Effects of training and detraining on glycosylated haemoglobin, glycaemia and lipid profile in type-II diabetics

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Abstract

Objective: the aim of the present study was to determine the effect of training and the consequences of detraining, comparing an aerobic training (AT) protocol with a resistance training (RT) in people with type-II Diabetes Mellitus (DMII).

Methods: a total of 30 individuals participated in the study, with ages ranging from 45 to 50 years, all diagnosed with DMII and not currently receiving pharmacological treatment. Participants were divided at random into an AT group (65% of their maximum aerobic capacity) and a RT group (1 x 2 x 3 protocol at 65% of 1RM). Measurements were taken of weight, body mass index, total cholesterol, HDL-C, LDL-C, triglycerides, glycaemia in a fasted state and glycosylated haemoglobin (HbA1C) at the beginning and at the end of the 6-week training period, and after a further 6 weeks of detraining.

Results: the results show that both physical training protocols are capable of inducing significant modifications in lipid profile, glycaemia in a fasted state and levels of HbA1C; however, after stopping the training programme only the RT group maintained the benefits of the reduction in LDL-C, HbA1C and the increase in HDL-C.

Conclusions: resistance exercise in individuals with DMII has an important influence on health and their effects could be maintained even if the training program is interrupted short-term.

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Key words: Type-II diabetes mellitus. Aerobic exercise. Resistance exercise. Detraining. Health.

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Introduction

Doing regular physical exercise has been proven to have a positive effect on the pathogenicity of several diseases\(^\text{1-2}\). However, little is known about the effect of detraining on difference health markers in persons with DMII. Both aerobic exercise\(^\text{3-4}\) and resistance exercise\(^\text{5-7}\) or a combination of these in the same training session\(^\text{8}\) have been shown to be an important non-pharmacological therapeutic complement to controlling DMII. It has been documented that exercise positively influences HbA\(_1c\), body mass index (BMI), glucose concentration after fasting and lipid profile in a group of non-medicated individuals with DMII. However, the laboratory personnel were blind to the study.

Materials and Methods

Participants

A total of 30 adults from the Young Men’s Christian Association (YMCA) health programme participated in the study (21 women and 9 men, aged 48.1 ± 1.7 years, with heights of 1.66 ± 0.0 m, weight of 71.7 ± 6.1 kg, BMI of 26.0 ± 2.1 kg/m\(^2\)). The inclusion criteria were men and women aged 45 to 50 years, diagnosed with DMII for at least 2 years and not currently using pharmacological treatment. Any person not completing the training programme, or those who completed less than 70% of the sessions were excluded (8 subjects, 21%). The study was carried out in accordance with international deontological standards for research involving human beings, as established in the Helsinki Declaration, and it was approved by the local ethics committee. All participants voluntarily signed an informed consent form and were fully aware of the procedures and objectives of the study.

Blood analysis

All participants visited the clinical laboratory on three occasions to determine their fasted glucose levels (after 12 h of fasting), lipid profile (total cholesterol, HDL-C, LDL-C and triglycerides (mg/dL)) and HbA\(_1c\) (%), at the start of the study, at the end of the first training period and after the detraining period. The procedure was carried out by extracting 10 ml of blood in a vacutainer with EDTA between 7:30 am and 9:00 am. After centrifugation, the blood serum was separated within one hour of taking the sample. It should be noted that the laboratory personnel were blind to the study.

Glucose concentration was determined using the Re-floflex S-1172115 glucometer (Boehringer Mannheim, Germany) based on the glucose-oxidase method\(^\text{17}\). Total cholesterol, HDL-C, LDL-C and triglycerides were measured by enzyme methods\(^\text{18}\). High density lipoproteins were measured by VLDL and LDL-C precipitation in the presence of magnesium ions. The LDL-C fraction was calculated using the Friedewald formula. HbA\(_1c\) (%) was measured by the immunoturbidimetric test using an automatic Cobra Integra 800 analyser (Roche Diagnostics, Switzerland) with a reference value of 4.4 to 6.4%. This methodology was in line with the standards of the National Glycated Haemoglobin Standardisation Programme\(^\text{19}\).

Physical training

The participants were randomly divided into two groups (aerobic and resistance). Each person on the AT group performed the modified Bruce protocol to estimate oxygen consumption indirectly and identify 65% of maximum aerobic capacity (the training level for the aerobic group). For the RT group, their 65% maximum strength was estimated using the 1-repetition maximum protocol (1RM). This protocol begins with a warm-up with a weight that is sufficiently light to allow at least 15 repetitions. The weight is then gradually increased on the basis of the participant's response.
until the subject can only perform one repetition, equivalent to 100% of their maximum strength. The test had a maximum of 6 series per muscle group, allowing a rest time of 3 minutes between each series in order to avoid excessive fatigue in the necessary zone.

The participants attended 3 sessions per week at the YMCA gym for a period of 6 weeks. The AT group warmed up for 10 minutes by walking, followed by 30 minutes continuous running and 10 minutes of warm-down. The RT group performed the 1x2x3 protocol (as many repetitions as possible during 1 minute, with 2 minutes rest, for 3 series)\(^2\). Eight separate muscle groups were worked: elbow flexors and extensors, wrist flexors and extensors, knee flexors and extensors, and ankle flexors and extensors. The length of the training periods for both groups was set at 50 minutes.

During the 12 weeks of the study, the participants were asked to maintain their normal habits regarding eating and physical activity. During the 6 weeks of training, no other type of exercise was carried out other than the session indicated in the study. For the period of 6 weeks of detraining, they were not allowed to perform any type of physical activity or training that could lead to bias in the results.

**Statistical analysis**

In order to determine the effect of the type of training and of the detraining, an ANOVA test was applied. When transferring the sphericity assumptions, the Geisser correction factor was applied. A Bonferroni test was used post hoc in all pair comparisons when a significant result was found. The variation scores of all measurements (pre-training, post-training and post-detraining) were also analysed. Finally, the size of the effect on each group was calculated (using Cohen’s d). The effect size was established in accordance with the following interpretation: trivial (0-0.19), small (0.20 to 0.49), medium (0.50 to 0.79) and large (0.80 and above)\(^\#\)

**Results**

Both the AT and the RT protocols led to positive changes after 6 weeks. The AT protocol saw significant improvements on almost all health indices, apart from HbA\(_{\text{1c}}\) and triglycerides. The RT group also saw significant changes in almost all indices, except for weight and BMI (Table I).

During the 6 weeks without physical training it can be seen that for the AT group the indices that had improved during the training period deteriorated significantly, apart from HDL-C which remained relatively low. It is important to note the results for HbA\(_{\text{1c}}\), which did not reduce significantly during the aerobic training but did rise significantly during the detraining period in comparison to the pre-training values (Table I).

For the RT protocol, several indices that had improved during training also deteriorated, though LDL-C remained low and HDL-C remained high. The pronounced increase in HbA\(_{\text{1c}}\) was not seen during detraining as was observed with the AT group (Table I).

With regard to effect size, Table II shows the values for Cohen’s d. Both groups followed the same trend, except for weight and BMI (positive values for the RT group, but a small effect with \(d < 0.2\)) and glycaemia and triglycerides (negative values for the RT group, but a small effect with \(d < -0.2\)).

**Discussion**

The results of this study are in agreement with the literature with regard to the importance of physical training as a non-pharmacological therapeutic tool,
It is also important to note that though glycaemia in a fasted state is significantly reduced with both protocols after 6 weeks of training, only the RT group was able to maintain the effect after stopping the exercise programme. A similar effect has been reported when combining aerobic and resistance exercise in the same training session. However, in the present study in the aerobic group not only did the values increase but they also went further than the values prior to training, which somewhat underlines the benefits to glycaemia of the 1x2x3 resistance training protocol used in the study.

The two study protocols were also seen to be effective at improving the lipid profile of the participants after training. The only marker that did not see significant improvement was triglycerides with the aerobic protocol. However, in general the results are in agreement with the literature on the benefits of regular physical exercise with regard to concentration levels of LDL-C, HDL-C, triglycerides and total cholesterol.

An interesting finding can be seen during the detraining period of the RT group. This type of training showed an important effect on maintaining high levels of HDL-C and maintaining reduced levels of LDL-C, despite fully stopping physical exercise. However, in another study that included a combination of aerobic and resistance exercise in the same session, the improvements in HDL-C and LDL-C levels were not maintained after 8 weeks of detraining. The differences in the training programmes (time, intensity, energy expenditure, etc.) make it very difficult to compare and analyse the differences between the results of the studies.

With regard to the levels of HbA1c, this index decreased with both protocols, as is well documented in the literature as an effect of a programme of physical exercise. However, only the RT group saw significant reductions. Another interesting aspect is that the values after the detraining period increased to levels above the reference values for both groups, though the

<table>
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<th>Calculations of effect size between groups (Cohen’s d) from pre-training, post-training and 6 weeks of detraining</th>
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<td><strong>Aerobic group</strong></td>
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<td><strong>Pre vs. Post</strong></td>
<td><strong>Post vs. detraining</strong></td>
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<td>Weight (Kg)</td>
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<tr>
<td>BMI (Kg·m⁻²)</td>
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<td>Total cholesterol (mg·dl⁻¹)</td>
<td>-0.28</td>
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<tr>
<td>LDL cholesterol (mg·dl⁻¹)</td>
<td>-0.36</td>
</tr>
<tr>
<td>HDL cholesterol (mg·dl⁻¹)</td>
<td>0.66</td>
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<tr>
<td>Triglycerides (mg·dl⁻¹)</td>
<td>-0.07</td>
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<td>Glycaemia (mg·dl⁻¹)</td>
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<tr>
<td>Glycosylated haemoglobin (%)</td>
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increase was only significant for the AT group, in a similar result to what was seen for glycaemia.

The results obtained in the present study show that resistance training fulfils an important function within a training plan. It has been documented that the combination of aerobic and resistance training generates an effect that may further enhance the effect on health in comparison to applying each training protocol separately. However, it should be noted that resistance training has different methodologies that can influence the results, such as the working intensity, number of repetitions, number of series, etc. For example, the good results obtained in the study by Sigal et al.

In addition to the factors described above, the variations seen in HDL-C and LDL-C may also be linked to the duration of the programme and mainly to weight loss, as documented in previous studies. In the case of HbA1c, there is no complete clarity as to how aerobic, resistance or a combined exercise protocol effects this index. However, the results obtained in the present study (decreases of 0.4 and 0.5% with aerobic and resistance training, respectively) are very similar to what was seen for glycaemia.

Finally, we can conclude that both the aerobic and the resistance training protocols are able to improve lipid profile, glycaemia in a fasted state and the level of HbA1c in persons with DMII. However, after 6 weeks of detraining, the RT protocol was shown to be more effective at maintaining the effects attained on HDL-C, LDL-C and HbA1c.

**Conflict of Interest**

None declared

**References**


