

The Effect of a Novel Viscous Polysaccharide along with Lifestyle Changes on Short-Term Weight Loss and Associated Risk Factors in Overweight and Obese Adults: An Observational Retrospective Clinical Program Analysis

Michael R. Lyon, MD, and Ronald G. Reichert, ND

Abstract

BACKGROUND: Viscous soluble dietary fiber has been demonstrated to reduce postprandial glycemia and may promote satiety. PolyGlycoPlex® (PGX®) is a highly viscous polysaccharide manufactured by reacting glucomannan with other soluble polysaccharides using a proprietary process (EnviroSimplex®). The resulting polysaccharide (α -D-glucurono- α -D-manno- β -D-manno- β -D-glucan, α -L-gulurono- β -D-mannuronan, β -D-gluco- β -D-mannan, α -D-glucurono- α -D-manno- β -D-manno- β -D-gluco, α -L-gulurono- β -D-mannurono, β -D-gluco- β -D-mannan) is a novel entity with the highest viscosity and water-holding capacity of currently known fibers. **MATERIALS & METHODS:** A total of 29 sedentary overweight or obese adults (23 women; six men), ages 20–65 with a body mass index (BMI) range of 25 kg/m² to 36 kg/m² participated in a clinical weight-loss program. PGX (5 g) was consumed with 500 mL water, 5–10 minutes before each meal, 2–3 times daily for 14 weeks. **RESULTS:** Significant reductions were observed ($p < 0.05$) in weight (-5.79 ± 3.55 kg), waist circumference (-12.07 ± 5.56 cm), and percentage body fat ($-2.43 \pm 2.39\%$) compared to baseline values. In addition, subjects employing PGX had a significant reduction of 19.26 percent ($n=17$; $p < 0.05$) and 25.51 percent ($n=16$; $p < 0.05$) in total and LDL plasma cholesterol values, respectively, at the end of the study period. **CONCLUSION:** The consumption of PGX in concert with lifestyle modifications may be a useful strategy for weight loss in overweight and obese individuals.

(*Altern Med Rev* 2010;15(1):68-75)

Introduction

According to recent data published by the World Health Organization, obesity has reached global epidemic proportions, with more than one billion adults affected by this chronic disorder.¹ Coronary artery disease, stroke, insulin resistance, metabolic syndrome, type 2 diabetes, hypertension, and cancer are well known medical co-morbidities associated with excess body weight.² In addition, a recent epidemiological study confirmed that adult obesity is associated with a significant reduction in life expectancy. This study estimates that 40-year old male and female nonsmokers lose an average 7.1 and 5.8 years of life, respectively, due to obesity.³ A number of therapeutic interventions are available for the overweight/obese individual, including surgery, drug therapy, and lifestyle modifications such as diet and exercise.

The cornerstones of healthy weight management are changes in diet and exercise. Although the research relationship between diet and exercise has not been consistent,⁴ a recent systematic review suggests a positive association.⁵ The authors report that in overweight and obese individuals, diet (i.e., caloric restriction) in conjunction with exercise accounted for a significantly greater initial weight loss than diet intervention alone (-13 ± 9.6 kg versus -9.9 ± 9.6 kg, respectively). Moreover, those employing the combination therapy maintained a higher degree of weight loss (+20%) compared to those utilizing dietary measures alone after 12 months (-6.7 ± 8.3 versus -4.5 ± 11.3 kg, respectively).

Ronald G. Reichert, ND –
Director of scientific affairs,
Canadian Centre for
Functional Medicine,
Coquitlam, BC
Correspondence address:
1550 United Boulevard,
Coquitlam, BC, Canada
V3K 6Y2
Email: doctorreichert@
functionalmedicine.ca

Michael R. Lyon, MD –
Medical director, Canadian
Centre for Functional
Medicine, Coquitlam, BC;
adjunct professor, University
of British Columbia, Food,
Nutrition, and Health
Program, Vancouver, BC

Key words: viscous fiber, weight loss, obesity, BMI, metabolic syndrome, PGX

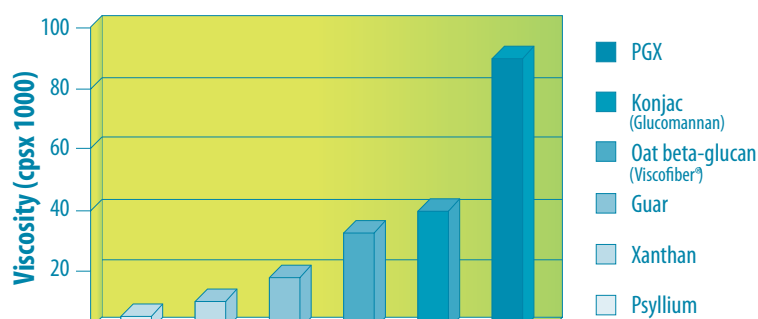
One weight control strategy is the intake of significant amounts of high-fiber foods, particularly foods or food supplements containing viscous soluble fiber.⁶ It is estimated the average U.S. citizen consumes 2.4 g of viscous soluble fiber daily – significantly less than the recommended 5-10 g of dietary viscous soluble fiber.⁷ Although the use of viscous dietary fiber has produced variable weight

may not be practicable for the population at large.

Due to the difficulty in obtaining ideal amounts of soluble fiber through diet alone, there is a need for soluble fiber concentrates that can be used as food ingredients or consumed as supplements to provide a consistently high intake of soluble fiber. Poly-GlycopleX® (PGX®) is a novel highly viscous polysaccharide (Figure 1) manufactured by reacting glucomannan with other soluble polysaccharides using a proprietary process (EnviroSimplex®). The resulting polysaccharide (α -D-glucurono- α -D-manno- β -D-manno- β -D-glucan, α -L-gulurono- β -D-mannuronan, β -D-glucosyl- β -D-mannan, α -D-glucurono- α -D-manno- β -D-manno- β -D-glucosyl, α -L-gulurono- β -D-mannurono, β -D-glucosyl- β -D-mannan) is a novel entity with the highest viscosity and water-holding capacity of currently known fibers.

A less viscous precursor to PGX has been investigated for its effects on insulin sensitivity,¹⁶ satiety,¹⁷ glucose control,¹⁸ and lipid modification,¹⁹ with positive effects in each case. While the full mechanism supporting the action of PGX has not yet been elucidated, its high viscosity and water-holding capacity presumably account for some of the effects seen on appetite and glycemic control. In a recent study, the intake of PGX decreased subsequent food intake compared to a medium-viscosity fiber (glucomannan) or a low-viscosity fiber (cellulose).²⁰ The volumetric effect of soluble fiber promotes a sense of fullness and satiety in direct proportion to the viscosity and water-holding capacity imparted to stomach contents by the fiber.²¹ The gel-like properties of viscous soluble fibers are thought to lower postprandial blood glucose and insulin levels by slowing gastric emptying and decreasing the absorption rate of carbohydrates.²² Viscous fiber may also impact satiety by promoting the secretion of anorexigenic gut peptide hormones such as cholecystokinin (CCK), peptide YY (PYY), and glucagon-like-peptide 1 (GLP-1).²³ In addition, the end-products of colonic fiber fermentation, including the short chain fatty acids (SCFAs) acetate, butyrate, and propionate, can impact glucose homeostasis through several mechanisms. SCFAs not only decrease hepatic glucose secretion and serum concentrations of free fatty acids, they also stimulate GLP-1.²² This retrospective 14-week analysis examines the efficacy of PGX and modest lifestyle modifications on weight loss, body mass index (BMI), and cardiometabolic risk factors, including plasma cholesterol, LDL cholesterol,

Figure 1. Viscosity of PGX Compared to Other Water-Soluble Polysaccharides after Hydrating for Three Hours



loss results,^{8,9} one such fiber – glucomannan from konjac root (*Amorphophallus konjac*) – has been shown to be helpful in weight reduction. In one study, glucomannan at a dose of 1,240 mg daily in conjunction with a 1,200-calorie per day diet resulted in a 3.8 ± 0.9 kg reduction in weight compared to 2.5 ± 0.5 kg decrease in the placebo group after five weeks of treatment.¹⁰ In addition to glucomannan, other sources of viscous soluble fiber include guar gum, psyllium, oat beta glucan, and barley beta glucan.

A substantial body of research suggests the aforementioned fibers can have a positive impact on diabetic glycemic control and cardiometabolic risk factors.¹¹⁻¹³ Moreover, there is significant evidence that those who follow a fiber-rich and plant-based diet (e.g., Portfolio diet) can substantially decrease both low-density lipoprotein (LDL) cholesterol (-29.6%) and blood pressure (-4.2 mmHg systolic and -2.3 mmHg diastolic).^{14,15} The “Portfolio diet” is a term coined by David Jenkins, MD, PhD, to describe how the combination of specific foodstuffs (i.e., soy, plant sterols, viscous fiber, nuts) act in concert to lower cardiovascular risk factors. Despite the Portfolio diet’s potential, consistent long-term compliance with a very high-fiber vegetarian diet

high-density lipoprotein (HDL) cholesterol, triglycerides, fasting insulin, fasting glucose, and glucose on a two-hour glucose tolerance test in overweight and obese adults.

Materials and Methods

Subjects

A total of 29 sedentary adults (23 women, six men), ages 20-65, with a BMI range of 25 kg/m² to 36 kg/m² were invited to participate through a series of advertisements placed in local newspapers. Subjects provided informed consent prior to participation. Individuals with type 2 diabetes, using tobacco, employing prescription or non-prescription weight-loss medications, using other weight-loss programs, pregnant or lactating, or having a BMI less than 25 kg/m² or greater than 36 kg/m² were not accepted into the program. The observational analysis was registered (ISRCTN50749194) at <http://www.controlled-trials.com> and was conducted in accordance with the ethical standards set forth in the Helsinki Declaration of 1975.

Anthropometric and other Measurements

Participants were evaluated on a bi-weekly basis for height (cm), weight (kg), and waist-hip measurements (cm) using a standard medical-type tape measure. Waist-hip measurements were taken at consistent anatomical locations approximately 2.2 cm above the navel and around the hip at the greater trochanter in subjects wearing a disposable paper gown. Percent body fat was determined using bioelectrical impedance testing (RJL Systems; Michigan, U.S.) at baseline and every two weeks thereafter. A computerized analysis of the impedance data was employed in order to determine BMI and percent body fat. Volunteers completed a self-report survey at week three and at the end of the PGX evaluation period, in which they rated whether the product curbed hunger and food cravings (i.e., very well, somewhat, not much, not much at all). In addition, general side effects were noted by each participant (i.e., flatulence, bloating, diarrhea, constipation) along with changes in bowel movements.

Diet and Supplementation

Each volunteer received general directions from a physician for healthy eating, weight loss, and exercise. Moreover, dietary and exercise counseling sessions were presented to the group every two weeks for 14 weeks. The emphasis in the lectures

was not calorie counting but rather the concepts of portion control and how to follow and maintain a low-fat, low-glycemic index diet. These recommendations included increasing vegetables, fruits, whole grains, and legumes, choosing low-fat items, and using lean proteins. In addition, suggestions were made regarding the benefits of meal planning and goal setting. General recommendations were also included, focusing on the variety, type, and timing of exercise (e.g., weight training, cardiovascular-aerobic training, and stretching) that would augment overall weight reduction. Subjects were provided PGX in granular form to add to water and instructed to consume 5 g in 500 mL water 5-10 minutes before each meal, 2-3 times daily for 14 weeks.

Blood Collection and Laboratory Biochemical Analysis

Laboratory measurements were performed by an independent laboratory in British Columbia, Canada. At baseline, subjects were asked to fast 10 hours before a blood draw procedure that included the following tests: plasma total cholesterol, triglycerides, HDL, LDL, glucose, insulin, and two-hour insulin. A 75-g oral glucose tolerance test was also performed according to the criteria and procedures determined by the laboratory. Those with aberrant risk factors were re-tested at week 14.

Statistical Analysis

A computerized statistical analysis was performed using the paired t-test to assess several variables including height, weight, BMI, percent body fat, and various laboratory values before and after treatment. Significant results were obtained in those variables that yielded a p value of <0.05.

Results

Weight Loss and other Anthropometric Parameters

During the 14 weeks of PGX use significant reductions in group weight (-5.79 ± 3.55 kg), waist measurements (-12.07 ± 5.56 cm), percent body fat (-2.43 ± 2.39 %), and BMI (-2.26 ± 1.24 kg/m²) were noted. Full results are seen in Tables 1A and 1B.

Similarly, and in concert with the group outcomes, both sexes demonstrated significant reductions in the tested weight loss variables. Men lost an average 8.30 ± 2.79 kg, while women lost 5.14 ± 3.49 kg over the 14-week study. Results for men are noted in Table 2A and for women in Table 2B.

Table 1A. Group 1: Men and Women Combined

Test	Sample Size	Week 0 Mean & SD	Week 14 Mean & SD	Change & SD	% Change
Weight (kg)	29	89.98 ± 14.43	84.19 ± 13.84	-5.79 ± 3.55	-6.44*
Waist (cm)	29	103.58 ± 12.78	91.51 ± 12.95	-12.07 ± 5.56	-11.65*
Hip (cm)	29	116.30 ± 7.67	106.83 ± 7.44	-9.47 ± 4.15	-8.14*
% Fat	29	40.30 ± 8.28	37.87 ± 8.88	-2.43 ± 2.39	-6.02*

*p<0.05 from week 0; SD=Standard deviation.

Table 1B. BMI for All Groups

Test	Sample Size	Week 0 Mean & SD	Week 14 Mean & SD	Change & SD	% Change
Male	6	35.03 ± 4.09	32.47 ± 3.78	-2.56 ± 1.22	-7.31*
Female	23	33.45 ± 7.57	31.27 ± 8.17	-2.18 ± 1.26	-6.52*
All	29	33.78 ± 6.96	31.52 ± 7.43	-2.26 ± 1.24	-6.70*

*p<0.05 from week 0; SD=Standard deviation; BMI in kg/m².

Table 2A. Group 1: Men (n=6)

Test	Week 0 Mean & SD	Week 14 Mean & SD	Change & SD	% Change
Weight (kg)	84.29 ± 7.85	79.15 ± 8.77	-5.14 ± 3.49	-6.00*
Waist (cm)	98.98 ± 8.99	87.55 ± 10.57	-11.43 ± 5.71	-12.00*
Hip (cm)	115.19 ± 6.73	105.92 ± 7.34	-9.27 ± 4.29	-8.00*
% Fat	43.88 ± 4.52	41.33 ± 6.15	-2.55 ± 2.63	-6.00*

* p<0.05 from week 0; SD=Standard deviation.

Table 2B. Group 2: Women (n=23)

Test	Week 0 Mean & SD	Week 14 Mean & SD	Change & SD	% Change
Weight (kg)	111.81 ± 9.18	103.51 ± 13.05	-8.30 ± 2.79	-7.43*
Waist (cm)	121.13 ± 9.65	106.63 ± 10.23	-14.50 ± 4.59	-12.00*
Hip (cm)	120.57 ± 7.62	110.36 ± 7.39	-10.21 ± 3.63	-8.00*
% Fat	26.58 ± 3.01	24.62 ± 2.97	-1.97 ± 1.15	-7.00*

* p<0.05 from week 0; SD=Standard deviation.

Lipid Levels

Compared to baseline values, subjects employing PGX had a significant reduction of 19.26 percent (n=17; p<0.05) and 25.51 percent (n=16; p<0.05) in plasma total and LDL-cholesterol values, respectively (Figure 2). Although a trend was noted toward a reduction in triglyceride and an increase in HDL-cholesterol values, the resulting changes were not statistically significant.

Fasting Plasma Insulin and Glucose

As a group and by the end of the study, participants employing PGX experienced a 6.96-percent reduction in fasting glucose (n=20; p<0.05), a 12.05-percent decline in glucose on the two-hour glucose tolerance test (n=21; p<0.05), and a 27.26-percent reduction in fasting insulin levels (n=17; p<0.05) compared to baseline (Figure 3). The decrease in two-hour insulin was not statistically significant.

Table 3 summarizes the overall laboratory data obtained during the 14-week trial.

Analysis of Efficacy using a Self-reporting Survey

In a self-reporting survey completed by the participants at the end of the study, 97.7 percent of PGX users noted a positive response to the product both in curbing food cravings and hunger.

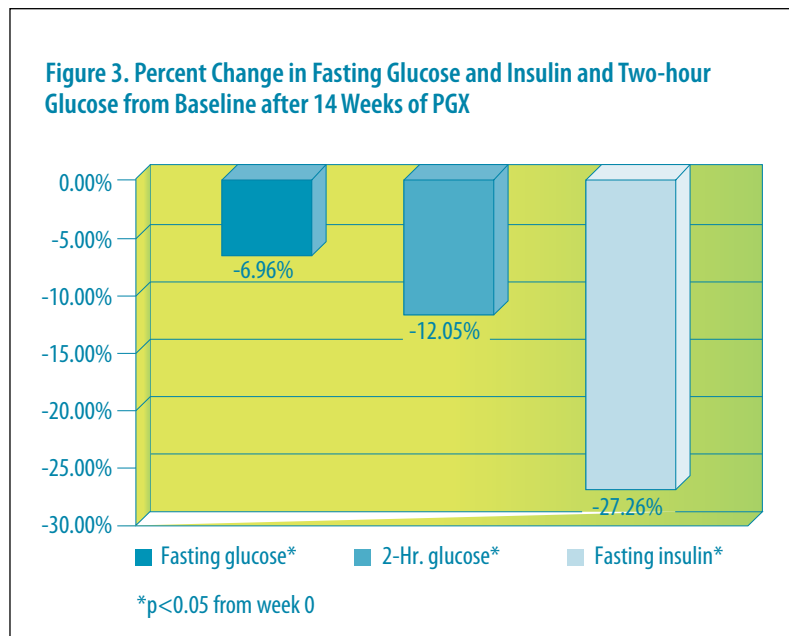
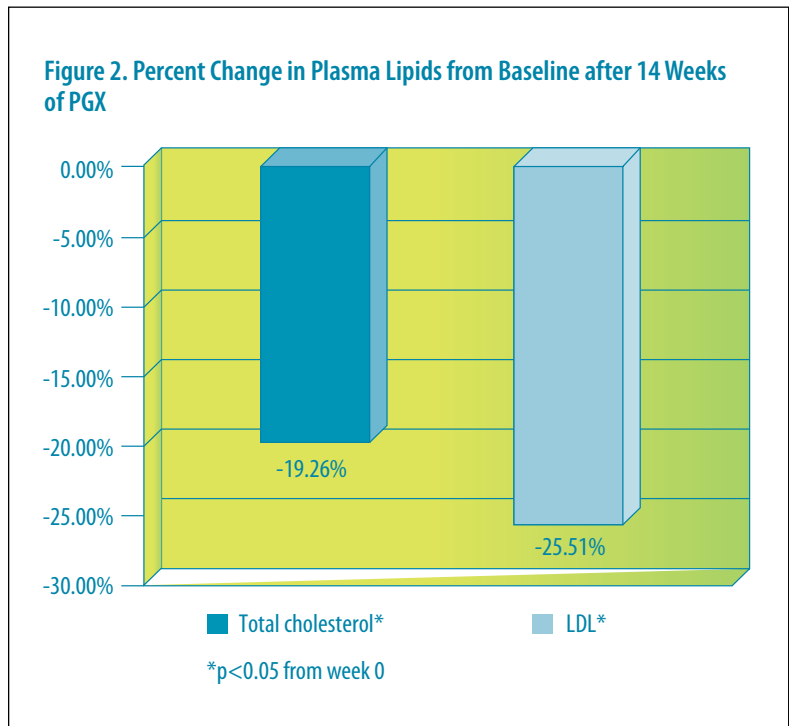
Side Effects of the Test Preparation

The test substance was generally well tolerated by the participants, with minor gastrointestinal (GI) symptoms comprising the majority of reported complaints. Sixty-eight percent noted mild GI symptoms (e.g., gas, bloating, constipation, loose stools) resolved within approximately three weeks of beginning the study. Thirty-two percent of participants experienced mild GI side effects throughout the study, but not sufficient in severity to discontinue use. A recent controlled study of PGX tolerance conducted in France confirmed the latter findings.²⁴

Discussion

Retrospective analysis of this medically supervised weight-loss program demonstrates the use of PGX with general changes in diet and physical activity over a 14-week period was of benefit in modifying cardiometabolic risk factors in overweight and obese subjects.

Overall, there was a significant reduction in group weight (-5.79 ± 3.55 kg), waist



measurements (-12.07 ± 5.56 cm), and percent body fat (-2.43 ± 2.39%) from baseline. Moreover, these latter physical changes were paralleled by a significant decrease in fasting plasma LDL (-25.51%), fasting glucose (-6.96%), and fasting insulin (-27.26%) levels over 14 weeks.

Some of the trends observed in this study have been recently corroborated by Kramer et al.²⁵ In this study, 42 overweight men and women

Table 3. Laboratory Data Analysis, Group Results

Test	Sample Size	Week 0 Mean & SD	Week 14 Mean & SD	Change & SD	% Change
*Total cholesterol (mmol/L)	17	5.69 ± 1.07	4.60 ± 0.82	-1.09 ± 0.63	-19.26
**Triglycerides (mmol/L)	17	1.92 ± 0.98	1.52 ± 0.56	-0.40 ± 0.89	-20.97
**HDL (mmol/L)	17	1.48 ± 0.53	1.53 ± 0.77	0.05 ± 0.67	3.33
*LDL (mmol/L)	16	3.40 ± 0.96	2.53 ± 0.64	-0.87 ± 0.56	-25.51
*Fasting glucose (mmol/L)	20	5.75 ± 0.78	5.34 ± 0.49	-0.40 ± 0.65	-6.96
*2 hr Glucose (mmol/L)	21	6.09 ± 2.10	5.35 ± 1.81	-0.73 ± 1.43	-12.05
*Fasting insulin (pmol/L)	17	89.41 ± 44.84	65.04 ± 33.21	-24.37 ± 36.29	-27.26
**2-hr. Insulin (pmol/L)	17	433.53 ± 270.32	355.76 ± 332.44	-77.76 ± 196.51	-17.94

* $p < 0.05$ from week 0; **NS (non-significant) from baseline; SD=Standard deviation.

(BMI > 25 kg/m²) were assigned to one of two groups: diet, glucomannan, and no exercise or diet, glucomannan, and exercise for an eight-week period. The volunteers in both groups ingested 1,500 mg glucomannan plus 237 mL water five minutes before their largest meals twice daily. After two months both the non-exercise and exercise groups had significant reductions in body mass (men -2.7 ± 1.4 kg; -3.0 ± 4 kg, respectively; women -2.2 ± 1.5 kg; -3.3 ± 1.5 kg, respectively), total cholesterol (men -17.9 ± 21.5 mg/dL; -18.8 ± 19.4 mg/dL, respectively; women -9.3 ± 20 mg/dL; -10.1 ± 19.5 mg/dL, respectively), and LDL cholesterol (men -16.1 ± 1.5 mg/dL; -15.2 ± 3 mg/dL, respectively; women -6.9 ± 8.4 mg/dL; -13.6 ± 8.4 mg/dL, respectively). The current PGX study demonstrated higher weight loss values, likely due to the fact that PGX is significantly more viscous than glucomannan and was employed at higher therapeutic levels over a longer period of time.

Other viscous, gel-forming fibers such as guar gum have been employed successfully in reducing cardiovascular risk factors in the obese.²⁶ However, studies of soluble fiber mixtures for reduction in body weight have to date provided mixed results. One research team determined the additional use of guar gum, or guar gum and alginate combined with glucomannan, did not stimulate additional reductions in weight compared to the use of glucomannan alone.¹⁰ In contrast, a recent controlled trial concluded that a combination of 3 g psyllium (*Plantago ovata*) and 1 g glucomannan at low dose (twice daily) or high dose (three times

daily) resulted in significant reductions in weight (-4.52 and -4.60 kg, respectively) and LDL-cholesterol levels (-0.38 and -0.24 mmol/L, respectively) compared to placebo over a 16-week period.²⁷ However, in the present study, individuals consuming PGX experienced a significant and greater reduction in weight (-5.79 ± 3.55 kg). In addition, it is interesting to note that men lost more weight on average (-8.30 ± 2.79 kg) than women (-5.14 ± 3.49 kg). This change could be attributed to basic sex differences seen in resting energy expenditure. Ferraro et al demonstrated the sedentary 24-hour energy expenditure is 5-10 percent lower in women compared to men after statistical adjustments for age, activity, and body composition.²⁸

The results obtained by PGX in reducing body weight (-5.79 kg) are comparable to those demonstrated in studies of individuals taking the anti-obesity medication orlistat (Xenical®, Alli®). Orlistat is a lipase inhibitor that reduces the absorption of fat.²⁹ In a controlled study, 391 mild-to-moderately overweight individuals who employed the drug orlistat at a dose of 60 mg three times daily for 16 weeks lost 3.05 kg, compared to 1.90 kg in the placebo group.³⁰ Whether or not the short-term weight loss achieved with lifestyle changes and PGX would remain stable over a one-year period or longer must be ascertained by longer-term controlled investigations.

PGX use also resulted in the reduction of other risk factors associated with mild-to-moderate obesity. After 14 weeks of PGX therapy a

significant reduction of plasma total (-19.26%; -1.09 mmol/L) and LDL (-25.51%; -0.87 mmol/L) cholesterol levels was demonstrated compared to baseline values ($p < 0.05$). The reduction in lipid values is comparable to the use of early generation statin drugs like lovastatin (Mevacor®). For example, one study noted that within one month of beginning lovastatin therapy, total and LDL cholesterol were decreased by 19 percent and 27 percent, respectively, in those with elevated cholesterol levels.³¹

While the use of PGX decreases blood lipid levels, it also may positively influence signs of metabolic syndrome, a collection of clinical conditions including visceral obesity, high serum glucose and insulin levels, hypertension, and dyslipidemia.³² Research has shown those who have metabolic syndrome have a 50-percent greater risk of experiencing a major coronary event.³³ As such, reductions in weight, fasting insulin, and glucose would confer significant health benefits on such individuals. A recent study suggests wheat-fiber powder may be superior to a standard high-fiber diet in patients with metabolic syndrome. While both the high-fiber and wheat-fiber powder groups lost weight (-1 kg) over five weeks, those who employed the wheat-fiber powder had significant reductions in blood pressure, fasting glucose, glucose on two-hour oral glucose challenge, total cholesterol, and LDL cholesterol. No significant reductions in insulin levels were reported.³⁴ Unlike this latter study, fasting insulin levels decreased from 89.41 ± 44.84 pmol/L to 65.04 ± 33.21 pmol/L ($p < 0.05$) in this current study. The reduction in fasting insulin likely reflects improved insulin sensitivity and may be due in part to increased GLP-1 activity and decreased postprandial hyperglycemia, along with the improvement in insulin sensitivity that accompanies weight loss.³⁵

These findings suggest the use of PGX in concert with lifestyle modifications may be of practical benefit to obese

individuals with certain cardiometabolic risk factors. Unlike standard medical interventions (e.g., bariatric surgery, obesity pharmacotherapy) to treat obesity and elevated cholesterol levels, PGX is associated with minimal side effects. This safety profile and apparent therapeutic efficacy suggest PGX should be considered for individuals who are overweight/obese, have elevated cholesterol levels, and are insulin resistant. Given these significant preliminary outcomes, a placebo-controlled trial is warranted using PGX.

Acknowledgment

The efforts of Ms. Tracey Wood, whose support and organizational expertise were invaluable during the completion of this study, are appreciated. PGX®, PolyGlycopleX®, and EnviroSimplex® are registered trademarks of InovoBiologic, Inc., Calgary, AB, Canada. All other trademarks belong to their respective owners. The authors received financial support from InovoBiologic, Inc., or its parent company for the preparation of this manuscript.

References

1. <http://www.who.int/mediacentre/factsheets/fs311/en/index.html> [Accessed January 29, 2010]
2. Fujioka K. Management of obesity as a chronic disease: nonpharmacologic, pharmacologic, and surgical options. *Obesity Res* 2002;10:116S-123S.
3. Peeters A, Barendregt JJ, Willekens F, et al. Obesity in adulthood and its consequences for life expectancy: a life-table analysis. *Ann Intern Med* 2003;138:24-32.
4. Skender ML, Goodrick GK, Del Junco DJ, et al. Comparison of 2-year weight loss trends in behavioral treatments of obesity: diet, exercise, and combination interventions. *J Am Diet Assoc* 1996;96:342-346.
5. Curioni CC, Lourenço PM. Long-term weight loss after diet and exercise: a systematic review. *Int J Obes (Lond)* 2005;29:1168-1174.
6. Queenan KM, Stewart ML, Smith KN, et al. Concentrated oat beta-glucan, a fermentable fiber, lowers serum cholesterol in hypercholesterolemic adults in a randomized controlled trial. *Nutr J* 2007;6:6.
7. Shamliyan TA, Jacobs DR Jr, Raatz SK, et al. Are your patients with risk of CVD getting the viscous soluble fiber they need? *J Fam Pract* 2006;55:761-769.
8. Pittler MH, Ernst E. Guar gum for body weight reduction: meta-analysis of randomized trials. *Am J Med* 2001;110:724-730.
9. Keithley J, Swanson B. Glucomannan and obesity: a critical review. *Altern Ther Health Med* 2005;11:30-34.
10. Birketvedt GS, Shimshi M, Erling T, Florholmen J. Experiences with three different fiber supplements in weight reduction. *Med Sci Monit* 2005;11:PI5-P18.
11. Rodríguez-Morán M, Guerrero-Romero F, Lazcano-Burciaga G. Lipid- and glucose-lowering efficacy of Plantago psyllium in type II diabetes. *J Diabetes Complications* 1998;12:273-278.
12. Keenan JM, Goulson M, Shamliyan T, et al. The effects of concentrated barley beta-glucan on blood lipids in a population of hypercholesterolaemic men and women. *Br J Nutr* 2007;97:1162-1168.
13. Reyna-Villasmil N, Bermúdez-Pirela V, Mengual-Moreno E, et al. Oat-derived beta-glucan significantly improves HDLC and diminishes LDLC and non-HDL cholesterol in overweight individuals with mild hypercholesterolemia. *Am J Ther* 2007;14:203-212.
14. Jenkins DJ, Kendall CW, Faulkner DA, et al. Long-term effects of a plant-based dietary portfolio of cholesterol-lowering foods on blood pressure. *Eur J Clin Nutr* 2008;62:781-788.
15. Jenkins DJ, Kendall CW, Marchie A, et al. Direct comparison of a dietary portfolio of cholesterol-lowering foods with a statin in hypercholesterolemic participants. *Am J Clin Nutr* 2005;81:380-387.

16. Vuksan V, Lyon M, Breitman P, Sievenpiper J. 3-week consumption of a highly viscous dietary fibre blend results in improvements in insulin sensitivity and reductions in body fat: results of a double-blind, placebo controlled trial. Presented at the 64th Annual Meeting of the American Diabetes Association. Orlando, Florida; June 4-8, 2004.
17. Breitman P, Vuksan V, Lyon M, et al. Impact of meal replacement viscosity on appetite and ad libitum food consumption in normal weight adolescents. Presented at the 8th Annual Canadian Diabetes Association (CDA)/Canadian Society of Endocrinology and Metabolism (CSEM) Professional Conference. Quebec City, Quebec; October 27-30, 2004.
18. Vuksan V, Jenkins DJ, Spadafora P, et al. Konjac-mannan (glucomannan) improves glycemia and other associated risk factors for coronary heart disease in type 2 diabetes. A randomized controlled metabolic trial. *Diabetes Care* 1999;22:913-919.
19. Rogovik A, Jenkins AL, Breitman P, Vuksan V. A blend of highly viscous polysaccharides decreases relative CVD risk in healthy individuals and those with diabetes and metabolic syndrome. Presented at the Natural Health Product Research Conference. Toronto, ON; March 3-5, 2006.
20. Vuksan V, Panahi S, Lyon M, et al. Viscosity of fiber preloads affects food intake in adolescents. *Nutr Metab Cardiovasc Dis* 2009;19:498-503.
21. Hoad CL, Rayment P, Spiller RC, et al. *In vivo* imaging of intragastric gelation and its effect on satiety in humans. *J Nutr* 2004;134:2293-2300.
22. Pereira MA, Ludwig DS. Dietary fiber and body-weight regulation. Observations and mechanisms. *Pediatr Clin North Am* 2001;48:969-980.
23. Juvonen KR, Purhonen AK, Salmenkallio-Marttila M, et al. Viscosity of oat bran-enriched beverages influences gastrointestinal hormonal responses in healthy humans. *J Nutr* 2009;139:461-466.
24. Carabin IG, Lyon MR, Wood S, et al. Supplementation of the diet with the functional fiber PolyGlycopleX® is well tolerated by healthy subjects in a clinical trial. *Nutr J* 2009;8:9.
25. Kraemer WJ, Vingren JL, Silvestre R, et al. Effect of adding exercise to a diet containing glucomannan. *Metabolism* 2007;56:1149-1158.
26. Krotkiewski M. Effect of guar gum on body-weight, hunger ratings and metabolism in obese subjects. *Br J Nutr* 1984;52:97-105.
27. Salas-Salvadó J, Farrés X, Luque X, et al. Effect of two doses of a mixture of soluble fibres on body weight and metabolic variables in overweight or obese patients: a randomised trial. *Br J Nutr* 2008;99:1380-1387.
28. Ferraro R, Lillioja S, Fontvieille AM, et al. Lower sedentary metabolic rate in women compared with men. *J Clin Invest* 1992;90:780-784.
29. Dixon JB. Weight loss medications – where do they fit in? *Aust Fam Physician* 2006;35:576-579.
30. Anderson JW, Schwartz SM, Hauptman J, et al. Low-dose orlistat effects on body weight of mildly to moderately overweight individuals: a 16 week, double-blind, placebo-controlled trial. *Ann Pharmacother* 2006;40:1717-1723.
31. Kannel WB, D'Agostino RB, Stepanians M, D'Agostino LC. Efficacy and tolerability of lovastatin in a six-month study: analysis by gender, age and hypertensive status. *Am J Cardiol* 1990;66:1B-10B.
32. Gallagher EJ, LeRoith D, Karnieli E. The metabolic syndrome – from insulin resistance to obesity and diabetes. *Endocrinol Metab Clin North Am* 2008;37:559-579.
33. Moller DE, Kaufman KD. Metabolic syndrome: a clinical and molecular perspective. *Annu Rev Med* 2005;56:45-62.
34. Šabovič M, Lavre S, Keber I. Supplementation of wheat fibre can improve risk profile in patients with dysmetabolic cardiovascular syndrome. *Eur J Cardiovasc Prev Rehabil* 2004;11:144-148.
35. Reaven G, Abbasi F, McLaughlin T. Obesity, insulin resistance, and cardiovascular disease. *Recent Prog Horm Res* 2004;59:207-223.