

Perceived exertion and rehabilitation with arm crank in elderly patients after total hip arthroplasty: A preliminary study

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Abstract—This preliminary study examined, in a restricted randomized trial, the effects of a 6-week arm-crank rehabilitation training program in elderly osteoarthritis patients after total hip arthroplasty, first on physiological and perceptual responses and second on physical function. Two groups of patients were studied: a training group ($N = 7$, mean age = 74.9 yr, standard deviation [SD] = 5.0 yr) who followed a training program in addition to traditional rehabilitation, and a control group who followed traditional rehabilitation only ($N = 7$ mean age = 75.4 yr, SD = 5.1 yr). At the beginning of the training program, the heart rate and the perceived exertion were not significantly correlated during the exercise session. However, at the end of the training program, five patients had a significant heart rate/perceived exertion relationship ($p < 0.05$). Furthermore, positive effects of the arm-crank rehabilitation training program were observed on cardioventilatory and functional responses in the training group compared with the control group. These results suggest that after an habituation period, most of our elderly osteoarthritis patients experienced physical sensations that were connected to physiological responses. Therefore, perceived exertion could be useful in these patients to regulate exercise intensity, especially at the end of and after the rehabilitation period.

Key words: arm-crank exercise, hip arthroplasty, perceived exertion, rehabilitation.

INTRODUCTION

To prescribe and manage an exercise intensity during a training program, most studies use physiological vari-

ables such as oxygen consumption, blood lactate, or heart rate (HR) measured during a maximal graded exercise test [1–4]. However, this physiological approach requires much instrumentation (e.g., HR or oxygen consumption recording) and medical supervision. Furthermore, in the majority of training programs, subjects are not consulted in the practical arrangements. Everything is organized by health professionals, and the subjects are left quite passive. Such a situation presents some drawbacks, especially with the home transfer of physical exercise, when the patient is encouraged to pursue regular physical exercise at home. Some authors reported that perceived exertion (PE) could be used to control and regulate exercise

Abbreviations: CG = control group, ECG = electrocardiogram, ES = effect size, HR = heart rate, M = mean, MMSE = Mini-Mental State Examination, PE = perceived exertion, PP = perceived pain, SD = standard deviation, SWEET = Square Wave Endurance Exercise Test, TG = training group, $\dot{V}CO_2$ = rate of carbon dioxide production, $\dot{V}O_2$ = rate of oxygen consumption, $\dot{V}E$ = ventilation per minute.

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intensity during a training program [5–7]. PE is commonly used to assess the degree of difficulty of physical exercise. In fact, PE provides a validated method to regulate exercise intensity that does not require medical instrumentation [8] and that can be used over a wide range of clinical, recreational, and athletic settings [7].

However, little is known about the influences of physical reconditioning on PE, especially in the deconditioned elderly. Therefore, it would be interesting to investigate elderly osteoarthritis patients, first before surgery and then after a rehabilitation training program. Indeed, it has been reported that the main clinical sign of osteoarthritis is a decline in functional activities, mainly due to intense pain and musculoskeletal restriction on the affected limb [9–11]. This intense pain causes difficulties in movement and induces a physical deconditioning (e.g., severe perturbations of cardiovascular fitness and exercise tolerance) [9–12]. To stop the deconditioning and pain, surgery is used when all conservative treatments have failed. The benefits of total hip arthroplasty on fitness, pain, mobility, and functional activities are well documented [13,14]. However, a total hip arthroplasty does not permit a total recovery concerning fitness [10]. Several studies have shown that exercise training in the elderly improves their physical fitness [15,16], and such training may help the elderly to maintain their independent living. Because the surgery temporarily weakens the lower limb, performing upper-limb training is preferable. The effects of upper-limb training have recently been examined by Tordi et al. [17] in paraplegics and Maire et al. [12] in the osteoarthrotic elderly. Both showed a significant increase of the fitness level and functional state of the subjects. Therefore, the use of an arm-crank rehabilitation training program after total hip arthroplasty could provide valuable data on the effects of physical reconditioning on PE in elderly, deconditioned osteoarthritis patients.

This preliminary study examined, in a restricted randomized trial, the effects of a 6-week arm-crank rehabilitation training program in elderly osteoarthritis patients after total hip arthroplasty, first on physiological and perceptual responses and second on physical function.

METHODS

Participating in this study were 15 volunteers (2 men and 13 women, mean age 75.1 yr, standard deviation [SD] 4.8 yr), retired patients undergoing total joint

arthroplasty of the hip. The participants were recruited by the surgeon, during a presurgery visit in the Polyclinic of Besançon, France. Only patients over 65 years of age whose main diagnosis was primary hip osteoarthritis were included. Patients were excluded if they were undergoing revision arthroplasties, were mentally handicapped, or were unable to sign the informed-consent form or understand the operator indications. The Mini-Mental State Examination (MMSE) was used to evaluate the cognitive state of patients [18]. Exclusion criteria also included medication that might have interfered with exercise testing and training, decompensated congestive heart failure, acute myocarditis and myocardial infarction, unstable agina pectoris, uncontrolled cardiac arrhythmias, severe aortic stenosis, severe hypertension and untreated hypertrophic obstructive cardiomyopathy, residence outside the Franche-Comté region, insufficient address for follow-up, or unwillingness to return for follow-up. One patient was excluded because of her treatment with β -blockade. In accordance with item 8b of the CONSORT statement [19], a stratified randomization was used for the assignment of patients according to gender and age to either a training group (TG) ($N = 7$, mean age 74.9 yr, SD 5 yr) or a control group (CG) ($N = 7$, mean age 75.4 yr, SD 5.1 yr). Because the extreme ages were 65 and 82, patients were divided into four age stratas (between 65 and 70, 71 and 75, 76 and 80, and more than 80 yr old). Each stratum was made up of the same number of patients in both groups. Men in both groups were of the same age. The characteristics of the patients are reported in **Table 1**.

Radiographs of the hips of the patients were taken before surgery and evaluated by the surgeons. The radiographic scoring system was adapted from the method of Danielsson [20]. The accepted the study plan local ethical committee, and all patients signed an informed-consent form.

DESIGN AND PROCEDURE

The study design is shown in the **Figure**. Patients performed a maximal graded test, under cardiologist supervision, using an arm-crank ergometer (Monark Rehab Trainer, Model 881E, Monark Exercise, Sweden) 1 month before surgery (T_1), during a presurgery visit with the surgeon, and 2 months after surgery (T_2). The arm-crank ergometer was calibrated before and after each

Table 1.Patient characteristics, cognitive level, and radiographics scoring by Danielsson* before first maximal graded test, T_1 .

Patients	Age (yr)		Gender		Height (m)		Danielsson's Radiographic Score		Mini-Mental State Examination	
	TG	CG	TG	CG	TG	CG	TG	CG	TG	CG
1	77.0	77.0	M	M	1.74	1.69	2.0	3.0	26.0	29.0
2	67.0	67.0	F	F	1.64	1.61	7.0	3.0	30.0	30.0
3	71.0	72.0	F	F	1.55	1.43	7.0	4.0	27.0	24.0
4	72.0	73.0	F	F	1.57	1.60	3.0	7.0	28.0	29.0
5	77.5	77.0	F	F	1.57	1.57	9.0	6.0	24.0	25.0
6	79.5	79.5	F	F	1.57	1.58	4.0	5.0	29.0	30.0
7	80.5	82.0	F	F	1.46	1.59	5.0	6.0	28.0	28.0
Mean \pm SD	74.9 \pm 5.0	75.4 \pm 5.1	—	—	1.58 \pm 0.08	1.58 \pm 0.08	5.3 \pm 2.5	4.9 \pm 1.6	27.4 \pm 2.0	27.9 \pm 2.4

*Danielsson LD. Incidence and prognosis of coxarthrosis. Acta Orthop Scand. 1964;66(1):112–14.

M = male, F = female, TG = training group, CG = control group, SD = standard deviation

test. After an initial warm-up period of 3 min, exercise began at a power output of 10 W for 2 min, followed by 10 W increments every 2 min until exhaustion, alternating an adapted increase of cadence and friction resistance [21]. The cadence was between 50 rpm and 70 rpm [22]. For a confirmation that exhaustion was reached, two of the three following criteria had to be met: a drop in arm-cranking cadence below 50 rpm, a respiratory exchange ratio value exceeding 1.0, attainment of 80 percent of age-predicted maximal HR ($220 - \text{age}$). Multichannel electrocardiograms (ECGs) (Nihon Kodhen, type 2R-701.VK) were monitored online before and during exercise. A cardiologist was present to supervise ECG signals for each subject. Pulmonary assessment was performed with a portable metabolic measurement system cart (Aerosport KB1-C, Aerosport, Inc., Ann Arbor, MI, USA, validated by King et al. [23]). Ventilation volumes were calculated with the use of a flat-plate orifice within an open pneumotachometer. The KB1-C was calibrated immediately prior to each test in the low-flow position according to the manufacturer's specifications with a 3 L Hans-Rudolph calibrated syringe (Hans-Rudolph, Inc., Kansas City, MO, USA). Expiratory gases were sampled and analyzed each 20 s period. The variables determined were rate of oxygen consumption ($\dot{V}O_2$), rate of carbon dioxide production ($\dot{V}CO_2$), respiratory exchange ratio, and ventilation per minute ($\dot{V}E$). HR was continuously monitored during the tests with a Sport Tester (Sports Tester Polar Vantage N, Polar Electro, Finland). The ventilatory threshold was assessed from respiratory exchange by three observers using the V-slope method [24]. The mean of the two closest values was taken into

account for calculation of the ventilatory threshold. The $\dot{V}O_2$, $\dot{V}E$, HR, and workload at ventilatory threshold were determined post hoc. In addition, maximal tolerated power (the highest load in watts that could be maintained with a constant pedaling speed for 1 min) was registered during maximal graded tests. At the end of these tests, PE and perceived pain (PP) of patients were assessed with the use of Borg's CR-10 [7]. At the beginning of the test, patients were provided with a typewritten set of standardized instructions for the use of the CR-10. Perceptual scale anchors were established according to the recommendations of Borg. Patients were instructed to give a CR-10 value immediately at the end of the test because during testing, arm cranking and the mouthpiece used to collect the respiratory gases did not allow patients to speak or point out CR-10 values with the finger. According to Borg's recommendations, specific instructions for scaling pain were given [7]. Patients were invited to evaluate the different kinds of pain and their intensities in relation to previous experiences of pain.

Two weeks after surgery, the CG stayed at the rehabilitation center for 6 weeks. This group undertook a traditional lower-limb muscular strength rehabilitation training program supervised by a physician and physiotherapist. This program was performed over 6 weeks and consisted of 30 min muscular strength, 30 min range of motion, and 30 min aquatics exercises each day. At the end of each training session, each subject was checked to ensure that the program was performed correctly.

Two weeks after surgery, the TG also stayed at the rehabilitation center for 6 weeks. TG performed the same rehabilitation training program as CG, but undertook an

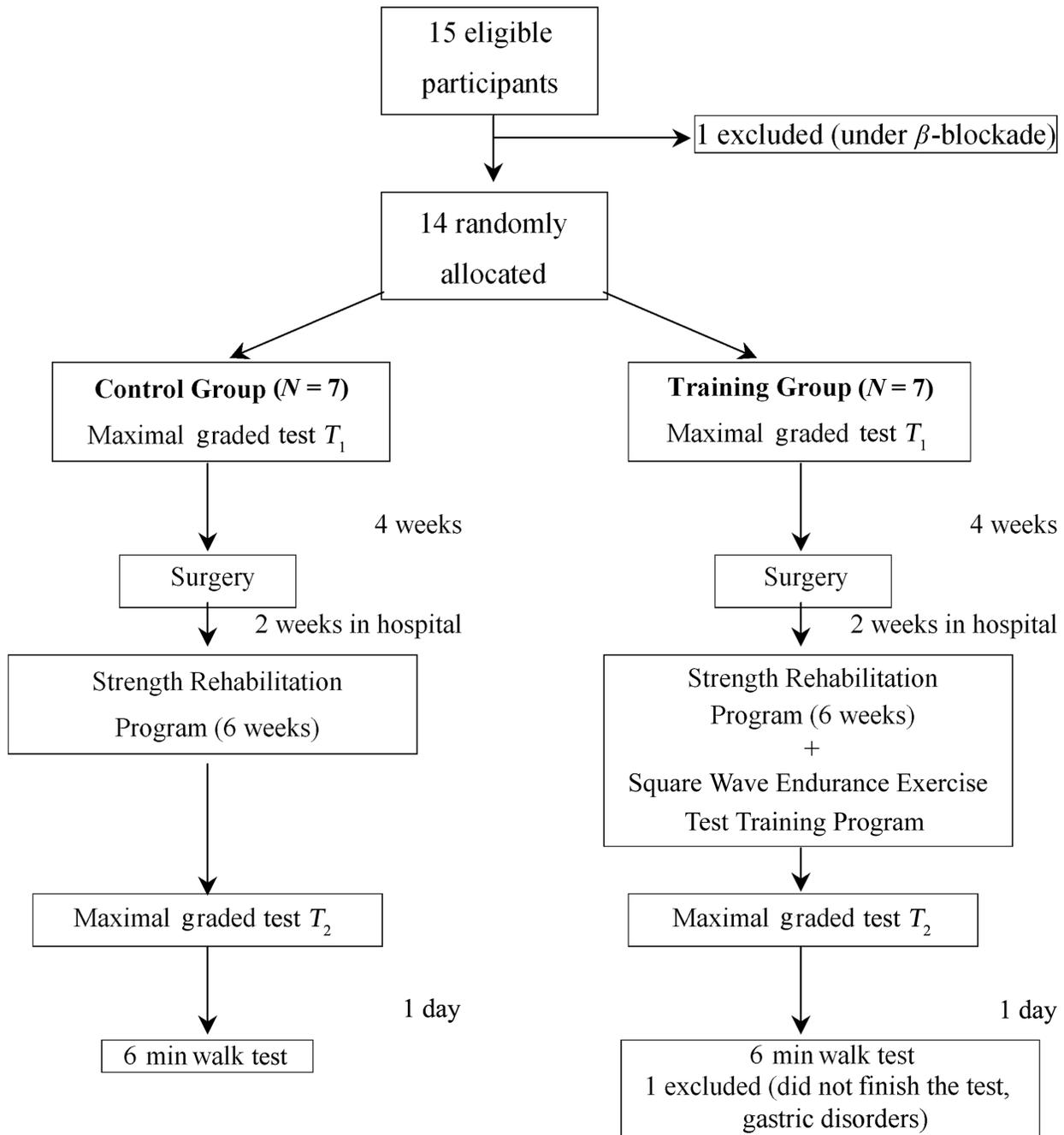


Figure.
Design of study.

additional arm-crank training program. This group had three training sessions per week, with interval training exercise periods of 30 min each for 6 weeks. The training consisted of a 30 min interval training session adapted from the Square Wave Endurance Exercise Test (SWEET) proposed by Gimenez et al. [3,4]. This type of

30 min exercise consisted of six successive work bouts of 5 min each. During each workout, a 4 min period of moderate exercise, named “base level,” was followed by a 1 min period of intense exercise, named “peak level.” The cranking cadence during the training sessions was between 50 rpm and 70 rpm. At the beginning of the

period, the base level was set at the ventilatory threshold and the peak level at 80 percent of the maximal tolerated power (which had been determined during T_1) with the use of the corresponding HR target. The HR was monitored during each training period. During the training program, improvements in the performance capacity were occurring. For maintenance of a sufficient intensity that aimed at reaching a maximal HR, or at least at 80 percent of maximal HR at the end of sixth peak, the loads for the base and peak were alternatively readjusted (+5 W) [3,4]. This readjustment took place when HR at the end of each training session was lower by 10 bpm compared to the greater HR record. At the end of each training session, a CR-10 scale was submitted to the patients. During the second training session (SWEET 2 [SW2]), expiratory gases were sampled and analyzed similar to the maximal graded tests. The base load and peak load were recorded. At the end of the training period (the last training session), the same training session as SW2 was performed, with the same measurements at the same workload (SWEET 2b [SW2b]). According to a previous study [6], this procedure allows a comparison, at a fixed workload, of the effects of the training program on the perceptual and physiological responses of patients.

At T_2 , both groups performed the functional 6 min walk test [25,26]. The walking track was a 30 m long empty hospital corridor. Patients were asked to walk back and forth along the track and to cover the longest possible distance in 6 min. Every 30 s, patients were encouraged in a standardized verbal way, and time was announced every 2 min. Distance, speed, stride length, and cadence were measured. During walking, all patients used bilateral crutches. No walking test was conducted at T_1 because of the impairment of functional state before surgery.

DATA ANALYSIS

Data are presented as mean and standard deviation. Because the data from the present study meet the statistical assumptions for using parametric statistics (i.e., homogeneity of variance and normality of the sample distribution), a two-way analysis of variance 2×2 (group \times measurement) and a Tukey post hoc test were used for a comparison of the physiological and perceptual responses in both groups between the two maximal graded tests. A paired t -test was used for a comparison of the perceptual

and physiological responses between SW2 and SW2b in TG. A t -test was used for a comparison of the measurements of the 6 min walk test between TG and CG. Statistical significance was accepted at the $p < 0.05$ level. Statistical power was calculated and had to be from 0.53 to 0.98 for the sample size, and the alpha level was set at 0.05 (SigmaStat, Jandel Corporation, San Rafael, CA). Effect size (ES) was also calculated for each test and displayed for every significant effect. Cohen's definition of small, medium and large ESs (ES = 0.2, 0.5, and 0.8, respectively) was used [27]. For each subject, an individual correlation analysis between HR (base and peak) and PE was performed. To observe possible changes in these relationships, we compared the individual HR/PE correlations found during the first nine training sessions with the values obtained during the last nine training sessions of the rehabilitation program.

RESULTS

All patients obtained an MMSE score above 24 (mean = 27.4, SD = 2 for TG, and mean = 27.9, SD = 2.4 for CG). The results obtained in the maximal graded tests are reported in **Table 2**. In both groups, 100 percent of subjects attained, in both maximal graded tests, at least two of the three criteria used to determine exhaustion state. No significant main effects for groups and measurement were found concerning the characteristics of the patients (body mass, body mass index), PE, PP, and maximum HR. Maximal tolerated power values indicated no significant effects on measurement and interaction. However, a significant effect on group for maximal tolerated power [$F(1,12) = 12.5$, $p < 0.01$, ES = 1.32, statistical power 0.91] was found. Post hoc analysis indicated that TG (mean = 30 W SD = 9.6) was significantly higher ($p < 0.01$) than CG (mean = 19.3 W, SD = 6.2) at T_2 . A significant main effect on group was found regarding the duration of the test [$F(1,12) = 13.38$, $p < 0.001$, ES = 1.42, statistical power 0.94]. Post-hoc analysis indicated that TG (mean = 5.7 min, SD = 1.9) had a significantly higher ($p < 0.001$) test duration than CG (mean = 3.6 min, SD = 1) for T_2 . Concerning peak, no significant effects on group and measurement $\dot{V}O_2$ were found. However, a trend on interaction was found [$F(1,12) = 3.24$, $p = 0.08$, ES = 0.68, statistical power 0.29]. At the end of T_2 , $\dot{V}O_2$ peak in TG (mean = 764.3 mL/min⁻¹, SD = 202.9) was higher than in CG (mean = 595.7 mL/min⁻¹, SD = 125.7).

Table 2.

Mean \pm standard deviation (SD) of body mass, mechanical, perceptive, heart rate (HR), ventilatory responses during first maximal graded test (MGT) (T_1), and second MGT (T_2) for training group and control group.

Variable	Training Group		Control Group	
	MGT 1 (Mean \pm SD)	MGT 2 (Mean \pm SD)	MGT 1 (Mean \pm SD)	MGT 2 (Mean \pm SD)
Body Mass (kg)	75.7 \pm 16.2	74.9 \pm 16.3	71.8 \pm 11.2	72.9 \pm 16
Body Mass Index (%)	30.1 \pm 5.8	29.3 \pm 5.9	28.7 \pm 3.7	29.0 \pm 4.7
Maximum Tolerated Power (W)	28.6 \pm 9.0	31.4 \pm 10.7*	21.4 \pm 6.9	17.1 \pm 4.9*
Duration (min)	5.5 \pm 1.7	6.0 \pm 2.1 [†]	3.9 \pm 1.2	3.3 \pm 0.8) [†]
Maximum HR (bpm)	138.3 \pm 8.3	138.1 \pm 10.5	127.7 \pm 16.2	124.4 \pm 18.4
Maximum Perceived Exertion	4.4 \pm 1.6	5.9 \pm 2.3	5.3 \pm 2.4	4.6 \pm 1.1
Maximum Perceived Pain	1.0 \pm 1.9	0.7 \pm 1.9	1.5 \pm 2.4	1.4 \pm 1.5
Peak (mL/min ⁻¹ /kg ⁻¹)	9.2 \pm 3.4	10.5 \pm 2.8	8.6 \pm 1.2	8.2 \pm 1.2
Peak (mL/min ⁻¹)	665.7 \pm 212.5	764.3 \pm 202.9	608.6 \pm 90.1	595.7 \pm 125.7
* $p < 0.01$ (effect on group)	† $p < 0.001$ (effect on group)			

The results of the SWEET Tests (SW2 and SW2b) are reported in **Table 3**. In TG, a significant decrease of PE ($t = 4.82$, $p < 0.05$, ES = 2.41, statistical power 0.98) was found between SW2 (mean = 3.80, SD = 0.9) and SW2b (mean = 1.5, SD = 1). However, no significant difference was found for PP between SW2 and SW2b. A significant decrease of HR_{Base} was found ($t = 3.32$, $p < 0.05$; ES = 1.57, statistical power 0.76) between SW2 (mean = 108.5 bpm, SD = 8.6) and SW2b (mean = 95.8 bpm, SD = 7.5). HR_{Peak} also significantly decreased ($t = 2.7$, $p < 0.05$, ES = 1.51, statistical power 0.56) between SW2 (mean = 119.4 bpm, SD = 9.6) and SW2b (mean = 104.3 bpm, SD = 10.4). Moreover, a significant decrease of final $\dot{V}O_2$ (corresponding to the higher value recorded during the last peak) was found ($t = 4.3$, $p < 0.05$, ES = 0.87, statistical power 0.94) between SW2 (mean = 7.6 mL/min/kg, SD = 1.8) and SW2b (mean = 5.47 mL/min/kg, SD = 2.9).

HR and PE correlations are as follows. No significant correlation was found for all patients during the first nine training sessions of the program between PE and HR_{Base} (mean $r = 0.41$, $p > 0.05$, extreme values = 0.16 to 0.66) and between PE and HR_{Peak} (mean $r = 0.35$, $p > 0.05$, extreme values = 0.03 to 0.59). However, during the last nine training sessions, the HR_{Base}/PE correlation (mean $r = 0.82$, $p < 0.05$, extreme values = 0.68 to 0.89) and also the HR_{Peak}/PE correlation (mean $r = 0.89$, $p < 0.05$, extreme values = 0.83 to 0.92) significantly increased in five patients. One patient from the TG did not finish the 6 min walk test (**Table 4**) because of gastric disorders,

independent of the protocol. After surgery and the rehabilitation training program with an arm-crank ergometer, TG (mean = 396.4 m, SD = 90.2) walked a significantly longer distance ($t = 3.44$, $p < 0.01$, ES = 1.91, statistical power 0.86) than CG (mean = 268.1 m, SD = 38.1). In the same way, when patients were walking, average speed was significantly higher ($t = 3.44$, $p < 0.01$, ES = 1.91, statistical power 0.86) in TG (mean = 66.1 m/min, SD = 15) than in CG (mean = 44.7 m/min, SD = 6.4). The stride length was significantly higher ($t = 2.73$, $p < 0.05$, ES = 1.62, statistical power 0.64) in TG (mean = 0.6 m, SD = 0.1) than in CG (mean = 0.5 m, SD = 0.1). The cadence was significantly higher ($t = 2.45$, $p < 0.05$, ES = 1.36, statistical power 0.53) in TG (mean = 105.2 steps/min, SD = 12.1) than in CG (mean = 90.9 steps/min, SD = 9).

Table 3.

Mean \pm standard deviation (SD) of perceptual, heart rate (HR), and peak $\dot{V}O_2$ responses at beginning (SWEET 2) and end (SWEET 2b) of training program that includes strength and arm cranking performed at same power output.

Variable	SWEET 2 (Mean \pm SD)	SWEET 2b (Mean \pm SD)
Perceived Exertion	3.8 \pm 0.9	1.5 \pm 1.0*
Perceived Pain	0.0 \pm 0.0	0.0 \pm 0.0
HR _{Base} (bpm)	108.5 \pm 8.6	95.8 \pm 7.5*
HR _{Peak} (bpm)	119.4 \pm 9.6	104.3 \pm 10.4*
Final $\dot{V}O_2$ (mL/min ⁻¹ /kg ⁻¹)	7.6 \pm 1.8	5.5 \pm 2.9*
* $p < 0.05$		

Table 4.Mean \pm standard deviation (SD) of performance during 6 min walk test 2 months after surgery (T_2).

Variable	Training Group ($N = 6$) (Mean \pm SD)	Control Group ($N = 7$) (Mean \pm SD)
Distance (m)	396.4 \pm 90.2 [†]	268.1 \pm 38.1
Speed (m/min)	66.1 \pm 15 [†]	44.7 \pm 6.4
Stride Length (m)	0.6 \pm 0.1 [*]	0.5 \pm 0.1
Cadence (steps/min)	105.2 \pm 12.1 [*]	90.9 \pm 9.0

* $p < 0.05$ [†] $p < 0.01$

DISCUSSION

This preliminary study involved a specific population of elderly osteoarthritis patients who were at risk because of aging and a state of deconditioning. For this reason, a large sample of patients was difficult to engage without preliminary results. We tested the hypothesis that an arm-crank rehabilitation program would increase first the fitness level and the accuracy of perceptual responses and second the physical function of osteoarthritis patients after total hip arthroplasty.

The results of the MMSE showed that patients did not present any cognitive impairment and could understand each indication and trial. The low size effect found in PE, PP, and HR_{Max} in both groups between T_1 and T_2 suggests that maximal graded tests were realized at the same relative intensity. However, the significant increase in maximal tolerated power and in the duration of the test with a large ES shows the positive effects of the arm-crank rehabilitation training program on physical fitness in osteoarthritis patients of the present study. Furthermore, this positive influence is supported by the trend found in the $\dot{V}O_2$ peak interaction ($\dot{V}O_2$ increased for TG, whereas it decreased for CG) and the medium ES values, but this observation needs more data because of the low statistical power. These results are in line with previous studies reporting positive effects of SWEET training on the physical fitness of young sedentary subjects [3,4]. The results obtained in the functional test (6 min walk test) confirm the positive effects of this rehabilitation training program on physical function; TG was able to cover a significantly longer distance in the walking test than was CG. During this test, TG obtained a faster walking speed, a longer stride length, and higher step frequency than CG. Then, in addition to the improvement of the cardiorespiratory fitness, we can also speculate that TG has improved its functional efficiency.

However, an interesting finding of this preliminary study is the low PE and PP values found in both groups at the end of maximal graded tests. A previous study [28] reported that, at the end of a maximal exercise, young sedentary subjects gave scores between 7 and 9 on the CR-10 scale. The low values observed in our study could partially be explained by the fact that elderly osteoarthritis patients have a specific perception of exercise and pain. Since the main effect for osteoarthritis pathology is intense pain [29], it may be possible that intense exercise could not be considered by such patients more painful than the pain due to osteoarthritis. A previous study has suggested that aging and physical deconditioning may also decrease the sensibility of pain and proprioceptors in elderly subjects by decreasing the speed and the quality of nervous transmission [30]. The subjects of our study were very deconditioned because of the osteoarthritis pain, and thus their PE could be disturbed. They had not performed physical exercises for several months, and their body sensations could be less accurate during intensive exercise than those in active elderly patients.

With the SWEET tests (SW2 and SW2b), we found that at a fixed workload, the PE decreased significantly between the beginning (SW2) and the end (SW2b) of the program. These results are in line with the significant decrease of the base level and peak HR recorded between both training sessions. The base and peak HR recorded during SW2b did not correspond to the ventilatory threshold and maximal tolerated power level calculated from T_1 . But these decreased HR results should be confirmed by further investigations because of a low statistical power. Therefore, the significant decrease in PE, HR, and peak $\dot{V}O_2$ observed in SW2b supports the view that the arm-crank training program increases the level of physical fitness of deconditioned, elderly osteoarthritis patients. Several studies reached the same conclusions concerning the influence of a SWEET training on the

cardiorespiratory adaptations, both in young sedentary subjects and in physically deconditioned patients [2,31].

The HR/PE relationship analysis revealed that during the first nine training sessions, the HR_{Base} and the HR_{Peak} were not significantly related to PE. The patients of this study may have been very deconditioned because they did not have any physical activity for several months. Then, their body sensations were diffuse, vague, and not in line with exercise intensity. These diffuse and vague body sensations could be the result of aging and/or deconditioning. However, after nine training sessions, the correlations between HR_{Base} , HR_{Peak} , and PE increased in five of our seven patients and became significant ($p < 0.05$). Such results suggest that the training program permitted a refinement of the PE in accordance with the HR response. Furthermore, the PE values found in TG at T_2 (i.e., after the rehabilitation training program) are closer than those usually observed in young healthy subjects at the end of a maximal graded test [28]. These PE values also agree with previous studies carried out in young, healthy [6,32], or cardiac subjects [33]. In these studies, it was suggested that PE was refined after an aerobic training program. Thus, our results suggest that PE is more affected by the level of physical fitness than by aging. Therefore, after a 6-week adaptation period, PE could be a useful tool for the monitoring of a training program in most elderly osteoarthritis patients after a total hip arthroplasty. The use of PE allows our patients to listen to the "signals of the body" [34]. Therefore, teaching patients how to use their PE during physical exercise could be valuable for the development of a training or rehabilitation program at home. In such a context, the patient would be more independent and autonomous, without using any instrumentation to control and manage his or her physical lifestyle. This could also have significant applications for health practitioners who use PE and PP to measure and control exercise intensity in elderly patients. However, one limitation of this preliminary study is the small sample of subjects involved in this study. Further investigations on a larger experimental sample of elderly osteoarthritis patients should be performed to confirm the results of this preliminary study.

CONCLUSION

In conclusion, this preliminary study suggests that physical deconditioning caused by osteoarthritis

decreases the sensitivity and accuracy of PE and PP in elderly patients. However, the arm-crank rehabilitation training program provided positive effects on the cardiorespiratory responses, functional capacities, and PE. Moreover, at the end of the training program, a majority of our patients refined their PE, which became more accurate. Further investigations on a larger sample are needed in future research to confirm our results.

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