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# Effects of oats on lipid profile, insulin resistance and weight loss

Jessica Schuster[1], Gabriela Benincá[1], Renata Vitorazzi[1] and Simone Morelo Dal Bosco[1,2]

[1]*Centro de Ciências Biológicas e da Saúde, Centro Universitário UNIVATES.*[2]*Universidade Federal de Ciências da Saúde de Porto Alegre - UFCSPA, Brazil.*

**Abstract**

***Introduction:*** **cardiovascular diseases are the main cause of morbidity worldwide. Such prevalence justifies the importance of functional foods that promote cardiovascular health, like β-glucan present in oats, with potential hypocholesterolemic and hypoglycemic effects.**

***Objective:*** **to evaluate the effects of an intervention with oats in blood glucose levels, HOMA-IR index, lipid profile, weight and Body Mass Index (BMI) of adult users of a health service in the interior of Rio Grande do Sul, Brazil.**

***Methods:*** **longitudinal study, case-control type with before and after experiment, conducted with individuals that are 22-60 years old, users of a health service. The individuals were distributed in Control (usual diet) and Case (usual diet + 40 g oats/day) groups. There was performed, at the beginning of the study and after eight weeks of monitoring, measuring of height and weight, calculation of BMI (kg/m²), blood collection for measurement of fasting glucose, insulin, total cholesterol, triglycerides and HDL cholesterol; and there were calculated the LDL cholesterol and HOMA-IR index. The data was expressed as mean±standard deviation and percentages. The Kolmogorov-Smirnov test, Student t test, Mann-Whitney and Wilcoxon tests were applied. A significance level of 5% was adopted ($p<0.05$).**

***Results:*** **the sample consisted of 82 subjects, divided into cases (n=38) and controls (n=44), mean age 40.07±10.49 years old, 58.5% were women. Comparing the results of all measured parameters at baseline and after eight weeks of monitoring, the Control group did not achieve a significant reduction in any parameter, showing a significant increase in blood glucose and HOMA-IR ($p<0.05$). The Intervention group had a significant reduction of all anthropometric and biochemical parameters analyzed ($p<0.001$).**

***Conclusion:*** **the findings demonstrate the beneficial effects of oats to cardiovascular health through significantly improving of the lipid and glycemic profiles, being**

**Correspondence:** Simone Morelo Dal Bosco.
Universidade Federal de Ciências da Saúde de Porto Alegre RS.
Rua Sarmento Leite, 245- Porto Alegre Rs.
Rio Grande do Sul Brasil, Cep: 90050-170.
E-mail: simonedb@ufcspa.edu.br

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**EFECTOS DE LA AVENA SOBRE EL PERFIL LIPÍDICO, LA RESISTENCIA A LA INSULINA Y LA PÉRDIDA DE PESO**

**Resumen**

***Introducción:*** **las enfermedades cardiovasculares son la principal causa mundial de morbilidad y mortalidad. Esta prevalencia justifica la importancia de los alimentos funcionales que promueven la salud cardiovascular, como el β-glucano, presente en la avena, con potenciales efectos hipocolesterolémicos e hipoglucemiantes.**

***Objetivo:*** **evaluar los efectos de una intervención con la harina de avena en los niveles de glucosa en sangre, el índice HOMA-IR, el perfil de lípidos, el peso y el índice de masa corporal (IMC) de los usuarios adultos de un servicio de salud en Río Grande do Sul, Brasil.**

***Métodos:*** **estudio longitudinal, controlado, realizado con personas de 22-60 años de edad, usuarios de un servicio de salud. Los individuos fueron asignados al grupo control (dieta habitual) o grupo Case (dieta habitual + 40 g de avena/día). Al inicio del estudio y después de ocho semanas de seguimiento se evaluaron el peso y la altura, calculado IMC, la sangre recolectada para la medición de glucemia en ayunas, insulina, triglicéridos, colesterol total y colesterol HDL; y se calculó el colesterol LDL y el índice HOMA-IR. Los datos se expresan como media ± desviación estándar y porcentajes. Se aplicaron el test Kolmogorov-Smirnov, la t de Student, el test Mann-Whitney y las pruebas de Wilcoxon. Se adoptó un nivel de significación del 5% ($p<0,05$).**

***Resultados:*** **la muestra estuvo constituida por 82 sujetos, divididos en casos (n=38) y controles (n=44) con una edad media de 40,07±10,49 años, 58,5% mujeres. Comparando los resultados de todos los parámetros medidos al inicio del estudio y después de ocho semanas de seguimiento, el grupo de control no obtuvo una reducción significativa en ningún parámetro, mostrando un aumento significativo de la glucosa en sangre y HOMA-IR ($p<0,05$). El grupo de intervención obtuvo una reducción significativa de todos los indicadores antropométricos y bioquímicos analizados ($p<0,001$).**

***Conclusión:*** **los resultados demuestran los efectos beneficiosos de la avena para la salud cardiovascular, mejorando significativamente los perfiles de lípidos y la glu-**

**a potential adjuvant in the prevention and treatment of metabolic disorders.**

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Key words: *Oats. β-glucan. Cardiovascular diseases. Serum cholesterol. Glucose. Insulin. HOMA-IR.*

**cemia, por lo que constituye un adyuvante potencial en la prevención y tratamiento de los trastornos metabólicos.**

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Palabras clave: *Avena. β-glucano. Enfermedades cardiovasculares. Colesterol en sangre. Glucosa en sangre. Insulina. HOMA-IR.*

## Abbreviations

BMI: Body Mass Index.
WHO: World Health Organization.
CVD: Cardiovascular Diseases.
DM: Diabetes Mellitus.
LDL-c: LDL cholesterol.
TC: Total Cholesterol.
HDL-c: HDL cholesterol.
TG: Triglycerides.

## Introduction

According to data from the World Health Organization (WHO), Cardiovascular Disease (CVD) is the leading cause of death worldwide, accounting for 30% of global deaths, similar to the rate found in Brazil[1,2]. In Brazil, in 2007, CVD accounted for almost a third of all deaths and 65% of all deaths in the age group 30-69 years old, reaching the adult population in full production phase, indicating a public health problem of the population[2]. Besides of the increase of cardiovascular diseases, another pathology is also emphasized, Diabetes Mellitus (DM), whose prevalence is increasing because of the growth and aging of the population, greater urbanization, increasing prevalence of obesity, physical inactivity and increased survival of diabetic patients[3].

The need for functional foods that promote cardiovascular health, including cholesterol-lowering foods, is growing. A functional ingredient is oats, which contains β-glucan. The β-glucan is a highly viscous soluble fiber localized mainly in cell walls of endosperm oat[4]. It is an important component in food in modulating of metabolic deregulations associated with the metabolic syndrome. However, the dose the form, the molecular weight and the carrier of β-glucan in the body mold its effect.[5]. Soluble dietary fiber intake has been associated with the response to postprandial insulin. There has been demonstrated a meaningful decrease in the level of fasting blood glucose and a tendency to reduce the resistance to insulin in type 2 diabetics individuals. This has been observed with the use of 3 g/day of β-glucan present in oats (60 g of the product)[6].

Variations in the source, processing, treatment, manufacture of a product, and interactions with other constituents of food matrix affect the number, solubility, molecular weight and structure of β-glucan in products[7]. Studies with β-glucan identified that low doses like 2g (40g of oats), can cause acute reduction of blood, while others suggest that a minimum of 4g (80g of oats) might be necessary for other gastrointestinal effects, like those that cause the release of appetite hormones[8]. Several regulator organs have approved a health claim about the effects of cholesterol reduction of β-glucan oat levels of 3.0 g/day (60g oats)[9].

Cereal grains and whole grain products (rich in fibrous polymers) are excellent sources of many substances, classified among the biologically active compounds, such as dietary fiber (arabinoxylans, β-glucans, cellulose, lignin and lignans), sterols, tocopherols, phenolic acids, vitamins and microelements. Although the concentrations of these substances in food are generally small, they have attracted the attention of researchers because of their biological activities and positive impacts on human health[10].

Mello *et al.*[11] analyzed that convincing evidence from epidemiological studies support a role for food products based on whole grains and sources of insoluble fiber in the prevention of diabetes mellitus. Paradoxically, in postprandial studies, soluble fiber and not the insoluble promote a favorable effect on glucose metabolism and on insulin if administered in sufficient quantities. Results of studies of medium and long term about the role of dietary fiber in improving glucose and insulin metabolism in subjects with and without diabetes, are less conclusive.

In this context, the aim of this study was to evaluate the effects of an intervention with oats in blood glucose level, HOMA-IR index, lipid profile, weight and Body Mass Index of a sample of individuals from a health service in the interior of Rio Grande do Sul, Brazil.

## Methods

Experimental design study Case - Control with before and after. The sample size was calculated considering the monthly attendances done at the Basic Health Unit of a town in the countryside of Rio Grande do Sul. The sample consisted of 82 individuals of both genres, included by adhesion, and according to the baseline characteristics, divided into two groups: Cases (n=38) and Controls (n=44). Both groups were followed for eight weeks; the Control group was instructed to follow their usual diet, and Case (intervention) group was instructed to follow their usual diet plus 40g of oats a day, in thin flakes, Cerélus® brand.

The oats composition was verified according to the label, and the nutritional composition in 40g: 126 kcal, 26g carbohydrate, 5.6g protein, 0g fat, and 4g of fiber. For the fractionation of samples of oats there was used an explorer digital scale OHAUS® brand of maximum capacity of 15.000g. The oats was fractionated into plastic bags and each participant received a total of 2.400g. The patients were instructed to ingest 40g of oats daily, preferably at breakfast accompanying the food of the meal or snack with fruit or juice, or at lunch with the food.

Both groups were assessed at baseline and after the eight weeks of monitoring. There was verified weight (kg) and height (m), there was performed the calculating the Body Mass Index (BMI - kg/m$^2$), and blood collection for measurement of fasting glucose, insulin and serum lipoproteins. The HOMA-IR index was calculated from the data of glucose and insulin.

Weight and height were measured with anthropometric scale platform type, coupled with the stadiometer Welmy® brand; the maximum scale capacity of 150 kg and 100g division, and stadiometer with extension of 2 meters, divided into centimeters and subdivided in millimeters; the participant wore a mild coat and without wearing shoes, positioned in the center of the equipment, erect, feet placed together and arms along the body, the head in the Frankfurt plane, according to standards established by the Ministry of Health[12].

The BMI was calculated from measurements of weight and height according to the formula: $BMI = W/H^2$, where W is the weight in kilograms and the height in meters squared. The BMI cut-off points used were those recommended by the World Health Organization[13]: underweight BMI < 18.5 kg/m$^2$, normal weight BMI between 18.5 to 24.99 kg/m$^2$ and overweight and obesity BMI ≥ 30 kg/m$^2$.

The collection of 5 ml of peripheral venous blood was obtained in previously scheduled time; the participant fasted 8-12 hours. Sampling was conducted by trained researchers with fine needle to minimize discomfort. The researchers used disposable protective material to avoid any risk of contamination. The laboratory measurements were performed in a private laboratory in automated equipment, through the enzymatic kinetic method. The concentration of LDL cholesterol (LDL-c) was determined according to the Friedewald formula[14]: LDL-c = Total cholesterol - (HDL-c + triglycerides/5). The HOMA-IR was calculated by using the formula described by Matthews in 1985[15]: HOMA-IR = insulin ($\mu$U/ml) x Blood glucose (mmol/l)/22.5. For the interpretation of the results, there were used as reference the cutting points of the Brazilian Diabetes Society[16] and the Brazilian Society of Cardiology[17]; blood glucose < 100 mg/dL, total cholesterol (TC) < 200 mg/dL, LDL-c < 130 mg/dL, HDL cholesterol (HDL-c) desirable > 40 mg/dL for men and > 50 mg/dL for women and triglycerides (TG) < 150 mg/dL.

There were excluded all adults that were in drug treatment to reduce blood cholesterol levels, individuals diagnosed with chronic renal failure, hypothyroidism, people who were receiving enteral diet or those who refused to participate in the experiment. All participants were previously informed about the objectives and the research methodology, and signed the Informed Consent Form. This study was approved by the Ethics Committee in Research of UNIVATES, under protocol number 012009.

The data was analyzed by using the SPSS Statistics from IBM ®, version 20.0 software. The level of significance adopted was 5% ($p < 0.05$). Univariate descriptive statistics (mean, standard deviation, and frequency) and bivariate (Student t test for independent samples and for paired samples, Mann-Whitney and Wilcoxon) were performed. There was used the Kolmogorov-Smirnov test to assess if the variables followed a normal distribution. The variables with normal distribution were analyzed by Student's t test, and those that did not follow normal distribution were analyzed by using the non-parametric Mann-Whitney and Wilcoxon tests. The Student's t test for independent samples and its non-parametric equivalent (Mann-Whitney) were applied to compare the Case and Control groups at baseline and after the intervention in terms of anthropometric and biochemical variables. The Student's t test for paired samples and the Wilcoxon test (nonparametric equivalent) were applied to compare the individuals within each group separately, before and after the intervention.

## Results and discussion

The study included 82 individuals at a mean age of 40.07 ± 10.49 years old; 58.5% women. Of these, 45.1% have University degree, followed by 37.8% of secondary school (undergraduate or graduate high school). According to the baseline characteristics, the sample was divided into Cases (n = 38) and Controls (n = 44). At the beginning of the study, weight, BMI, TC, TG, HDL-c, LDL-c, glucose, insulin and HOMA-IR, were assessed; there was a significant difference between the groups for all variables except for the weight. The baseline results of the Case and Control groups are shown in table I.

In table II there are shown the anthropometric and biochemical results after the eight-week-follow-up period. The Case group had a reduction of all of the analyzed parameters, approaching the results of the Control group and decreasing the difference between the groups, and it remained significant only for BMI, TC, TG and LDL-c.

Comparing the results of all measured parameters at the beginning of the study and after eight weeks of follow-up, the Control group did not reduce significantly any parameter, showing significant increase in blood glucose and HOMA-IR. The Intervention group had a significant reduction of all anthropometric and biochemical indexes analyzed ($p < 0.001$). The results can be checked in table III.

**Table I**
*Anthropometric and biochemical characteristics of Case and Control groups in pre-intervention period*

| | Control Group [n 44] Average (DP) | Case Group [n 38] Average (DP) | P |
|---|---|---|---|
| Weight | 70,83 (10,66) | 73,88 (11,57) | 0,218 |
| BMI | 24,59 (2,39) | 26,86 (3,47) | 0,001 |
| TC | 168,57 (23,98) | 214,05 (25,62) | <0,001 |
| TG | 128,04 (17,53) | 147,92 (23,53) | <0,001 |
| HDL-c | 51,57 (9,17) | 46,08 (6,60) | 0,007 |
| LDL-c | 91,39 (27,93) | 138,39 (23,64) | <0,001 |
| Glycemia | 89,70 (10,34) | 105,58 (22,37) | <0,001 |
| Insulin | 11,73 (6,90) | 17,34 (10,37) | <0,001 |
| HOMA-IR | 2,63 (1,65) | 4,89 (4,14) | <0,001 |

SD = Standard Deviation; weight in kg; Body Mass Index (BMI) = weight in kg divided by height in meters squared. Rate of TC (total cholesterol); HDL-c (HDL cholesterol), LDL-c (LDL cholesterol), TG (triglycerides) and glucose described in mg/dL. Insulin μU/L. HOMA-IR = insulin ((μU/L) x glucose (nmol/L)/22.5. Student t test for independent samples for comparison between groups, considering significant $p < 0.05$ (5%).

**Table II**
*Anthropometric and biochemical characteristics of Case and Control groups after the intervention*

| | Control Group [n 44] Average (DP) | Case Group [n 38] Average (DP) | P |
|---|---|---|---|
| Weight | 70,40 (10,26) | 72,52 (11,01) | 0,374 |
| BMI | 24,45 (2,30) | 26,36 (3,24) | 0,004 |
| TC | 169,27 (24,47) | 188,45 (19,99) | <0,001 |
| TG | 128,16 (13,94) | 137,39 (15,70) | 0,001 |
| HDL-c | 50,70 (9,38) | 49,79 (6,11) | 0,989 |
| LDL-c | 92,93 (29,19) | 111,18 (20,41) | 0,001 |
| Glycemia | 90,77 (10,35) | 91,76 (13,80) | 0,889 |
| Insulin | 12,02 (6,88) | 12,76 (5,86) | 0,118 |
| HOMA-IR | 2,73 (1,67) | 3,00 (1,78) | 0,223 |

SD = Standard Deviation; weight in kg; Body Mass Index (BMI) = weight in kg divided by height in meters squared. Rate of TC (total cholesterol); HDL-c (HDL cholesterol), LDL-c (LDL cholesterol), TG (triglycerides) and glucose described in mg/dL. Insulin μU/L. HOMA-IR = insulin ((μU/L) x glucose (nmol/L)/22.5. Student t test for independent samples for comparison between groups, considering significant $p < 0.05$ (5%).

Similar to these findings, a recent clinical trial aimed to evaluate the effects of an intervention with oats. Individuals with BMI ≥ 27 kg/$m^2$ and aged between 18 and 65 years were randomly divided into a Control group (n = 18) and treated with oats (n = 16), while the Control group received placebo and the Intervention group received oats, for 12 weeks. The results showed that the use of oats promoted reduction of body weight and BMI, and more than 60% of the treated group reduced the amount of body fat. Liver function tests showed decreases in patients who consumed oats[18].

Another study evaluated patients with uncontrolled T2DM and insulin resistance, defined as a dose of more than 1UI/day/kg. The main outcomes were the daily insulin requirement and mean levels of blood glucose, which were evaluated before, after and 4 weeks after the intervention. Hospital environment and diet adapted to DM alone led to a better glycemic control (158 ± 47mg/dl). A two-day intervention of oats in the diet decreased even more the blood glucose (118 ± 37 mg/dl), $p < 0.05$. This was associated with a significant reduction of insulin dose by 42.5% (before: 145 ± 68.9 IU/day, after 83 ± 34.2 IU/day, $p < 0.001$) as well as a significant decrease (-26.4%, $p < 0.01$) of leptin levels. After the outpatient period of four weeks, the dose of insulin remained significantly decreased (83 ± 20.2 U/kg/day, $p < 0.01$). The glycemic control was comparable to the levels of glucose in the hospital environment[19]. Although this sample does not constitute of individuals with DM, important results have been ob-

**Table III**
*Comparison of anthropometric and biochemical parameters in Case and Control groups in pre and post intervention*

| | *Control Group [n 44]* | | |
|---|---|---|---|
| | *Baseline* | *Post-intervention* | *P* |
| Weight | 70,83 (10,66) | 70,40 (10,26) | 0,073 |
| BMI | 24,59 (2,39) | 24,45 (2,30) | 0,052 |
| TC | 168,57 (23,98) | 169,27 (24,47) | 0,354 |
| TG | 128,04 (17,53) | 128,16 (13,94) | 0,479 |
| HDL-c | 51,57 (9,17) | 50,70 (9,38) | 0,167 |
| LDL-c | 91,39 (27,93) | 92,93 (29,19) | 0,124 |
| Glycemia | 89,70 (10,34) | 90,77 (10,35) | 0,022 |
| Insulin | 11,73 (6,90) | 12,02 (6,88) | 0,077 |
| HOMA-IR | 2,63 (1,65) | 2,73 (1,67) | 0,025 |
| | *Case Group [n 38]* | | |
| | *Baseline* | *Post-intervention* | *P* |
| Peso | 73,88 (11,57) | 72,52 (11,01) | <0,001 |
| IMC | 26,86 (3,47) | 26,36 (3,24) | <0,001 |
| CT | 214,05 (25,62) | 188,45 (19,99) | <0,001 |
| TG | 147,92 (23,53) | 137,39 (15,70) | <0,001 |
| HDL-c | 46,08 (6,60) | 49,79 (6,11) | <0,001 |
| LDL-c | 138,39 (23,64) | 111,18 (20,41) | <0,001 |
| Glicemia | 105,58 (22,37) | 91,76 (13,80) | <0,001 |
| Insulin | 17,34 (10,37) | 12,76 (5,86) | <0,001 |
| HOMA-IR | 4,89 (4,14) | 3,00 (1,78) | <0,001 |

SD = Standard Deviation; weight in kg; Body Mass Index (BMI) = weight in kg divided by height in meters squared. Rate of TC (total cholesterol); HDL-c (HDL cholesterol), LDL-c (LDL cholesterol), TG (triglycerides) and glucose described in mg/dL. Insulin $\mu$U/L. HOMA-IR = insulin (($\mu$U/L) x glucose (nmol/L)/22.5. Student t test for independent samples for comparison between groups, considering significant $p<0.05$ (5%)

tained in the Intervention group regarding the reduction of blood glucose (-13.08%, $p<0.001$) and the degree of insulin resistance, measured indirectly through the HOMA index IR (-38.65%, $p<0.001$). At baseline, the Case group was classified in pre-diabetes, and after the intervention in normality.

Ibrügger and collaborators investigated the effects of three different sources of β-glucan incorporated in a drink and yoghurt on serum lipids and feces. There were four periods of three weeks of intervention: control of 3.3g/day of oats, barley, and barley genetically modified. The treatment did not cause changes in TC, LDL-c and HDL-c compared with the Control group; however, the use of 3.3 g/day of β-glucan in oats, in 3 weeks resulted in a greater reduction in these parameters compared to the Control group. Changes in the levels of LDL in the β-glucan treatments were not related to the structure of β-glucan. The reduction of TC was significantly higher after the treatment with β-glucan present in oats, in comparison with the control ($p=0.03$). The results do not fully support the hypocholesterolemic effects of β-glucan present in oats and barley. However, substantial differences compared to the baseline values suggest a potential effect of β-glucan from oats, probably due to its greater solubility and viscosity[20]. The fact that the sample of the above mentioned study is constituted by healthy adults may have influenced the less significant results after the intervention. In this study, the Case group was in pre-diabetes (blood glucose > 100 mg/dl and < 126 mg/dl) had TC and LDL-c elevated and TG at the limit. After the intervention, all parameters were found suitable.

A double-blind randomized study evaluated 75 hypercholesterolemic men and women who were randomly assigned to one of two treatments: consumption of oats or dextrose. The results showed that oats produced significant reduction in TC and LDL-c after the intervention, and the reduction of LDL-c was significantly higher than in the Control group who ingested dextrose[21], confirming the superior benefits of oats in lipid profile.

Given the increase of the incidence and prevalence of cardiovascular diseases, a recent systematic review included publications of the last eighteen years; from 13 studies included ten were developed with humans, assessing the effects of β-glucan from oat. Nine of the thirteen studies analyzed showed significant reduction in total cholesterol, twelve showed a reduction in LDL, four showed an increase in HDL-c, demonstrating the effectiveness of oats to the improvement of the lipid profile in humans and biological models[22].

A literature review of studies published between 1997 and 2010 showed that the intake of β-glucan from oats, in daily doses of at least 3g (60g of oats), reduces the levels of TC and LDL-c by 5-10% in normocholesterolemic or hypercholesterolemic individuals[4]. In this study, the change of lipid parameters was similar or even higher: there was a reduction of 7.12% in TG, 11.96% in TC, 19.66% in LDL-c, and increase of 7.45% of HDL-c in comparing the results of the group that received oats before and after the intervention.

## Conclusion

These findings demonstrate the beneficial effects of oats to the cardiovascular health through the significant improvement of the lipid profile, glucose, insulin resistance and weight reduction after eight weeks of intervention, constituting a potential adjuvant in the prevention and treatment of metabolic disorders.

## Declaration of ethics in research with human subjects

The authors state that this study followed all ethical principles for research on human beings, and it was approved by the Research Ethics Committee (UNIVATES), certified by the National Board of Health, under protocol number 012009, of Univates of RS. They also state compliance with the ethical standards according to the Declaration of Helsinki.

## Conflicts of interest

The authors declare they do not have any kind of conflict of interests.

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