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High Intensity Crossfit Training Compared to High Intensity Swimming: A Pre-Post Trial to Assess the Impact on Body Composition, Muscle Strength and Resting Energy Expenditure

Simone Perna,[1] Chiara Bologna,[1] Irene Degli Agosti,[2] and Mariangela Rondanelli[1]

[1]1University of Pavia, Department of Public Health, Experimental and Forensic Medicine, Section of Human Nutrition, Endocrinology and Nutrition Unit, Azienda di Servizi Alla Persona, Pavia, Italy
[2]Azienda di Servizi alla Persona, Pavia, Italy, Pavia, Italy

[*]*Corresponding author*: Dr. Simone Perna, PhD, Department of Public Health, Experimental and Forensic Medicine, Section of Human Nutrition and Dietetics, Azienda di Servizi alla Persona di Pavia, University of Pavia, Via Emilia 12, Pavia, Italy. Tel: +39-0382381706, E-mail: simoneperna@hotmail.it

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Abstract

Objectives: The aim of this study was to evaluate the impact of two different forms of high intensity training i.e. power CrossFit and intermittent swimming, on body composition markers, max strength and resting energy expenditure.
Methods: This pre-post trial was conducted on twenty three subjects (14 female, 9 male; mean age = 31.74 ± 7.46 years; BMI = 23.665 ± 2.994 kg/m^2). They were assigned into interventions of CrossFit training or swimming (CrossFit/Swimming: 10/13) for 8-weeks (60 min, 3 times per week). Using dual X-ray energy absorptiometry (DXA), we measured body mass composition markers such as body weight, total free fat mass, total fat mass, arms and legs free fat mass, and percentage of android and gynoid fat mass. Also muscle strength and resting energy expenditure were measured at baseline and immediately after 8 weeks of training intervention. Feasibility measures of recruitment and injury were also assessed. These variables were measured at baseline and after 8 weeks and compared within and between groups, using paired t-tests and linear regression models, to detect significant changes.
Results: Between groups, data comparisons (pre-post intervention training) demonstrated a significant effect of CrossFit on gynoid fat (β = -1.42%; CI 95% -2.81; -0.03; P = 0.047), and suggestive but not significant variations in decreasing for total fat mass (β -1427 g, CI 95%: -2861, 7, 31; P = 0.051) and android fat (β = -2.64%, CI 95%: -5.36, 0.08; P = 0.056).
Conclusions: This study showed the potential benefits of high intensity training in improvement of body composition markers. In particular, CrossFit is more effective than swimming in losses of total fat mass, specifically of gynoid and android fat mass. Further research is needed to understand the potential of CrossFit training on health.

Keywords: CrossFit Training, High Intensity Training, Body Composition, DXA, Strength, Energy Expenditure

1. Background

High-intensity interval training (HIIT) has been used as an alternative to traditional aerobic training (1).

HIIT is practical for many individuals due to the minimum time required when compared to traditional continuous endurance training. In the last few years a new variation of HIIT that combines high-intensity endurance training with varied and multiple-joint movements has become popular. High-intensity power training (HIPT) differs from traditional HIIT in that it does not include rest periods but it focuses on sustained high power output and resistance (2).

Depending on the age and fitness level of the subjects as well as the duration and intensity of the intervention; improvements of muscle mass, strength and VO2 max have been reported (3-5). In literature there are different studies that evaluated the effects of high-intensity sports on different aspects of body composition and health. In particular, it was concluded that HIPT is an effective training strategy to improve cardiovascular health, physical performance (6), basal metabolic rate and body composition (1).

Previously, in literature the high intensity training was compared with low to medium-intensity, with good results. Currently, there are no studies that compare various forms of training at high intensity. The aim of this study is to compare the effects of two high intensity training methods on body composition markers, muscle strength and basal metabolic rate.

2. Methods

2.1. Study Participants

We evaluated both male and female subjects, with a history of moderate training activity, from May 2014 to June 2015, at metabolic and body composition lab of the University of Pavia.

Fourty participants were recruited. Twenty participants received the high intensity power CrossFit training group voluntarily, the other twenty performed high intensity intermittent swimming training (controls).

The inclusion criteria were that participants must be aged above 18 years and below 45 years, available to complete all exercise sessions and with a previous history of moderate training, such as fitness or gym activity. Subjects were included in this study if they were physically active and healthy. A preliminary visit was conducted to detect the lack of inclusion criteria. Participants were excluded if they participated in regular physical high intensity training previously, and if they had unstable medical conditions such as cardiovascular disorders, musculoskeletal injury, and cardiopulmonary disorders that might affect the performance. Each athlete had given informed consent to participate in this research.

2.2. Instruments

2.2.1. Body Composition Markers

Body composition was measured by dual-energy X-ray densitometry (DXA) using a Lunar Prodigy DEXA (GE Medical Systems, Waukesha, Wisconsin). The in vivo coefficients of variation were 0.89% and 0.48% for fat and muscle mass, respectively. Free fat mass (FFM; in grams), % free fat mass (%FFM), fat mass (FM; in grams), % fat mass (%FM), android fat %, gynoid fat % were evaluated on the basis of total body scan data. Absolute DXA data were compared to previously established age- and sex-matched reference values (7).

2.2.2. Maximal Handgrip Strength Test

The handgrip strength of the dominant hand was assessed using a Jamar dynamometer (Sammons Preston, Mississauga, ON, Canada). Standard assessment procedures were followed as described in a previous study (8). Briefly, participants squeezed the dynamometer as hard as possible three times, and the highest grip-strength value was used for analysis. The inter- and intra-rater reliabilities of this test have been reported to be good to excellent (ICC = 0.94 - 0.98) in adults.

2.3. Training Protocol

Subjects participated in a high intensity training program three non-consecutive days (Monday, Wednesday and Friday) per week throughout the entire eight-week training period. All training was performed under the supervision of the principal investigators and trained HPL research assistants.

The CrossFit group utilized training for 60-minute sessions. Nine movements (i.e. air squat, front squat, overhead squat, press, push press push jerk, deadlift, sumo deadlift high pull, and medicine ball clean) were introduced in sessions 1 - 2. Remaining sessions included warm-up and stretching (10 - 15 minutes), instruction and technique practice (10 - 20 minutes), workout (5 - 30 minutes), and cool-down and stretching (5 minutes). Swimmers group completed session lasted 60 minutes and consisted of 20 60 seconds all-out free-style swimming (front crawl) intervals interspersed by 2 min of passive recovery after training principles previously described.

2.4. Resting Energy Expenditure

Resting energy expenditure (REE) was measured using a ventilated hood and open-circuit calorimeter (QUARK RMR, Cosmed, Rome, Italy). Before each evaluation, the device was calibrated to 95% O_2 and 5% CO_2. All subjects underwent the test in the morning after a 12-hours overnight fast. The subjects were instructed to avoid any intense physical activity during the 24-hours period before REE measurement. Oxygen consumption (VO_2) and carbon dioxide production (VCO_2) were continuously measured for 25 minutes. The first 5 minutes were discarded to ensure adequate acclimation. The subjects were instructed to avoid hyperventilation, fidgeting, or falling asleep during the test.

2.5. Statistical Analysis

For each outcome, one-way ANOVA was performed for assessment differences between intervention groups at baseline. Analysis of covariance (ANCOVA) was performed using of covariate sex, percentage of fat mass, percentage of gynoid fat and fat mass in grams were used to compare crossfitter and swimmer over the time (i.e. mean differences between treatments over the time). The statistical package SPSS version 20 was used for statistical analysis (9). A value of $P < 0.05$ was considered statistically significant.

3. Results

Participant flow diagram is shown in Figure 1. Fifteen athletes received CrossFit training, and another fifteen athletes received swimming training. In either groups there

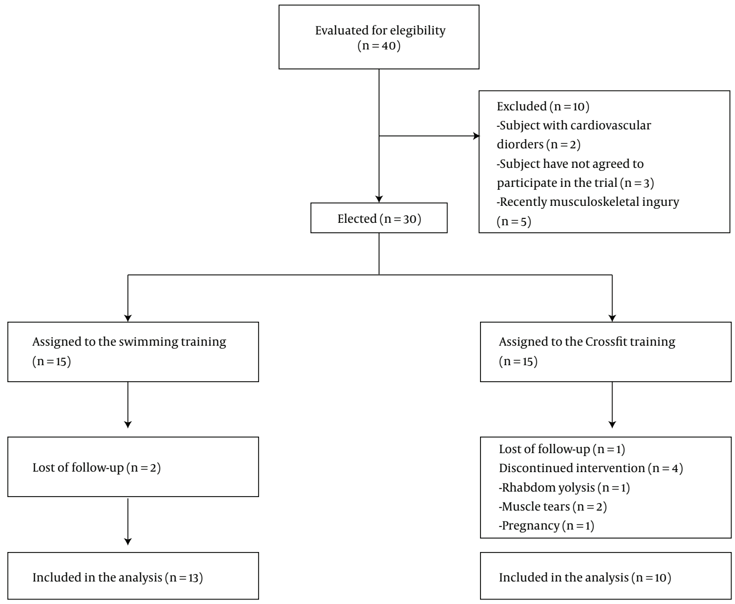

Figure 1. Participant Flow Diagram

were drop outs. The reasons were injuries, 5 among crossfitters and 2 among swimmers. Recruitment was performed from May 2014 to June 2015. The follow-up was 8 weeks.

Table 1 shows the baseline outcomes in both groups. There were no significant difference between-groups.

Nevertheless, as showed in Table 2, the between-treatment comparisons (over the time) by analysis of covariance (ANCOVA) demonstrated a significant effect of CrossFit. Between groups, data comparisons (pre-post intervention training) demonstrated a significant effect of CrossFit on gynoid fat (β = -1.42%; CI 95% -2.81; -0.03; P = 0.047), and suggestive but not significant variations in decreasing for total fat mass (β= -1427 g, CI 95%: -2861, 7,31; P = 0.051) and android fat (β=-2.64%, CI 95%: -5.36, 0.08; P = 0.056).

4. Discussion

This study shows that 8-weeks of high power training CrossFit program, based on progressive resistance, power strength and functional training, improved resting energy expenditure, and all body composition parameters. It's particularly more effective in total fat mass losses compared to high intermittent swimming training.

No differences were found in changes on arms and legs free fat mass between the two groups, but in a medium long time, CrossFit seems to have important effects on legs free fat mass. This potential of CrossFit, specifically in legs improvement, has been described previously in a study performed by Glassman in 2006 (10). Our data showed that CrossFit also increased muscle strength. But no significant differences between trainings were found. Thus, regarding the REE data, the CrossFit was no more effective than swimming in increasing this parameter. This last data might explain the association with the decrease in total fat mass and the increasing in free fat mass. This relationship has been reported in several studies on the general population (11, 12).

Limitations included the small size of the sample and a previous history of moderate training for all participants. Finally, because of the small sample size, these results may not generalize outside of these participants. This study included a control condition but no randomization were made.

Study strengths included adherence: drop-out rates of 13 % (2/15) for swimmer and 33% (5/15) for crossfitter participants. Only one crossfitter subject experienced a serious injury (these episodes are typical in CrossFit as described in literature (13).

The CrossFit training was safely conducted among participants of our study. Another point of strength was the assessment of body composition using DXA, which is the gold standard for body composition evaluation.

Future research could include a larger sample with extended follow-up to determine the effects of CrossFit high intensity power during a medium long time period.

Table 1. Sample Characteristics at Baseline[a]

Variable	Crossfitters (N = 10)	Swimmers (N = 13)	P Value	Total (N = 23)
Age, y	33.10 ± 9.826	30.69 ± 5.186	0.778	31.74 ± 7.460
Weight, kg	71.66 ± 19.134	68.88 ± 8.483	0.975	70.09 ± 13.821
BMI, kg/m²	24.71 ± 4.291	22.86 ± 1.007	0.315	23.67 ± 2.994
Arms free fat mass, g	6.99 ± 3.043	6.67 ± 1.610	0.704	6.81 ± 2.287
Legs free fat mass, g	19.81 ± 6.673	20.11 ± 3.859	0.480	19.98 ± 5.135
Free fat mass, g	53.18 ± 16.557	54.0 ± 9.404	0.416	53.64 ± 12.681
Fat mass, g	15.80 ± 7.203	12.03 ± 4.412	0.167	13.67 ± 5.958
Gynoid fat, %	31.26 ± 11.183	24.91 ± 10.011	0.174	27.67 ± 10.779
Android fat, %	27.69 ± 11.090	25.67 ± 8.952	0.286	26.55 ± 9.750
A/G ratio	0.89 ± 0.239	1.08 ± 0.290	0.099	1.00 ± 0.281
Tissue, g	68.97 ± 17.962	66.02 ± 7.995	0.938	67.31 ± 13.004
Free fat mass, %	76.54 ± 9.052	81.47 ± 7.356	0.179	79.33 ± 8.323
Fat mass, %	23.46 ± 9.052	18.53 ± 7.356	0.179	20.67 ± 8.323
Handgrip strenght (right), kg	47.80 ± 13.935	48.92 ± 13.543	0.854	48.35 ± 13.739
Resting energy exp., kcal	1401.50 ± 440.66	1475.08 ± 264.72	0.343	1438.29 ± 352.69

[a] In bold: $P < 0.05$.

Table 2. Between-Treatment Changes (Baseline to 8 Weeks)[a,b]

Variables	Pre - Training (Swimmers)	Post - Training (Swimmers)**	Pre - Training (CrossFit)	Post - Training (CrossFit)**	Mean Difference and CI 95% (Crossfitters Minus Swimmers[c])	F	P Value
Weight, kg	71.66 ± 19.13	69.70 ± 0.47	68.88 ± 8.48	68.10 ± 0.54	-0.70 (-2.33; 0.92)	0.84	0.372
BMI, kg/m²	24.710 ± 4.291	23.29 ± 0.20	22.862 ± 1.01	23.54 ± 0.24	0.25 (-0.50; 0.98)	0.49	0.493
Arms free fat mass, g	6995 ± 3043	6804 ± 131	6668 ± 1610	6757 ± 155	-46.50 (-536.53; 443.54)	0.04	0.843
Legs free fat mass, g	19810 ± 6673	20029 ± 247	20112 ± 3859	20248 ± 286	219.10 (-631.93; 1070,13)	0.30	0.593
Free fat mass, g	53176 ± 16557	53548 ± 508	53999 ± 9404	54410 ± 590	861.19 (-909.08; 2631.46)	1.06	0.318
Fat mass, g	15797 ± 7203	13229 ± 426	12025 ± 4412	11801 ± 492	-1427.24 (-2861.79; 7.31)	4.41	0.051
Gynoid Fat, %	31.26 ± 11.183	27.30 ± 0.41	24.91 ± 10.011	25.88 ± 0.48	-1.42 (-2.81; -0.03)	4.63	0.047
Android fat, %	27.69 ± 11.090	26.33 ± 0.74	25.67 ± 8.952	23.69 ± 0.88	-2.64 (-5.36; 0.08)	4.24	0.056
Free fat mass, %	76.542 ± 9.052	79.33 ± 0.16	81.469 ± 7.356	79.36 ± 0.19	0.03 (-0.52; 0.57)	0.01	0.922
Fat mass, %	23.458 ± 9.052	20.32 ± 0.50	18.531 ± 7.356	18.66 ± 0.58	-1.66 (-3.35; 0.03)	4.30	0.054
Handgrip strength (right), kg	47.80 ± 13.935	48.94 ± 0.80	48.92 ± 13.543	47.49 ± 0.93	-1.45 (-4.17; 1.27)	1.28	0.274
Resting energy exp., kcal	1401.50 ± 440.661	1616.38 ± 79.46	1475.08 ± 264.723	1483.31 ± 92.0	-133.07 (-405.22; 139.08)	1.07	0.315

[a] β = mean difference between treatments over the time, adjusting the covariate: sex and % body fat, % free fat mass, % gynoid fat and fat mass in grams.
[b] Post analysis data were estimated for covariate (sex and % body fat, % free fat mass, % gynoid fat and fat mass in grams.)
[c] In bold: $P < 0.05$.

4.1. Conclusions

Overall, both forms of training appear to have caused the same improvements in the body composition of all athletes, but between thegroups, the crossfitter group have seen more effects on fat mass decrease, specifically in the reduction of gynoid and android fat. Future approaches of CrossFit training: it could also be administered in conjunction with nutrition intervention in the hope of eliciting changes to body composition in a large samples of overweight or obese participants.

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Footnote

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