BLOOD PRESSURE AND HEART RATE RESPONSE TO TWO RESISTANCE TRAINING TECHNIQUE OF DIFFERENT INTENSITY

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Abstract

Regular practise of physical activity would contrast obesity and several related disease¹, but exercise should be enjoyable and useful to be part of person’s lifestyle. It has been recently demonstrated that High Intensity Resistance Training (HIRT) may increase resting energy expenditure after exercise and may reduce Respiratory Ratio hence improving fat oxidation. The shorter exercise time commitment may help to reduce one major barrier to exercise that is the lack of time. The aim of this study was to verify if HIRT was a safety way of training by the monitoring of Blood Pressure (BP) and Heart Rate (HR) during one session of this kind of exercise and compare it to common protocols propose by ACSM Guidelines (TT).

Twenty healthy volunteers performed one session of both type of RT: HIRT technique consists of 6 repetitions, 20” rest, 2/3 repetitions, 20” rest, 2/3 repetitions with 2’30” rest between sets; TT consisted of 3 sets of 15 repetitions with 1’15” rest between sets. We measured Blood Pressure and Heart Rate during exercise and we calculated mean arterial pressure (MAP) and the Rate Pressure Product (RPP); basal lactate was measured after each session.

Subjects shown similar HR response to both training (HIRT=128,20±15,64; TT= 116,29±14,78), also minimal and maximal value weren’t significant different (HIRT= 89,50±18,39 and 149,33±16,26; TT=84,33±15,23 and 150,00±16,12). Any difference also in SBP (HIRT=128,87±12,46) or DBP (HIRT=73,38±10,90; TT=73,94±9,66) interesting was the analysis of maximal and minimal BP and MAP value: during HIRT subjects reach level of DBP minor than during TT (p<0.05) and MAP was significant higher than baseline (p<0.05) only in TT.

Subjects showed the same cardiovascular response to different intensity of resistance training. Furthermore, DBP, that is the most important BP parameter, reached lower level during HIRT than TT. The results of this study suggest that HIRT could be a safety way of training, and it could be propose to contrast obesity.

Keywords: resistance training, blood pressure, heart rate, HIRT
**Introduction**

Physical exercise is an essential element for a healthy lifestyle treatment in several diseases such as obesity, diabetes or hypertension (American College of Sports Medicine 2009, Ehrman et al. 2013).

The social cost for pharmacological treatment of these non communicable diseases is great (Machlin, Soni 2013). Moreover, the side effects of some drugs could contribute to increase public health costs. Thus regular physical activity could play a double role in contrasting chronic diseases: one is the primary prevention among major risk factors (Toledo, Goodpaster 2013, Durstine, Moore & Durstine 2009), the second is contrasting the disease progression (Ellis, Motl 2013, Xi et al. 2012, Nunan et al. 2013). For these reasons, the most important recommended guidelines are: healthy nutritional lifestyle and regular physical activity (PA).

The major recognized cause of death is myocardial infarction (Rosamond et al. 2007, Ehrman et al. 2013, Durstine, Moore & Durstine 2009) that is often related to other pathologies such as diabetes, hypertension and other metabolic diseases (Paffenbarger, Wing & Hyde 1995, Tipton 1991, Lee, Paffenbarger & Hsieh 1991) so the reductions of such cardiovascular risk factors may became very important to improve quality of life and reduce mortality (Paffenbarger et al. 1986). It is well documented that physical exercise contrasts some of these risk factors as hypertension, blood cholesterol and triglycerides (TG) and fat mass (Wing 2013; Wescott 2012; Boillon 2012).

The first guidelines suggested to practise from 15 to 60 minutes of aerobic exercise, 3 to 5 days per week at 60% to 90% of maximum heart rate (HR) (Pollock, Froelicher 1990). Endurance training (ET) increases general aerobic capacity, has positive effects on reducing HR and blood pressure either at basal condition and in response to exercise. Moreover, endurance training could decrease submaximal $O_2$ demand, reduce blood LDL and increase blood HDL and TG: overall, as a consequence, aerobic exercise reduces the risk of cardiovascular diseases (Tsai et al. 2004, Maeda et al. 2003, Ketelhut, Franz & Scholze 1997)

Currently the recommended intensity of ET is moderate (50-85% of HR peak) with a continuous pace (Balady et al. 2007, Garber et al. 2011, Davies et al. 2010). But in the last years many studies have demonstrated the efficacy of high Intensity Interval training (HIIT) on VO2 peak (Duffield, Edge & Bishop 2006, Ready, Eynon & Cunningham 1981, Hood et al. 2011) cardiac remodelling (Piepoli 2010) and glycemia (Whyte et al. 2013, Kessler, Sisson & Short 2012, Gillen et al. 2012). The resistance training (RT) recently has been introduced in published guidelines as an efficient non pharmacological treatment (Garber et al. 2011, Westcott 2012). But RT has more variables than Endurance Training: kind of resistance used (rubber band, weights, etc), volume of training (sets x reps), speed of movement, time under tension and so on (Paoli 2012, Paoli, Bianco 2012). Different combinations of these parameters could modify the final results on physical fitness, and moreover, on cardiovascular remodelling. Current guidelines for the most common chronic diseases recommended 1-3 sets of 8-12 reps at 60%-80% of IRM (Garber et al. 2011). Although, some recent studies have demonstrate that High Intensity Resistance Training seems to be more effective, in reducing plasma fibrinogen and increasing plasma HDL levels (Sheikhholeslamieh Vatani et al. 2011) and in improving abdominal obesity and cardiovascular health (Gremeaux et al. 2012), than moderate resistance training.

A major problem in PA prescription is the adherence of sedentary subjects to training protocols, indeed recent studies have evidenced that obese people prefer shorter but more intense exercise to a longer but more moderate fatigue (Bartlett et al. 2011). This observation suggests that subjects with pathologies, who need PA, are not incline to sustain physical efforts for a long time and this would be cause of low compliance.

In addition, one of the major barriers to the practice of regular physical activity is the lack of time (Stutts 2002, Trost et al. 2002, Kimm et al. 2006). Finding a protocol that is at the same time short but efficient in reducing cardiovascular risk
factors would be a good way to contrast sedentariness related chronic diseases with PA.

For these reasons the aim of our study was to verify the cardiovascular effects of a High Intensity Resistance Training (HIRT) compared to a more commonly prescribed resistance training protocol (TT).

Materials and methods
Twenty healthy volunteers (22±1.5 years; 64.21±11.18 kg; 21.98±2.78 BMI) participated to the study. The participants were moderate physically active without direct previous resistance training experience. All participants performed one session of both type of RT.

The high intensity resistance training (HIRT) technique consisted of 6RM repetitions followed by a 20 second rest; then the subjects had to lift the same weight until failure (habitually 2 repetitions) followed by another 20 second rest period with repetitions to fatigue. This sequence counted as one set, then the subjects rested 2’30” before performing a second set. The traditional training (TT) technique consisted of 3 sets of 15 repetition with 1’15” rest between sets. Subjects were tested using the leg extension exercise. The first day the participants familiarized with the machine and practiced the training technique. The second day (3-4 days after familiarization session) we performed pre-testing measurements of basal Heart Rate, Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP) and performed a 1RM test, then subjects were randomly assigned to one of the two training groups. At each subject were administered both protocols in two different periods of time. Subjects performed first TT or HIRT according to a random schedule. Blood pressure (BP) was measured through a sfigomanometer (Pic Classic Med) at the beginning and at the end of each set; Heart Rate (HR) was recorded by a heart rate monitor (Polar FT80; Kempele, Finland) at basal time, before and after each set and during rest between sets. Moreover we calculated the mean arterial pressure (MAP) defined as DBP+1/3(SBP-DBP) and the Rate Pressure Product (RPP), which is a physiological index to determine the cardiovascular risk, as the product of HR and SBP. Furthermore blood lactate was measured (LAT) using SensLab Lactate Scout – Test strips (Bautzner Staße 67; Leipzig, Germany) based on capillary blood lactate (Hunter, Seelhorst & Snyder 2003) before training, immediately after the training session, after 5 and 15 minutes the end of training.

Data analysis was performed using GraphPad Prism 4.0 software (GraphPad Software, San Diego California USA). A one way ANOVA for repeated measurement was conducted to analyse differences inside the same training group and a two way ANOVA was used to verify differences between groups, a Bonferroni test post-hoc was used to clarify the effect of multiple comparison. P-value was set at 0.05.

Results
Two way ANOVAs showed no significant differences between the two training protocols in all the measurements: HR (HIRT=128.20±15.64 bpm; TT= 116.29±14.78 bpm), SBP (HIRT=134.82±13.90 mmHg; TT= 128.87±12.46 mmHg) or DBP (HIRT=73.38±10.90 mmHg; TT=73.94±9.66 mmHg) and LAT. The results of all measurements are shown in table 1. HR increases significantly during both protocols presenting similar trend during exercise (figure 1).

Figure 1. HR during TT protocol (A) and HIRT protocol (B);* significantly different from baseline, p<0.05
<table>
<thead>
<tr>
<th></th>
<th>PRE</th>
<th>1</th>
<th>1rec</th>
<th>2</th>
<th>2rec</th>
<th>3</th>
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<tbody>
<tr>
<td>Heart</td>
<td>82.72±12.30</td>
<td>89.75±15.09</td>
<td>142.00±15.79</td>
<td>98.92±17.92</td>
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<td>113.58±10.09</td>
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<td>124.58±14.81</td>
<td>139.42±9.98</td>
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<tr>
<td>Blood</td>
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<td>71.58±7.45</td>
<td>73.50±9.83</td>
<td>73.25±10.14</td>
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<td>94.42±8.83</td>
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<td>97.64±8.79</td>
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<td>BMI</td>
<td>89.38±10.71</td>
<td>100.96±12.14</td>
<td>192.88±25.68</td>
<td>122.30±21.80</td>
<td>203.06±28.40</td>
<td>137.65±27.79</td>
<td>211.07±27.06</td>
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<table>
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<tr>
<th></th>
<th>PRE</th>
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<th>mms</th>
<th>mmr</th>
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<td>Heart</td>
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<td>137.25±18.13</td>
<td>141.83±15.73</td>
<td>104.17±19.39</td>
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<td>Stroke</td>
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<td>136.50±15.13</td>
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<tr>
<td>Blood</td>
<td>72.17±8.16</td>
<td>73.08±10.85</td>
<td>69.33±7.32</td>
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<td>74.50±11.75</td>
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<tr>
<td>Weight</td>
<td>72.17±8.16</td>
<td>93.67±12.34</td>
<td>86.97±8.17</td>
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<tr>
<td>BMI</td>
<td>108.86±24.93</td>
<td>185.22±42.99</td>
<td>126.71±24.93</td>
<td>196.56±25.06</td>
<td>195.61±34.43</td>
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For TT: PRE= basal value; 1=before the first set; 1rec=after the first set; 2=before the second set; 2rec=after the second set; 3=before the third set; END=after the last set. For HIRT: PRE=basal value; 1=before the first 6 reps; 20”=after the first 6 reps; 2’30”=during rest between the two macro-sets; mms=mean of mini set; mmr= mean of mini rest of 20”; END= after the last set. For blood lactate (LAT): PRE= basal value; 0= immediately after the exercise; 5’= 5 minute after the exercise; 15’= 15 minute after the exercise.
The peak of HR was determined by the maximum and minus value reached during all the sets: no significant differences between the two groups were detected (figure 2).

**Figure 2.** Peak of HR reached during all the sets; minimum value (A) and maximum value (B).

SBP increases significantly from baseline in both protocols while DBP didn’t change. Interestingly DBP peak reached a lower mean value during HIRT (64.17±8.48 mmHg) than TT (69.58±8.35 mmHg) (figure 3). At the end of TT, MAP was significantly higher than baseline (11.81±7.17); no differences were found in HIRT technique (7.53±11.85) (figure 4).

**Figure 3.** DBP peak reached during TT and HIRT.

**Figure 4.** MAP value in TT (A) and HIRT (B).

At the end of exercise RPP (figure 5) increases significantly in both TT (155.47±27.74) and HIRT (86.75±33.25), but this was greater in TT (p<0.05).
Figure 5. RPP during TT and HIRT, the differences between the two protocols was significant; ** p<0.05 *** p<0.001.

Blood lactate (LAT) was measured before and at the end of each protocols (table 2). LAT was significantly higher immediately after exercise and after 5 minutes compared to baseline (p<0.001 and p<0.05 respectively), and decreases after 15 minutes (p<0.05) as shown in figure 6. There was no significant difference between the two protocols.

Table 2. Blood lactate

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<thead>
<tr>
<th></th>
<th>PRE</th>
<th>0</th>
<th>5'</th>
<th>15'</th>
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<tr>
<td>TT</td>
<td>1.9±0.8</td>
<td>5.8±1.5</td>
<td>5.6±1.7</td>
<td>3.8±1.3</td>
</tr>
<tr>
<td>HIRT</td>
<td>1.6±0.7</td>
<td>5.9±1.6</td>
<td>5.6±1.6</td>
<td>3.8±1.3</td>
</tr>
</tbody>
</table>

Figure 6. Blood lactate (LAT) after TT and HIRT.

Discussion

The aim of this study was to verify the cardiovascular response to an high intensity resistance training compared to the resistance protocols proposed by ACSM Guidelines (Garber et al. 2011) that we defined traditional training (TT). It has been demonstrated that RT could be a good strategy for cardiovascular prevention and rehabilitation (Garber et al. 2011, Umpierre, Stein 2007). Previous researches that have investigated cardiovascular response during resistance training showed a good heart rate stability, without any dangerous increase in blood pressure or demonstrated damage to ventricular function (Umpierre, Stein 2007, Kiselev et al. 2005). In our study heart rate varied during both exercise but returned to similar baseline values during rest between sets. The increase of heart rate was superimposable in both training protocols and, more important, a pause of 1 minute during TT and 2’30” during HIRT was sufficient to enable our healthy young subjects to return to baseline condition. The HR peak reached during HIRT wasn’t different from TT; nevertheless RPP increase was greater in TT than in HIRT. These results deserve some comments, it seems that the intensity of RT didn’t affect the myocardial O₂ uptake (measured by RPP), whilst the increase of RPP is probably caused by the duration of the efforts. The magnitude of blood pressure and heart rate is not enough if taken as single factors but becomes significant when it’s considerd as the
RPP. The duration of HIRT technique is probably not sufficient to increase myocardial VO\textsubscript{2} such as HR and SBP as previously seen. Other authors had previously demonstrated that high intensity interval protocols increase systolic blood pressure (Fleck, Dean 1987, Meyer et al. 1999, Cheetham et al. 2002), our study confirms these results, in fact both protocols had shown an increase of systolic blood pressure at the end of the last set, but no differences was found in MAP during exercise. Other studies had demonstrated that during efforts with high load HR, SBP and also DBP increased more than with low load training (Umpierre, Stein 2007, Terra et al. 2008). Our findings suggest that HIRT technique, in which the intensity reaches the 80% of 1RM, SBP, DBP and MAP do not dangerously increase.

It is also interesting to note that during HIRT, the DBP reached lower peaks respect to TT, while no differences was found for SBP. This data confirms what Lamotte and colleague (Lamotte, Niset & van de Borne 2005) found some years ago, i.e. there is a better blood pressure response during high intensity training than in low intensity one, with minor peak reached during the first kind of exercise.

Normally exercise that induce grater increase of HR and BP are contraindicated in cardiopathic patients; HIRT technique does not present risks in a greater extent than the common training protocols proposed by ACSM guidelines (Garber et al. 2011). This effect could probably be explained by the dynamic execution of HIRT in which there is a very short period of arterial occlusion induced by muscle contraction and, on the other side, a broader rest period before the next efforts.

**Conclusions**

The results of our study suggest that high intensity resistance training is safe as the commonly proposed protocols to cardiovascular patients and suggested by ACSM’s guidelines. Moreover, as previously demonstrated from our group (Paoli et al. 2012), HIRT technique has more positive effects on body weight, free fat mass and blood cholesterol than lower intensity training. This finding leads us to suppose that HIRT should be a potentially safe training protocol for the prevention of cardiovascular risk factors.

Further studies are needed to evaluate the efficacy and safety of HIRT in overweight or hypertensive subjects.

**References**


43. Westcott, W.L. 2012, "Resistance training is medicine: effects of strength training on health", Current sports medicine reports, vol. 11, no. 4, pp. 209-216.
