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Oatmeal Diet Days May Improve Insulin Resistance in Patients with Type 2 Diabetes Mellitus

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Schlüsselwörter
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Introduction

The prevalence of type 2 diabetes mellitus is increasing like in no other disease. In Germany, about 7.2% of the population already suffers from type 2 diabetes mellitus [1]. In the region around Augsburg, 16% of the 55- to 74-year-olds suffer from type 2 diabetes mellitus [2]. There is almost no other disease in which lifestyle modifications appear to have as many primary and secondary prophylactic effects as in diabetes. Diet is of course one of the most important aspects among lifestyle modifications. By the second half of the 20th century, oatmeal diet was part of the clinical routine in the treatment of diabetics with hyperglycemia, however over time this practice has later become increasingly forgotten. A small study [3] involving 14 patients showed that 2 so-called oatmeal diet days for type 2 diabetics with severe insulin resistance (IR) reduced the required insulin dosage significantly, whereby at the same time this also improved their blood glucose levels. This positive effect continued for up to 4 weeks. Interestingly, levels of adiponectin, a protective adipokine, increased significantly in the 4-week follow-up. The exact pathophysiological mechanisms are still unclear and there is, to our knowledge, a lack of data regarding the effects on any therapeutic response.

Since 2007, 50 patients with type 2 diabetes and a high insulin requirement (usually >100 international units of insulin (IU) per day) underwent a 2-day oatmeal diet at our department of diabetology (approved by the German Diabetes Association, DDG). In daily clinical practice, treatment of such patients is often frustrating, since escalation of insulin doses often simultaneously leads to rising blood glucose levels.

The present study shows the results of a retrospective evaluation of 50 patients with type 2 diabetes who were treated consecutively in order to achieve a reduction in their required dose of insulin. At the same time, it was aimed to improve their blood glucose control. The objective of this evaluation was to assess treatment feasibility in clinical routine as well as effectiveness of the treatment. We also examined parameters which may have an impact on therapy response.

Patients and Methods

From May 2010 to July 2012, 50 patients with type 2 diabetes mellitus and severe insulin resistance (DM-2-IR), who had been admitted to the ward for therapy optimization, were treated consecutively after they had given their consent. The patients were obese (body mass index (BMI) 38.5 kg/m^2, standard deviation (SD) 7.6), and their diabetes had been poorly controlled (HbA1c 9.6%, SD 1.7).

The only exclusion criterion was a recognized intolerance or aversion of the patient against oats. The following parameters were determined prior to the beginning of treatment: mean blood glucose concentration (MBG, average of the blood sugar levels measured preprandial before the 3 main meals and at bedtime), daily insulin requirement (sum of all insulin applications over 24 h in IU), weight, height, BMI, lipid profile,

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time since diagnosis, presence of obstructive sleep apnea (OSA) as well as HbA1c. The intervention started usually on day 2 after admission. During the intervention participants were offered 4 carbohydrate units (e.g., 80 g) of wholegrain oat flakes cooked and seasoned in water or stock together with raw cucumber or turnip for their 3 main meals on 2 consecutive days. Other food or glucose-containing beverages were not allowed. Before as well as after the 2-day treatment, the patients could choose between 3 standard menus provided by the hospital. The insulin doses during and after the treatment were adjusted according to blood glucose levels with a target range of about 140 mg/dl.

The MBG and the daily insulin requirement were recorded up to the third day following the 2-day intervention. Since the intervention was a routine treatment in the clinical setting, the type of insulin (immediate- and slow-acting insulin, manufacturer, etc.) varied according to the prior outpatient prescriptions.

In order to assess the approximate level of insulin sensitivity (IS), we calculated the logarithm of the product of the daily insulin requirement (IU) and MBG (mg/dl); a high level represents a low IS. Patients who achieved an insulin reduction of >20% were classified as responders. Statistics were performed using SPSS Inc., version 20. After testing for normal distribution (Kolmogorov-Smirnov test), the paired student t test was used to compare between pre and post interventional data.

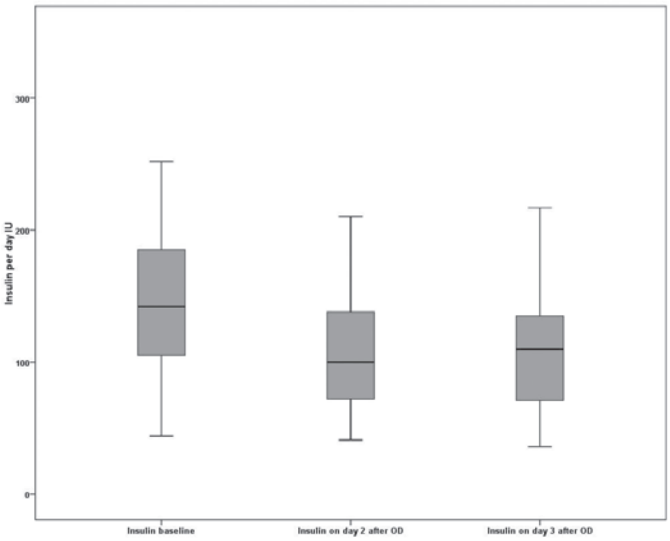

Fig. 1. The boxes indicate the daily insulin doses (IU) at baseline, on day 2, and on day 3 following the 2-day oatmeal diet (OD; day 2: $t = 5.78$; $p < 0.001$, day 3: $t = 3.7$; $p = 0.001$).

Results

In the observation period, a total of 50 patients were treated with the 2 oatmeal diet days intervention (26 female, 24 male, mean age 64.9, SD 10.15). 5 patients were discharged on the third day after intervention. Thus the data of all 50 patients could be evaluated up to the second day after intervention and that of 45 patients up to day 3 post treatment. Clinical and paraclinical parameters are shown in table 1. The mean daily insulin requirement prior to the intervention was 151.1 IU (SD 54.05) and has decreased to 104.3 IU (SD 46.5) 2 days after the intervention; down by around 31% ($t = 5.78$; $p < 0.001$). 3 days after intervention, the value rose to 114.52 IU (SD 63.8), still showing a reduction of 24.2% compared to the baseline value ($t = 3.7$; $p = 0.001$), (table 2, fig. 1). The MBG prior to the intervention was 192.8 mg/dl (SD 58.3); 2 days after the intervention it decreased to 173.4 mg/dl (SD

Table 1. Clinical and paraclinical parameters at baseline

	Mean	SD
Age, years	64.9	10.15
Height, cm	171.7	8.63
Weight, kg	111.6	21.39
BMI, kg/m^2	38.7	7.54
Time since diagnosis, years	18.4	9.09
HbA1c, %	9.6	1.70
Triglyceride, mg/dl	298.5	144.72
Total cholesterol, mg/dl	190.7	38.95
HDL, mg/dl	43.5	8.44
LDL, mg/dl	95.0	40.17

SD = standard deviation; BMI = body mass index; HbA1c = glycated hemoglobin; HDL = high-density lipoprotein; LDL = low-density lipoprotein.

Table 2. Mean blood glucose concentration (average of the blood glucose levels measured prior to all 3 main meals and at bedtime) and the daily insulin requirement (sum of all insulin applications over 24 h) at baseline and on the days indicated

	Mean	SD	t	p
MBG at baseline, mg/dl	192.8	58.29	–	–
MBG on day 1 of OD, mg/dl	160.2	42.87	5.35	< 0.001
MBG on day 2 of OD, mg/dl	149.1	33.96	5.61	< 0.001
MBG on day 2 after OD, mg/dl	173.4	39.68	2.10	0.041
MBG on day 3 after OD, mg/dl	167.3	47.32	2.72	0.009
Insulin at baseline, IU/d	151.1	54.05	–	–
Insulin on day 1 of OD, IU/d	106.2	39.26	7.14	< 0.001
Insulin on day 2 of OD, IU/d	77.6	33.35	10.13	< 0.001
Insulin on day 2 after OD, IU/d	104.3	46.53	5.79	< 0.001
Insulin on day 3 after OD, IU/d	114.5	63.77	3.70	0.001

SD = standard deviation; t = paired student t-test (to calculate changes to baseline); MBG = mean blood glucose concentration; OD = oat diet; IU = international unit of insulin.

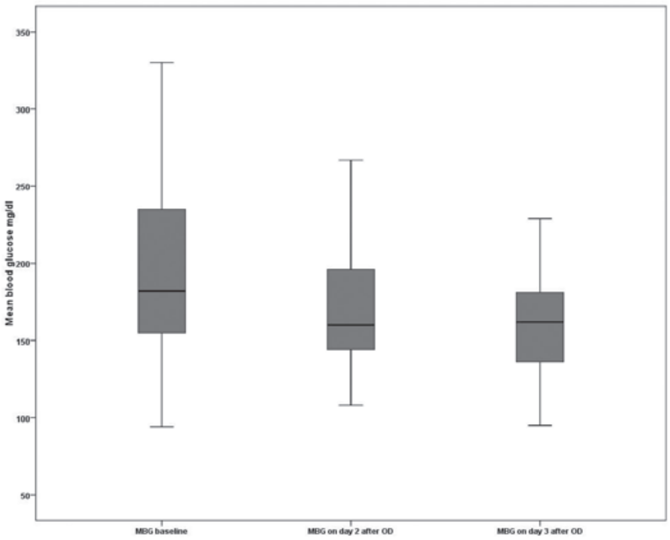

Fig. 2. The boxes indicate changes in mean blood glucose (MBG) at baseline, on day 2, and on day 3 following the 2-day oatmeal diet (OD; day 2: t = 2.1; p = 0.041, day 3: t = 2.72; p = 0.009).

39.7), down by 10% (t = 2.1; p = 0.041). 3 days after the intervention, the MBG further decreased to 167.3 mg/dl (SD 47.3), down by 13.2% (t = 2.72; p = 0.009; table 2, fig. 2).

The IS improved from 4.42 (SD 0.2) to 4.2 (SD 0.24; t = 7.4; p < 0.001) on day 2 after intervention. On day 3, the IS improved to 4.22 (SD 0.29) compared to the baseline level (t = 6.23; p < 0.001; all paired student t test). 32% of patients suffered from OSA. Linear regression showed no obvious connection between the tested factors BMI, HbA1c, time since diagnosis, OSA, and triglycerides and the change in IS. In 62% of the patients it was possible to reduce the insulin dose required at baseline by more than 20% (responders). The feasibility of the treatment proved to be very good.

Discussion

There are, as yet, few data with only small study populations [3] on the effectiveness and feasibility of acute treatment using oatmeal diet for severe IR amongst patients with type 2 diabetes mellitus. The present retrospective analysis evaluated the routine administration of an oatmeal diet over 2 days in a group of 50 patients with DM-2-IR. The intervention led to a clear improvement in median IS, and in 62% of the patients it was possible to lower the insulin dosage required by more than 20%. Feasibility proved to be good, and no undesired side effects were observed.

The investigation of a possible link between increased plasma insulin levels and cardiovascular disease showed controversial results [4]; recent studies showed an increased incidence of cancer with hyperinsulinemia [5] as well as increased overall mortality [6]. Since high levels of insulin are also associated with weight gain [7], reduction of the insulin dosage therefore appears to be desirable in many respects.

The high proportion of soluble fiber in oats, especially beta-glucans, causes an increased viscosity in the small intestine. This leads to a slowdown in digestion and absorption of starches, lipids, and proteins as well as their metabolites [8], a low glycemic index [9], a lipid-lowering effect (especially for LDL) [10], an increased excretion of bile acids, and a rapid saturation.

The oatmeal diet might have a positive effect on intestinal flora (microbiota), e.g., a higher proportion of lactobacilli and bifidobacteria could be shown after in vitro shake-flask anaerobic fermentations in human fecal cultures [11].

Insights into the interaction of the intestinal flora with obesity, diabetes, and IR have rapidly grown in recent years. Animal experiments have shown that the intestinal flora not only differs between obese mice and mice with normal weight. A transplantation of feces from obese mice to normal weight germ-free mice led to a significant weight gain under otherwise identical conditions [12, 13]. Meanwhile, results of large sequence studies on the intestinal flora, including those on diabetics, are available. After bariatric surgery in patients with morbid obesity and diabetes, the intestinal flora had changed significantly after 3 months. Compared to baseline values, the density of *Faecalibacterium prausnitzii* had decreased significantly; this correlated directly with the fasting blood glucose measured in the morning [14].

One characteristic feature of the intestinal flora of diabetics is the relatively small number of butyrate-producing intestinal bacteria. Moreover, on the basis of 50 distinct markers of the feces, the investigators could differentiate between type 2 diabetics and healthy controls [15]. Using concentrated oat beta-glucans, an increase of short-chain fatty acid butyrate in the colon could be obtained [16]. Butyrate is produced by bacteria of the intestinal flora. Thus the characteristic changes of the intestinal flora in diabetics possibly may be partially reversed by oatmeal. Endoluminal butyrate is also essential for the regeneration and functional integrity of the colonic mucosa [17]. It has anticarcinogenic properties promoting apoptosis [18], and it possibly inhibits the growth of tumor mass in colon carcinomas [19].

One of the most important exogenous modulators of the gut flora is diet. Changes in the nutritional composition can affect the intestinal flora already within one day [20]. Thus changes in the microbiota due to oatmeal diet may be a crucial factor for the improvement of IS. However, the increase of the proportion of oat fiber in the daily diet showed no change in the intestinal flora, although the IS had improved [21].

A large number of factors are now known to trigger or increase insulin resistance, including hypertriglyceridemia, OSA, obesity, age, inflammation, medication, etc. A regression analysis showed that hypertriglyceridemia, OSA, obesity, and age had no apparent impact on the success of treatment. However, this must be considered with caution because of the relatively small number of patients investigated in the present study.

Limitations of the Study

The observation period after the oatmeal diet lasted for only 3 days. A longer follow-up observation period would be desirable. This study is a retrospective analysis of a clinical routine, in which the assessment of serum insulin is not provided. Thus it was not possible to calculate the well-established homeostasis model assessment (HOMA) index as a parameter in order to assess the IS [22]. However, to get an idea of the IS level, we calculated the logarithm of the product of daily insulin requirement (IU) and MBG (mg/dl). However, this is obviously not a validated method. Since there was no control group with other weight reduction diets, fasting, or other carbohydrate diet, the specific effect of oats in this case remains unclear.

In conclusion, the results do encourage us to conduct a prospective randomized controlled trial which should also record hormone regulation, coherence, and quality of life parameters. This would also entail a longer follow-up observation period.

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Disclosure Statement

The authors declare that they have no conflict of interest concerning this paper.

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