital Lapeyronie, université Montpellier 1 – université Montpellier 2, CHRU de Montpellier, 34295 Montpellier cedex 5, France

KEYWORDS

Exercise;
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Summary

Context. – Low-intensity physical activity targeted at the level of maximal lipid oxidation (LIPOX_{max} or FAT_{max}) has a similar efficiency for reducing weight compared to protocols at higher intensities, whose compliance is lower, and has specific beneficial effects on lipid oxidation and eating behavior. Since no study lasting more than 5 months was available, we undertook this study in order to assess the effect of LIPOX_{max} training over 2 years.

Methods and results. – We present the first results of follow-up over 1 year of 47 subjects (mean BMI 35.08 ± 0.94 (range: 24 to 53) performing this type of exercise training without prescription of restrictive diet (but with initial nutritional assessment highlighting dietary mistakes). Two comparison groups with the same age and BMI were also followed: 45 subjects performing a low-fat diet and 62 subjects who did not change their habits. After 12 months, subjects trained at the LIPOX_{max} lost on the average -7.84 ± 2.83 kg (weight change from -23 to 4 kg), compared to -8.92 ± 2.35 kg in the low-fat diet group, while in the absence of changes in lifestyle weight tends to increase (0.92 ± 0.58 kg). In total, 12% of LIPOX_{max}-trained subjects lost more than 10 kg and 14% lost between 5 and 10 kg. On Hill's scale of eating behavior, they increased their score of satiety (2.29 ± 1.16 $P < 0.05$). There was a correlation ($r = 0.379$, $P = 0.05$) between weight loss and reduction of nibbling. There was also a gradual increase in weekly exercise volume.

* Corresponding author.

E-mail address: j-brun@chu-montpellier.fr (J.-F. Brun).

Conclusion. – These data of follow-up in a condition of “real life” confirm the efficacy over 1 year of this type of physical activity in obesity, and is consistent with the concept that it is favored by effects on eating behavior.

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MOTS CLÉS

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Résumé

Contexte. – L'activité physique à faible intensité ciblée sur l'oxydation maximale des lipides (LIPOX_{max}) a une efficacité amaigrissante au moins équivalente à celle des protocoles à plus hautes intensités dont la compliance est moindre, notamment en raison de ses effets davantage satiétogènes qu'orexigènes qui en font un modulateur du comportement alimentaire. Les études publiées sont de durée inférieure à six mois.

Méthodes et résultats. – Nous présentons le suivi sur un an de 47 sujets d'IMC moyen $35,08 \pm 0,94$ (extrêmes: 24 à 53) réalisant ce type de ré-entraînement sans prescription de diète restrictive (mais avec entretien initial mettant en évidence les erreurs nutritionnelles). Par comparaison, sont suivis en parallèle deux groupes de même âge et de même IMC : 45 sujets réalisant un régime hypolipidique et 62 sujets qui ne modifient pas leurs habitudes. Les sujets entraînés au LIPOX_{max} ont perdu de 23 ± 4 kg. À 12 mois en moyenne, ils ont perdu $-7,84 \pm 2,83$ kg contre $-8,92 \pm 2,35$ kg sous régime hypolipidique et $+0,92 \pm 0,58$ kg en l'absence de modification des habitudes. Au total, 12 % des sujets entraînés au LIPOX_{max} ont perdu plus de 10 kg et 14 % entre 5 et 10 kg. Sur l'échelle de Hill, ils ont augmenté leur score de satiété ($+2,29 \pm 1,16$ $p < 0,05$). Il y a une corrélation ($r = 0,379$, $p = 0,05$) entre perte de poids et diminution du grignotage.

Conclusion. – Ces données de suivi en condition de « vraie vie » confirment l'efficacité à 1 an de ce type d'activité physique dans l'obésité, qui semble favorisée par ses effets sur le comportement alimentaire.

1. Introduction

While until recently exercise was only considered as a complementary tool for the management of weight, beside diet, surgery and drugs, it is now recognized as the cornerstone of the treatment of obesity, inducing not only an energy deficit but a reversal of many metabolic disturbances resulting in a “reprogramming” of body fuel homeostasis [1]. In this context, low-intensity physical activity targeted at the level of maximal lipid oxidation (LIPOX_{max} or FAT_{max}) has a special interest. It has been shown to have at least a similar efficiency for reducing weight as protocols at higher intensities, whose compliance is lower, and most of this effect is explained by specific beneficial effects on lipid oxidation and eating behavior [2]. However, the longest published study had only 5 months duration [3]. Therefore, this follow-up study was undertaken in order to describe over long time (2 years) the natural history of weight loss of subjects performing this type of exercise training without prescription of restrictive diet (but with initial nutritional assessment highlighting dietary mistakes). We present here the first results of this follow-up after 1 year.

2. Materials and methods

2.1. Patients

At this time of the study, 47 subjects (mean BMI 35.08 ± 0.94 (range: 24 to 53) were included in the LIPOX-training group and assigned to perform this type of exercise training. No

restrictive diet was imposed, but there was always an initial nutritional assessment with an auto-questionnaire and a consultation during which dietary mistakes were pointed out. A French translation of Hill's questionnaire of appetite and eating behavior was used to assess satiety and hunger throughout the study. An additional question to quantify nibbling with an analogical numeric scale was added to this questionnaire. Exercise volume was quantified on the basis of the early weekly time used for exercise as self-evaluated by the patients.

Two matched comparison groups with the same age and BMI were also followed: 45 subjects performing a low-fat diet and 62 subjects who did not change their habits.

Characteristics of patients included in the study are shown on Table 1.

2.2. Exercise calorimetry

All subjects were asked to come and perform test in the morning after an overnight fast (12 hours). The test consisted of five six-minute steady-state workloads theoretically set at 20, 30, 40, 50, and 60% of P_{max} . However, these intensity levels can be modified during the test according to the evolution of the respiratory exchange ratio ($RER = VCO_2 / VO_2$) in order to obtain values of RER below and above 0.9 which is the level of the Crossover Point (COP) which is defined below. The subjects performed the test on an electromagnetically braked cycle ergometer (Ergoline Bosch 500). Heart rate and electrocardiographic

Table 1 Comparison of the three groups of patients described in the study, showing their correct matching for body mass index, fatness and baseline calorie and nutrient intake.

	Age	BMI	%G	kCal/24 h	Protein g/kg/j	P%	G%	L%
Low-fat <i>n</i> = 45	43.76 ± 2.31	36.72 ± 1.03	42.72 ± 0.94	1867.21 ± 75.00	0.71 ± 0.04	14.50 ± 0.48	56.78 ± 1.78	28.66 ± 1.90
LIPOX _{max} <i>n</i> = 63	50.85 ± 2.12	34.53 ± 0.76	41.78 ± 0.85	2079.43 ± 113.16	0.80 ± 0.05	19.41 ± 1.03	56.50 ± 2.24	23.73 ± 2.04
Controls <i>n</i> = 62	42.23 ± 1.93	34.55 ± 0.80	40.74 ± 0.72	1862.63 ± 88.44	0.72 ± 0.04	15.94 ± 0.68	56.77 ± 1.78	27.21 ± 1.56

parameters were monitored continuously throughout the test by standard 12-lead procedures. Metabolic and ventilatory responses were assessed using a digital computer based breath-to-breath exercise analyzing system (Jaeger MS-CPX). Thus, we could measure VO₂, VCO₂ (in mL/min) and calculate the non-protein RER. Lipid oxidation (LIPOX) and carbohydrate utilization (Glucos) rates were calculated by indirect calorimetry from gas exchange measurements according to the non-protein respiratory quotient

technique as previously reported [3]. This technique provided carbohydrate and lipid oxidation rates at different exercise intensities. Additionally, after smoothing the curves, we calculated the two parameters quantifying the balance between carbohydrates and lipids induced by increasing exercise intensity: the maximal lipid oxidation point (LIPOX_{max}) and the Crossover Point (COP). The LIPOX_{max} is the exercise intensity at which lipid oxidation reaches its maximal level before decreasing while carbohydrate

Figure 1 Upper panel: weight loss expressed as percentage of the initial weight in the 3 groups of subjects, showing that control subjects continue to gain weight while there is a similar weight loss in the group submitted to LIPOX_{max} training and that submitted to a low-fat diet. Lower panel: individual variation of weight in subjects submitted to LIPOX_{max} training.

utilization further increases. It is calculated as previously reported after smoothing of the curve plotting lipid oxidation as a function of power. The maximal lipid oxidation rate at the $\text{LIPOX}_{\text{max}}$ was expressed in $\text{mg}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$. The crossover point (COP) is the exercise intensity at which the part of carbohydrate utilization used to provide energy becomes predominant over lipid oxidation. Beyond this point, the subject is referred to as "gluco-dependent". It was calculated as the exercise intensity where 70% of the substrates used to provide energy are carbohydrates and 30% are lipids [3].

3. Statistical analysis

Overall comparisons between mean values were performed by Kruskal-Wallis one-way Anova on ranks, followed by pairwise multiple comparisons using Dunn's method. Significant differences were accepted at $P < 0.05$. All values are mean $\pm$ SEM. Statistical analyses were performed with SigmaStat 1.0 (Jandel Scientific).

4. Results

Results are summarized on Fig. 1. After 12 months, subjects trained at the $\text{LIPOX}_{\text{max}}$ lost on the average -7.84 ± 2.83 kg (weight change from -23 to 4 kg), compared to -8.92 ± 2.35 kg in the low-fat diet group, while in the absence of changes in lifestyle weight tends to increase (0.92 ± 0.58 kg). On the whole, 12% of $\text{LIPOX}_{\text{max}}$ -trained subjects lost more than 10 kg and 14% lost between 5 and 10 kg. On Hill's scale of eating behavior, they increased their score of satiety (2.29 ± 1.16 $P < 0.05$). There was a correlation ($r = 0.379$, $P = 0.05$) between weight loss and reduction of nibbling. There was also a gradual increase in weekly exercise volume ($P < 0.05$).

5. Discussion and conclusion

These data of follow-up confirm for the first time over 1 year the efficacy of this type of physical activity in obesity. We present here only preliminary results and the whole study will cover a 2-year period in order to describe the full time-course of this weight reduction. Our results are consistent with the concept that the weight-lowering effect of such a procedure is favored by important effects on eating behavior.

The main limitation of this study performed in a condition of "real life" is that only patients who continue to be followed are studied, while those who drop out are not taken into account in the calculations. Experimental studies on weight reduction procedures should preferably include all patients with an 'intention to treat', so that non-responders and poorly compliant patients can be included in the statistical analysis. Such a difference in design may induce a bias in the magnitude of the final results. However, there is at least one $\text{LIPOX}_{\text{max}}$ study performed according to these standards: this is the $\text{LIPOX}_{\text{max}}$ Reunion Study (until now only presented in congresses, full paper to appear), which evidences a weight reduction of a similar magnitude as that observed here.

It is interesting to observe the time-course of weight loss in this study. Most of the time all weight-reducing procedures are characterized by an initial rapid weight loss, followed by a plateau explained by body homeostatic resistance to slimming, and most often, there is a rapid return to the initial weight or to a slightly higher one. The effect of low-intensity exercise as observed in this study seems to exhibit a different kinetics and appears to be more prolonged. Further results of this follow-up over 24 months will precise this picture.

When our team and others proposed to target exercise training in obesity at the level of maximal lipid oxidation, some criticism arose among exercise specialists. It was assumed that such a level was too low to result in efficient weight loss. The current paradigm is that exercise efficiency is only explained by the energy deficit it induces. Therefore, when a limited time is available for exercise, it seems logic to promote the stronger workload as possible in order to maximize its effects. Clearly, high volumes (15–20 hr/wk) of high intensity exercise training are a very powerful tool for reducing body weight [4]. However, they are undoubtedly difficult to undertake on a large scale in sedentary obese and diabetic patients.

Therefore, in the majority of patients low volumes of exercise are the realistic exercise prescription. The usual belief is that this limited quantity of exercise should therefore be targeted preferentially at high intensity in order to elicit more energy expenditure and thus to be more efficient. However, this belief is probably wrong. There is increasing evidence that low volume high intensity exercise frequently results in increased appetite and nibbling, probably explained by a reduction of glycogen stores, and this may lead to a paradoxical exercise-induced gain in fat mass. Thus, low volume high intensity exercise does not have the same effects as high volume high intensity exercise, which induced an important energy deficit. By contrast, low volumes of exercise performed at low-intensity in the zone of $\text{LIPOX}_{\text{max}}$ result most of the time in increased satiety and decreased nibbling that seem to explain most of their efficiency for weight loss.

Our study supports our previous statement that low-intensity training targeted at the level of maximal lipid oxidation is an easy to apply, safe and efficient procedure to reduce body weight. It is also known that it improves carbohydrate homeostasis, low grade inflammation and lipid status, while preserving fat-free mass [3]. Most of its efficiency on weight reduction seems, as previously reported [2] and further confirmed here, to be due to a satiating effect that helps to decrease interprandial nibbling and overall calorie intake. The mechanism of these changes in eating behavior is likely to be mediated by neurohormonal changes. For example, a role of gastro-intestinal polypeptides such as peptide YY, glucagon-like-peptide-1, pancreatic polypeptide and ghrelin can be hypothesized, as suggested by a growing body of literature, but this issue remains to be investigated.

The main finding of this preliminary report is that, when studied over a period of one year, the effects of training at the $\text{LIPOX}_{\text{max}}$ are prolonged and gradually increase the extent of fat mass loss. Currently, demonstrated metabolic and behavioral effects of this exercise procedure lead to

think that it should be considered, not a simple add-on to restrictive diet, but as a central tool in the management of obesity, helping to better adhere to diet and re-programming energy metabolism toward a greater use of lipids.

This study was presented at the 8th European Sport Medicine Congress of EFSMA and 6th Joint Meeting SFMES & SFTS (Strasbourg November 25–28, 2013), at the “30^e Congrès de la Société française d’endocrinologie” (Paris, October 2–5, 2013), and at the Journées francophones de nutrition (JFN 2013), Bordeaux, December 11–13, 2013.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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