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Oxygen Consumption During Workout Circuit Training in Patients with Coronary Heart Disease

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Abstract

Objective: To propose and evaluate the novel training method of workout circuit training in cardiovascular rehabilitation for patients with coronary heart disease.

Methods: Nineteen patients with coronary heart disease (54.8 ± 6.8 years old) followed 3 different training regimes: continuous training on an ergometer, interval training in the form of workout circuit training and interval training on a cycloergometer. During each training session, the oxygen consumption ($\dot{V}O_2$) was noted and compared to references values.

Results: Circuit training and interval training on a cycloergometer resulted in equal oxygen consumption ($p = 0.106$). Circuit training elicited a higher $\dot{V}O_2$ percentage than continuous training on an ergometer ($p = 0.016$). The time spent training at a high $\dot{V}O_2$ percentage is more important than the duration of continuous training. No cardiac events appeared during circuit training.

Keywords: Cardiac Rehabilitation, Coronary Heart Disease, Workout Circuit Training, Interval Training, Oxygen Consumption

Introduction

Cardiovascular rehabilitation is recommended (Class I level A) [1] for patients with coronary heart disease. Rehabilitation is beneficial to patients and is accompanied by a reduction in cardiac mortality and the number of re-hospitalizations as well as an improvement in the quality of life [2]. This is possible because the physical activity practiced in rehabilitation significantly improves physiological parameters ($\dot{V}O_2$ peak, $\dot{V}O_2$peak threshold, LDL levels, blood pressure, blood sugar and endothelial function) [1-3].

Different types of training are recommended for coronary patients (strength training and continuous or interval aerobic training) [1,4]. It is now recognized that high-intensity interval training (IT) provides greater benefits than continuous-type training (CET) in terms of the $\dot{V}O_2$peak parameter. This has been verified in athletes, sedentary people and coronary patients [5-14]. In cardiac rehabilitation, all studies relating to IT have been carried out on an ergometer. However, there are other ways to practice IT, such as workout circuit training (WCT). We believe WCT may provide equivalent results to ergometer IT in terms of the oxygen consumption parameter but has additional benefits. We therefore investigated, in coronary patients, if WCT is comparable to IT on an ergometer and if it is superior to CET in terms of the $\dot{V}O_2$ parameter.

Methods

Population

This study was carried out in a cardiovascular rehabilitation centre (Bois-Gibert, Ballan-Miré, France) with the participation of 19 patients. The inclusion criteria were acute coronary syndrome with myocardial infraction less than one year prior, left ventricular ejection fraction greater than or equal to 50%, no ischemia evident on a stress test, and maximum power greater than 80 watts. Patients with a medical contraindication to the practice of physical activity were excluded from the study.

Stress tests

Stress tests were performed on an ergocycle (Ergoline, Ergometer, Bitz, Germany). Heart rhythm analysis was performed with a 12-lead electrocardiogram (MediSoft, Ergocard CPX Clinical, Sordinnes, Belgium). The stress test protocol started at a resistance of 20 W with an increment of 20 W every 2 minutes. The pedalling speed was set between 60 and 70 rotations per minute. Using the results of the exercise test, a theoretical $\dot{V}O_2$ peak was calculated using Hawley's formula (estimated $\dot{V}O_2max = 0.01141 \times$ maximum aerobic power + 0.435) [15,16].

Training sessions

The subjects performed 3 different training sessions. The order of training over 3 consecutive days was as follows: day 1, continuous ergometer training (CET); day 2, workout circuit training (WCT) and day 3, interval ergocycle training (IT). The subjects had at least one training session before the measurements with a learning of effort perception (Borg scale).

The 3 training methods consisted of 5 minutes of a specific warm-up, 19 minutes and 15 seconds of effort and 5 minutes of recovery. For the WCT and IT, the effort phase was characterized by 3 series of 8 exercises or repetitions of 30 seconds with inter-exercise recoveries of 15 seconds and inter-series recoveries of 60 seconds.

The instruction we gave was to work according to the feeling of perceived effort (Borg scale [17]). The patients had to be at 13/20 during the CET. For CT and IT on the ergocycle, the target intensity was 15/20 at peak and 8/20 in recovery. Patients had no feedback as to their heart rate or power output on the ergometers. They were the ones who varied the power and/or pedalling speed according to how they felt. During the WCT, they adjusted their effort by varying the speed of their movements. During training, we used a countdown with visual and sound indications to guide the patient (application: 'Interval Timer - HIIT Training' - Polycents). The supervisor also gave information on the time and the number of sets and repetitions remaining.

WCT consisted of the following sequence of 8 exercises: n°1 running; n°2 plank; n°3 thruster; n°4 bicycle crunches; n°5 boxing with walking; n°6 mountain climber; n°7 step with box (30 cm) and n°8 lunge with shoulder press.

Variables measured

The number of adverse events (cardiovascular, injury etc.) was noted. In addition, during each training session, an analysis of $\dot{V}O_2$ was carried out with portable equipment (Métamax 3B, Cortex, Leipzig, Germany). The $\dot{V}O_2$ data recorded during the sessions were studied by using MétaSoft Studio® software. We analysed the time spent in intervals of % of estimated $\dot{V}O_2$ max that we defined as follows: ([0; 40%]; [40%; 60%]; [60%; 80%]; [80%; 100%]; [100%–120%] and [120%–140%]). The averages of $\dot{V}O_2$ were also calculated over the exercise period (from 5 min to 19 min 15 sec into the session).

Statistical analyses

The data obtained were analysed by a repeated measures ANOVA (JASP 0.11.1.0 software), with the significance threshold set at $p \leq 0.05$. Bonferroni post hoc tests were carried out to visualize the relationships between the training methods.

Results

Population

The characteristics of the population are presented in Table 1. Subjects had stable coronary disease with no unstable angina. The origin of acute coronary syndrome was atherosclerosis. The mean time between coronary syndrome and the first training session was 70 days.

Medical treatment was stable during the protocol. Patients who previously smoked were in smoking cessation during rehabilitation. Cardiovascular risk factors other than body mass index and tobacco, as well as medical treatment other than betablockers, are not mentioned because they do not influence the $\dot{V}O_2$ parameter

Oxygen Consumption

The results are presented in Table 2. Repeated-measures ANOVA shows a significant difference in mean $\dot{V}O_2$ flow between CET and WCT (66.13 ± 10.04% vs 73.28 ± 9.81%, p = 0.016) and between CET and IT (66.13± 10.4% vs 78.69 ± 8.11%, p < 0.001).

The analysis of the time spent per zone of % of $\dot{V}O_2$ confirms the study of the averages. In fact, the subjects spent more time at low intensity (range 40%–60% of estimated $\dot{V}O_2$max) with CET compared to IT (4.41 min vs 1.34 min, p = 0.015). This is also the case for moderate intensity (60%–80% zone of estimated $\dot{V}O_2$max) between CET versus WCT training (11.56 min vs 8.36 min, p = 0.019).

Table 1: Population. Mean ± standard deviation ; or number

Sex (M/F)	16	/	3
Age (years)	54,8	±	6,8
Body mass index (kg/m²)	28,9	±	4,1
$VO2_{peak\ estimated}$ ($mL.min^{-1}.kg^{-1}$)	25,9	±	4,06
Bétablockers (yes/no)	18	/	1

Table 2: Average of $\dot{V}O_2$ and time spent in each % of estimated $\dot{V}O_{2peak}$ for each type of training. *Significant difference between CET and WCT (p<0.05)

	CET	WCT	IT	
Average of $\dot{V}O_2$ during training	66.13	73.28	78.69	*£
Time (0%-40% $\dot{V}O_{2peak\ estimated}$)	0.64	0.43	0.12	
Time (40%60% $\dot{V}O_{2peak\ estimated}$)	4.41	3.37	1.34	α£
Time (60%-80% $\dot{V}O_{2peak\ estimated}$)	11.56	8.36	8.44	*
Time (80%-100% $\dot{V}O_{2peak\ estimated}$)	2.53	5.91	8.23	*£
Time (100%-120% $\dot{V}O_{2peak\ estimated}$)	0.11	1.02	1.11	£
Time (120%-140% $\dot{V}O_{2peak\ estimated}$)	0	0.08	0.03	

£ Significant difference between CET and IT (p<0.05)

α Significant difference between WCT and IT (p<0.05)

Conversely, WCT training allows for a longer duration of work at a high percentage of estimated $\dot{V}O_2$peak (80%–100% range) than CET (5.91 min vs 2.53 min, $p = 0.006$). The same is true for IT (8.23 min vs 2.53 min, $p < 0.001$).

There was no significant difference in the time spent at a high % of estimated $\dot{V}O_2$peak (80%–100% zone) between WCT and IT training.

Discussion

The objective of this study was to validate a protocol in the form of workout circuit training for coronary patients to expand the repertoire of training offered. We wanted to verify that this type of training required a high percentage of $\dot{V}O_2$ and that it could be comparable to the widely recommended IT but traditionally practiced on an ergometer [9,18].

According to our results and the solicitation of $\dot{V}O_2$ during a session, we propose that training in the form of WCT carried out during a training cycle of several sessions should make it possible to improve the parameters of $\dot{V}O_2$peak, $\dot{V}O_2$threshold, endothelial function and other cardiovascular risk factors that are important in coronary patients, as does IT on an ergometer [19-22].

We defined an effort time of 30 seconds for WCT and IT because this duration allows the subject to work with higher loads than a longer time of one minute without increasing the feeling of perceived exertion [23]. Like other authors, we also believe that a 30” effort modality is preferable during the first interval-type training sessions [20]. In addition, the 30/15 mode is interesting for developing adaptations at the level of the aerobic and anaerobic pathways when exercise stress is close to 100% of maximum cardiorespiratory capacity [24].

However, although the intensity of the aerobic effort, recorded by the $\dot{V}O_2$ parameter, is the same between the WCT and the IT on the ergometer, the training sessions differ in certain aspects, and we believe that they can also be considered as complementary. The $\dot{V}O_2$ reflects a central (cardiac output) and peripheral (arterio-venous difference in O2) component. We can therefore ask ourselves if the two training modalities modify these two parameters in the same way.

In addition, WCT solicits a different level of motor coordination and different muscle groups than those used in the repetitive, coordinated movement of an ergometer. The different aspects of physical capacity, including balance, strength, motor coordination and anaerobic capacity, should on these points be impacted differently by the two types of training. The advantage of WCT recruiting the whole body in the abovementioned aspects is highly relevant to patients in reconditioning, bringing benefits in terms of autonomy and quality of life [25].

We have constructed this WCT sequence with little equipment so that it can be reproduced independently by the patient. Indeed, the adherence of coronary patients to physical practice over the long term is not always good. We believe that this type of training, which can be performed at home, in a varied, fun and inexpensive way, can be a solution to maintaining adherence to an exercise prescription. In addition, the time spent on high-intensity activity is less than 15 minutes. This shows the patient that a short practice time allows for an effective, high-intensity session.

High-intensity WCT training has been shown to be safe for stable coronary patients. We did not find any adverse events in our study. This is in agreement with the literature, which demonstrates that high-intensity IT offered more conventionally on an ergometer to coronary patients does not increase the risk of a cardiac event [5, 8-9, 26-27].

We did not find a similar study in the literature with which to compare our results.

A limitation of the study is the number of included subjects. We wanted to include more subjects, but the period of Covid-19 put an end to recruitment. In a future study, the order of training could be randomized. A larger study comparing WCT and CET during a long period of rehabilitation is needed.

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