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Original article

Effect of aquatic interval training with Mediterranean diet counseling in obese patients: Results of a preliminary study

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ABSTRACT

Background: No previous studies have investigated a high-intensity interval training program (HIIT) with an immersed ergocycle and Mediterranean diet counseling (Med) in obese patients. We aimed to compare the effects of an intensive lifestyle intervention, Med and HIIT with a water-immersed versus dryland ergocycle, on cardiometabolic and exercise parameters in obese patients.
Methods: We retrospectively identified 95 obese patients at their entry into a 9-month Med and HIIT program: 21 were trained on a water-immersed ergocycle and 74 on a standard dryland ergocycle. Body composition, cardiometabolic and exercise parameters were measured before and after the program.
Results: For obese patients performing water- and dryland-exercise (mean age 58 ± 9 years versus 55 ± 7 years), BMI was higher for the water- than dryland-exercise group (39.4 ± 8.3 kg/m^2 versus 34.7 ± 5.1 kg/m^2, $P < 0.05$), and total fat mass, fasting glycemia and triglycerides level were higher ($P < 0.05$). Both groups showed similarly improved body composition variables (body mass, waist circumference, fat mass, $P < 0.001$), fasting glycemia and triglycerides level ($P < 0.05$). Initial maximal aerobic capacity (metabolic equivalents [METs]) and maximal heart rate (HR_{max}) were lower for the water- than dryland-exercise group ($P < 0.05$). For both groups, METs, resting HR, resting blood pressure, abdominal and leg muscle endurance were similarly improved ($P < 0.05$).
Conclusions: A long-term Mediterranean diet and HIIT program with water-cycling is as effective as a dryland program in improving body composition, fasting glucose, triglycerides level, blood pressure and fitness in obese patients. A Mediterranean diet combined with water-cycling HIIT may be efficient for severely obese patients at high risk of musculoskeletal conditions.

1. Introduction

Obesity is a major public health concern associated with high health care cost and important comorbidities such as cardiovascular diseases, type 2 diabetes, stroke, hypertension, certain types of cancer and osteoarthritis [1–3]. Among the most effective strategies to prevent and treat obesity, long-term lifestyle intervention based on nutrition and physical activity is recommended for body composition and cardiometabolic risk management in obese populations [4]. A Mediterranean diet has been shown to reduce the incidence of major cardiovascular events in patients with high cardiovascular risk [5] and to be very effective in the reduction and long-term maintenance of body mass in obese patients [6,7]. In addition, a Mediterranean diet combined with high-intensity interval training (HIIT) for 12 weeks had greater benefits for cardiometabolic variables than the diet alone in patients with metabolic syndrome [8]. Similarly, we demonstrated that a program of 9 months of Mediterranean diet counseling (Med) and HIIT was efficient in improving body composition, systolic blood pressure (BP), and VO_2 peak [9–11]; the benefits were similar by gender and obesity phenotype [9]; the HIIT was well tolerated and safe at the cardiovascular level in these patients [9–11].

In obese populations, traditional modes of aerobic exercise, such as walking and/or running are often associated with increased risk of musculoskeletal injuries due to accumulated stress on

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lower-joint extremities [4,12], which reduces adherence to exercise training. Because of these musculoskeletal problems, the American College of Sports Medicine (ACSM) has recommended non-weight-bearing exercise including aquatic aerobic exercise for this population to reduce stress on the lower extremities and spine [4,13–15]. To date, only 2 short-term studies (12–13 weeks) have compared the effectiveness of aquatic aerobic exercise and dryland-exercise training on aerobic fitness and body composition in obese people [13,14]. The studies demonstrated a similar improvement in body composition and aerobic fitness with continuous walking exercise modes. However, the effectiveness of the water training program on other cardiometabolic risk factors (BP, glycemia, blood lipid levels) were not documented, and only one study used a nutritional intervention [13,14].

We recently developed a method to calculate external power output (P_{ext}) on an immersed ergocycle (IE) from the pedalling cadence in healthy adults [16,17]. This calculation is one advantage of use of the IE as compared to walking in water, for which P_{ext} is difficult to determine [16,17]. As well, because water immersion affects VO_2 and heart rate (HR), the use of a certain percentage of P_{ext} for HIIT prescription may be more practical and accurate than HR percentage [16,17].

To our knowledge, no previous studies have used a HIIT program with an IE in obese subjects. The aim of this study was to compare the long-term effects of a program of 9 months of Med and HIIT (intensive lifestyle intervention) involving an IE versus a dryland ergocycle on body composition, cardiometabolic and exercise variables in obese patients.

2. Material and methods

2.1. Patients

This retrospective study was conducted at the Cardiovascular Prevention and Rehabilitation Center of the Montreal Heart Institute. The data from a 9-month intensive lifestyle modification program (Med and HIIT) were analyzed. This clinical program was on a voluntary basis and participants were paying for the program. As well, patients could choose to do the exercise training on dryland or in the water according to their preference. Inclusion criteria at baseline were age >18 years and obesity defined as fat mass percentage >25% for men and >35% for women [18]. We included patients receiving pharmacological therapy for their cardiovascular risk factors (i.e., hypertension, diabetes). Patients with a history of coronary heart disease (documented previous myocardial infarction, coronary revascularization, or documented myocardial ischemia on myocardial scintigraphy) were excluded. We included 95 obese patients; 74 (mean age: 55 ± 7 years, body mass index [BMI]: 34.7 ± 5.1 kg/m^2, waist circumference [WC]: 110 ± 12 cm) were trained by standard dryland cycling and 21 (mean age: 58 ± 9 years, BMI: 39.4 ± 8.3 kg/m^2, WC: 115 ± 18 cm) were trained in the water with an IE [16,17]; the dryland and IE training are described below. The research protocol was approved by the Montreal Heart Institute Ethics Committee.

2.2. Measurements

Before and after the program, all patients underwent a complete clinical evaluation including measurement of height, body mass, WC, regional body composition with bioimpedance analysis (Tanita, model 418C, Japan) to assess fat mass, trunk fat mass, fat-free mass and resting metabolic rate [19]. Classical cardiovascular risk factors considered were diabetes, hypertension, active smoking and dyslipidemia [9,10,20]. A maximal exercise treadmill test with an individualized ramp protocol and fasting blood test (glucose, lipid profile) were also performed [15]. During the individualized ramp protocol, speed and slope were progressively increased to achieve a linear load and an exercise duration of approximately 10 min [21]. Criteria for the maximal exercise test were rate of perceived exertion ≥18 and/or ≥85% of age-predicted maximal HR, or patient exhaustion, with cessation caused by fatigue and/or other clinical symptoms (dyspnea, abnormal BP responses) or electrocardiogram (ECG) abnormalities that required exercise cessation. During maximal exercise testing, ECG and BP were monitored continuously during exercise and 5-min recovery [15]. Maximal exercise tolerance was defined as the highest level of metabolic equivalents (METs) achieved during the exercise test. All patients were instructed to take their usual medications before exercise testing and during the program. Patients also performed abdominal and thigh muscle endurance tests (Shirado test and squat wall test) as we previously described [9,10]. Attendance at the exercise training program was obtained from medical charts and from an electronic system that automatically records each subject's entry into our center, as we previously described [9,10,20]. Weekly supervised exercise training sessions and physical activity performed in and/or outside of the center were recorded in a diary [9,10,20].

2.3. Intensive lifestyle intervention program

Supervised exercise training sessions (HIIT and resistance exercise) consisted of 2 to 3 supervised weekly 60-min sessions. Subjects were encouraged to perform 1 or 2 additional unsupervised, continuous, moderate-intensity sessions per week, such as walking and/or cycling (45-min duration, Borg scale level: 12–14) at or outside of the center [9–11].

2.3.1. High-intensity interval training

HIIT prescription was based on the results of the baseline maximal treadmill exercise test and estimated maximal aerobic power (MAP) on dryland and IE as described [9–11,16,17]. MAP was estimated from the maximal metabolic equivalents treadmill value as follows: treadmill metabolic equivalents value was converted to oxygen uptake expressed in milliliters per minute; treadmill VO_2 peak in milliliters per minute was then converted to cycling VO_2 peak value in milliliters per minute by subtracting 16%; and cycling VO_2 peak value was then converted to watts by using a sex-specific conversion chart [10]. For the dryland-exercise group, HIIT sessions were performed on an ergocycle (Precor®, model 846i, USA) under supervision of a kinesiologist and consisted of a 5-min warm-up at 50 watts (W), followed by 2 sets of 10 min each of repeated bouts of 15 to 30 s at 80% of MAP interspersed by a 15- to 30-s period of passive recovery and a 5-min cool-down at 50 W [9–11]. The targeted Borg rating of perceived exertion (RPE) was set at 15 during the exercise sessions [9–11]. The two 10-min periods were separated by a 4-min passive recovery. Total exercise time was 34 min for the HIIT session [10]. For the water-exercise group, HIIT sessions were performed on an IE [16,17] (Hydrorider®, Aquabike professional, Italy) under supervision of a kinesiologist. The same HIIT protocol as for the dryland-exercise was used with the same percentage of MAP [16,17] and a targeted RPE of 15. The P_{ext} expressed in watts (W) was calculated by multiplying the total net force (F) overcoming the resistance of the system movement (pedalling system and legs) by the velocity (m/s) of pedal displacement as described [16,17]. Finally, a certain level of pedalling cadency (rpm) on the IE was used to give the corresponding 80% of MAP level; this rpm level was adjusted during HIIT to reach the targeted RPE of 15 [16,17].

2.3.2. Resistance training program

Resistance training with dryland-exercise was prescribed and performed under supervision of a kinesiologist and consisted of 20 min of circuit weight training performed with free weights and elastic bands adapted to each patient's capacity [9–11]. For each muscle group (biceps, triceps, chest, back and leg muscles), patients performed 1 set of 15 to 20 repetitions, followed by a 30-s rest period, at a target RPE of 15 [9–11]. For the water-exercise group, similar muscle groups were targeted, with the same number of repetitions and intensity (RPE level), with the exception of the accessories used. Upper-arm movements with dumbbell foam (biceps, triceps, chest and back muscles) and leg-kicking movements (leg muscles: jogging and cross-country skiing) were used with a similar number of sets, repetitions and RPE as for dryland-exercise.

2.3.3. Nutritional counseling intervention

All patients had 5 one-to-one meetings with a dietician in our center. The first visit was used to obtain data on eating habits and motivation and provide the principles of the Mediterranean diet [9–11]. The macronutrient composition (% of daily calories) of this diet was protein (20%), carbohydrates (45%; with a high intake of fibers), and total fat (35%; saturated fatty acids: 7%; monounsaturated fatty acids: 25%; polyunsaturated fatty acids: 2.5%, ω6/ω3 ratio: 3–6). The total daily energy consumption was adapted to each patient, without severe restrictions [9–11]. The aim was to meet, as far as possible, the Canadian guidelines (2000–2400 kcal/day). Subsequent visits at 5, 12, 20 and 36 weeks aimed to review principles and adherence to the Mediterranean diet and the reported dietary intake and answer any questions. Additionally, participants received 2 group teaching sessions aimed at providing guidance regarding cardiovascular risk factor control, reading food labels and tasting Mediterranean-style dishes [9–11].

2.4. Statistical analysis

Data are expressed as mean ± SD and/or number (%). All analyses involved use of Statview 5.0 (SAS Inst. Inc., Cary, NY, USA). Normal distribution of the data was verified by a Shapiro-Wilk test. Data were logarithmically transformed when this assumption was not met. For continuous variables, differences were evaluated by two-way ANOVA (group and time), with post-hoc Bonferoni testing, and two-sided $P \leq 0.05$ considered statistically significant.

3. Results

3.1. Baseline characteristics of obese patients

Baseline characteristics for patients performing dryland and water-exercise are in Table 1. Both groups mainly consisted of middle-aged obese women. Hypertension, dyslipidemia and diabetes were the most prevalent cardiovascular risk factors in both groups. Initial BMI was higher for the water- than dryland-exercise group ($P < 0.05$).

3.2. Body composition variables

Initial BMI and total fat mass were higher for the water- than dryland-exercise group ($P < 0.05$; Table 2). After the program, body mass, BMI, WC, total fat mass, and trunk fat mass were reduced similarly in both groups ($P < 0.001$). We found no interaction (group × time) effects ($P > 0.05$) for all body composition variables for both groups.

Table 1
Baseline characteristics of obese patients performing dryland- or water-exercise combined with Mediterranean diet counseling.

Characteristics	Dryland (n = 74)	Water (n = 21)
Age (years)	55 ± 7	58 ± 9
Male/female (n)	19/55	2/19
Height (cm)	166 ± 18	163 ± 11
Body mass (kg)	96.2 ± 17.3	102.8 ± 25.8
BMI (kg/m²)	34.7 ± 5.1	39.4 ± 8.3*
WC (cm)	110 ± 13	116 ± 18
Resting SBP (mmHg)	130 ± 13	127 ± 16
Resting DBP (mmHg)	82 ± 7	75 ± 8
Hypertension	64 (86.5)	19 (90.5)
Diabetes	14 (18.9)	6 (28.6)
Dyslipidemia	33 (44.6)	9 (42.8)
Smoking	6 (8.1)	0 (0.0)
Drug therapy		
Antiplatelet agents	15 (20)	8 (38)
Beta-blockers	5 (6)	4 (19)
Calcium channel blockers	6 (8)	2 (9)
ACE inhibitors	4 (5)	7 (33)
Angiotension receptor blocker	19 (25)	4 (19)
Statins	25 (33)	12 (57)

Data are No. (%) unless indicated; BMI: body mass index; WC: waist circumference; SBP: systolic blood pressure; DBP: diastolic blood pressure; ACE: angiotensin converting enzyme.
* $P < 0.05$.

3.3. Blood sample variables

Fasting glycemia and triglyceride levels were higher for the water- than dryland-exercise group ($P < 0.05$; Table 3). After the program, fasting glycemia and triglycerides level were improved in both groups ($P < 0.05$). We found no interaction effect (group × time, $P > 0.05$) for all blood lipid variables for both groups.

3.4. Exercise variables

Levels of METs and HR_{max} were lower for the water- than dryland-exercise group ($P < 0.05$; Table 4). After the program, resting BP, METs, resting HR and muscle endurance were significantly improved in both groups ($P < 0.05$). We found no interaction effect (group × time, $P > 0.05$) for exercise variables for both groups.

4. Discussion

To our knowledge, this study is the first to report the long-term effects of a program of Mediterranean diet counseling and HIIT with water IE in obese subjects. Despite an initial higher BMI and total fat mass in the water- than dryland-exercise group, body composition variables (body mass, WC, fat mass) were improved in both groups after the program. As well, despite higher fasting glycemia and triglycerides level in the water- than dryland-exercise group, fasting glycemia and triglycerides level were improved in both groups with the program. Initial METs and muscle endurance were lower for the water- than dryland-exercise group, but both were improved in both groups after the program. As well, we document the effectiveness of our water-exercise program on cardiometabolic variables such as BP and blood lipid levels. Finally, this study is the first to report the similar positive

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Table 2
Anthropometric variables before and after an intensive lifestyle intervention for obese patients by exercise type.

Variables	Dryland (*n* = 74)		Water (*n* = 21)		*P*-value
	Before	After	Before	After	
Body mass (kg)	96.2 ± 17.3	92.4 ± 16.9	102.8 ± 25.8	98.7 ± 26.2	a = 0.21 b < 0.0001 c = 0.82
BMI (kg/m^2)	34.7 ± 5.1	33.2 ± 4.9	39.4 ± 8.3	37.8 ± 8.6	a = 0.0045 b < 0.0001 c = 0.87
WC (cm)	110 ± 13	104 ± 18	116 ± 18	111 ± 21	a = 0.13 b = 0.0024 c = 0.48
Total fat mass (kg)	38.9 ± 10.2	35.5 ± 10.5	47.9 ± 18.6	43.4 ± 18.9	a = 0.033 b < 0.0001 c = 0.53
Fat mass percentage (%)	41.5 ± 7.1	39.4 ± 7.5	45.6 ± 5.1	43.2 ± 7.1	a = 0.069 b < 0.0001 c = 0.78
Lean body mass (kg)	55.0 ± 11.7	54.6 ± 11.4	55.1 ± 12.0	54.0 ± 11.8	a = 0.94 b = 0.0171 c = 0.22
Trunk fat mass (kg)	20.6 ± 5.0	18.7 ± 5.4	22.3 ± 7.0	20.6 ± 8.7	a = 0.31 b = 0.0002 c = 0.76
Trunk fat mass percentage (%)	40.6 ± 5.7	38.0 ± 6.7	42.1 ± 3.9	39.7 ± 6.9	a = 0.37 b = 0.0003 c = 0.87
Resting metabolic rate (kcal/day)	1686 ± 344	1662 ± 334	1721 ± 402	1675 ± 393	a = 0.83 b = 0.0004 c = 0.21

Data are mean ± SD; a: group effect; b: training effect; c: interaction effect.

effects of both programs on resting HR and muscle endurance in obese patients.

Previous studies of water-exercise training in obese patients were often of shorter duration (12–13 weeks), involved continuous-endurance walking exercise alone [14] or were combined with a calorie restriction diet [13]. From a clinical perspective, the improvement in body composition after our Med and water HIIT program are consistent with the ACSM's recommendation for non-weight-bearing exercise in obese people [15].

The water-exercise group having higher initial BMI and total fat mass than the dryland-exercise group can be explained by the retrospective nature of our study in a clinical routine setting. Indeed, severely obese people may have been more attracted to the water ergocycle training. In the water-exercise group, our results on improved body mass (−6.3 kg), WC (−5.5 cm), and total (−4.9 kg) and trunk fat mass (−1.8 kg) are greater than in some studies [14,22–25] but similar to those of Gappmaier et al. [13]. The differences from the study of Greene et al. could be due to

Table 3
Blood lipid variables before and after an intensive lifestyle intervention for obese patients by exercise type.

Variables	Dryland (*n* = 74)		Water (*n* = 21)		*P*-value
	Before	After	Before	After	
Fasting glucose (mmol/l)	5.56 ± 1.03	5.16 ± 0.73	6.93 ± 3.68	6.19 ± 2.85	a = 0.0121 b = 0.0002 c = 0.25
Total cholesterol (mmol/l)	4.86 ± 1.14	4.65 ± 1.01	4.46 ± 0.92	4.48 ± 0.93	a = 0.25 b = 0.43 c = 0.34
HDL-cholesterol (mmol/l)	1.34 ± 0.38	1.33 ± 0.19	1.28 ± 0.28	1.26 ± 0.36	a = 0.22 b = 0.93 c = 0.95
LDL-cholesterol (mmol/l)	2.84 ± 0.95	2.70 ± 0.96	2.44 ± 0.85	2.48 ± 0.90	a = 0.17 b = 0.66 c = 0.41
Total cholesterol/HDL ratio	3.71 ± 1.04	3.72 ± 1.11	3.36 ± 1.31	3.74 ± 1.00	a = 0.35 b = 0.43 c = 0.38
Triglycerides (mmol/l)	1.43 ± 0.68	1.30 ± 0.59	1.81 ± 1.12	1.71 ± 1.18	a = 0.0473 b = 0.16 c = 0.83
Triglycerides/HDL ratio	1.20 ± 0.73	1.07 ± 0.72	1.66 ± 1.43	1.63 ± 1.69	a = 0.0055 b = 0.61 c = 0.79

Data are mean ± SD; HDL: high-density lipoprotein; LDL: low-density lipoprotein; a: group effect; b: training effect; c: interaction effect.

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Table 4
Exercise variables before and after an intensive lifestyle intervention program for obese patients by exercise type.

Variables	Dryland (n = 74)		Water (n = 21)		ANOVA (P-value)
	Before	After	Before	After	
Resting SBP (mmHg)	130 ± 13	124 ± 14	127 ± 16	124 ± 14	a = 0.56 b = 0.0445 c = 0.35
Resting DBP (mmHg)	82 ± 7	77 ± 6	75 ± 8	76 ± 7	a = 0.12 b = 0.0084 c = 0.24
Maximal exercise capacity (METs)	8.7 ± 1.6	9.5 ± 1.7	7.0 ± 1.4	7.7 ± 1.7	a = 0.0001 b = < 0.0001 c = 0.99
Resting HR (bpm)	74 ± 11	70 ± 10	71 ± 9	67 ± 11	a = 0.26 b = 0.0016 c = 0.87
Maximal HR (bpm)	160 ± 17	161 ± 16	148 ± 19	150 ± 22	a = 0.0167 b = 0.3052 c = 0.83
Delta HR at 1 min (bpm)	−27 ± 8	−28 ± 7	−24 ± 8	−26 ± 10	a = 0.23 b = 0.22 c = 0.43
Squat wall test (s)	78 ± 51	143 ± 89	40 ± 23	94 ± 46	a = 0.19 b = 0.0021 c = 0.75
Shirado test (s)	73 ± 49	120 ± 54	39 ± 20	75 ± 7	a = 0.27 b = 0.0008 c = 0.64

Data are mean ± SD; SBP: systolic blood pressure; DBP: diastolic blood pressure; METs: metabolic equivalents; HR: heart rate; a: group effect; b: training effect; c: interaction effect.

the authors' use of moderate-intensity continuous exercise training (MICET), the absence of a diet component and a shorter training duration [14]. As compared with the caloric restriction approach of Gappmaier et al. [13], our Med intervention aimed to improve nutritional quality and satiety and preserve palatability to favor long-term weight loss and maintenance [6,7,26]. In the dryland-exercise group, our results for improved body mass (−3.6 kg), WC (−4.9 cm), and total (−3.5 kg) and trunk fat mass (−1.9 kg) were slightly lower than in previous studies involving Med and HIIT [8–11] but similar to other studies involving HIIT only [27,28]. As recently demonstrated with dryland-exercise [8–11], these data suggest that Med combined with HIIT performed in water also optimizes the improvement in body composition in obese patients. Improvements in body composition (i.e., body fat mass and WC reduction) in obese patients with exercise and/or diet reduced mortality [29–31] and had numerous other health clinical benefits on osteoarthritis, inflammation/oxidative stress, quality of life, physical functioning, cognition, and frailty [6,32–35].

The higher fasting glycemia and triglycerides level in the water- than dryland-exercise group can be explained by the retrospective nature of our study in a clinical routine setting. Severely obese people may have more preference for the water ergocycle training, which indicates a worsening of some blood variables. However, we demonstrated similar improvement in fasting glycemia and triglycerides level in both groups. This finding underlies the effectiveness and benefits of combined Med and HIIT in the water-exercise group for those 2 variables, benefits that are more extensively addressed for dryland conditions [8–11]. For the water-exercise group, our results agree with a previous study showing reduced glycated hemoglobin and triglyceride levels in patients with type 2 diabetes [36] but disagree with 2 other studies of overweight women [22,23]. Regarding lipid variables, we found no improvements in the water and dryland-exercise groups, which agrees with previous studies of overweight women (water training) [22,23] and obese subjects after Med and dryland HIIT [8–10].

In the water-exercise group, we observed an initial lower exercise capacity (METs) and maximal HR (HR_{max}) compared to the dryland-exercise group, which reflects a lower aerobic fitness in this more severe obese group [37,38]. The lower HR_{max} suggests a lower chronotropic response in the water-exercise group, probably because of the higher prevalence of impaired fasting glycemia known to be responsible for autonomic control abnormalities [9,38]. However, both groups showed similar improvements in resting HR, resting BP, maximal aerobic capacity and muscle endurance. In the water group, regarding METs improvements (+0.7 METs), our result is lower than previous findings [13,14] or higher [39] than previously reported in obese subjects with water training. Similarly, for the dryland-exercise group, the improvement in METs was slightly lower than our previous findings [9–11] and those of other studies [40] for a similar intervention. This finding is not sufficient to reach the clinical threshold benefit of METs improvement (+1 METs) known to reduce cardiovascular mortality [41,42]. This lack of clinical improvement in METs might be explained by an initial moderate and/or normal fitness in our sample [42] and potentially a large proportion of non-response to exercise training [43]. Recently, in obese patients with type 2 diabetes (n = 161), only 36.6% responded (VO_2 peak ≥ 5%) to aerobic training [43].

Regarding muscle endurance improvements for the water-exercise group, our study agrees with one study of overweight women that demonstrated muscle strength improvements after a deep-water training program [44]. Our results for muscle endurance suggest a similar improvement in functional capacity and the ability to carry out activities of daily living [10]. Moreover, greater abdominal muscle endurance could prevent other disabling symptoms, such as low back pain [45].

In both obese groups, we reported similar improvements in resting BP (dryland: −6 mmHg, water: −3 mmHg) and HR. For the water-exercise group, these findings agree with those of 2 previous studies of obese women and type 2 diabetes patients [23,36] but disagrees with another of obese women [24]. Finally for the dryland-exercise group, our results agree with our previous report [9–11], but one study found higher BP reduction [8]. Our BP and resting HR results could suggest clinical benefits such as reduced cardiovascular events [9,41,42].

Our study contains several limitations, including its non-randomized retrospective design, representing the experience of one single institution, no control group, and no generalization to all obese patients. The enrolment in the program was not free for subjects, so our data can be extrapolated to only people who could afford to pay for a lifestyle intervention. As well, the enrolment in the program required a certain degree of motivation, given that recruitment was on a self-initiative basis. This study reflects the results of an intensive lifestyle intervention performed in routine clinical settings, and baseline characteristics and number of obese subjects differed in the 2 groups. As well, maximal exercise capacity (METs) was estimated rather than measured directly (gas exchange). Therefore, the accuracy of VO_2 uptake and the maximal nature of the test is not strong. Finally, data on adherence to the Mediterranean diet were not collected; the present study cannot assess the contribution of diet and exercise training to the cardiometabolic improvements observed.

In conclusion, a long-term, intensive lifestyle intervention including Mediterranean nutritional counseling and HIIT performed with a water IE or dryland ergocycle may improve body composition, BP, resting HR, fasting glycemia, triglycerides level, maximal aerobic capacity and muscle endurance in obese patients. A Mediterranean diet combined with water ergocycle HIIT may be an efficient alternative for treatment of obesity. The use of a water ergocycle for HIIT is consistent with the ACSM's recommendations for non-weight-bearing activities in obese subjects [15]. Our findings may guide clinicians and health practitioners in the use of water-based HIIT (combined with Mediterranean diet counseling) particularly in patients with severe obesity at high risk of musculoskeletal conditions. Future randomized control studies using similar interventions (Mediterranean diet counseling and HIIT) should be performed to confirm our observational results.

Disclosure of interest

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

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