RESEARCH PAPER

Effect of Probiotic Supplementation on Body Weight Gain in Streptozotocin-Nicotinamide Induced Diabetic Rats

Dr. D. Mathivanan [1], Dr. A. Perumal [2*], Dr. R. Preethi [3] and Dr. G. Ariharasivakumar [4]

[1] PhD Scholar, Department of Anatomy, Srinivasan Medical College and Hospital,Dhanalakhsmi Srinivasan University,Tiruchirappalli, Tamil Nadu, India – 621 112.
[2] Professor, Department of Anatomy, Srinivasan Medical College and Hospital,Dhanalakhsmi Srinivasan University, Tiruchirappalli, Tamil Nadu, India - 621 112.
[3]Assistant Professor, Department of Pathology, Karpagam Faculty of Medical Sciences and Research, Coimbatore, Tamil Nadu, India-641 032
[4] Professor & Head, Department of Pharmacology, KMCH College of Pharmacy Coimbatore, Tamil Nadu, India – 641048
***Corresponding author:** maddiballack@gmail.com*
1mathianatomy@gmil.com, 3preethrajamani.r@gmail.com and 4sanjaaari@gmail.com

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ABSTRACT

Background: Altered nutrient utilization and impairment of body-weight gain are associated with diabetes mellitus. Repeated measurements of body weight provide a simple physiological index of the overall metabolic consequences of diabetes and of the response to therapy. Probiotic supplementation has been postulated as an adjunctive approach in metabolic disorders.

Objective: In the present study, the effect of probiotic supplementation on body-weight gain was evaluated in male Wistar rats with streptozotocin–nicotinamide (STZ–NA)-induced diabetes in comparison with normal control and untreated diabetic animals.

Materials and Methods: Albino Wistar rats (adult males) were used. Overnight-fasted rats were induced diabetic by intraperitoneal injection of nicotinamide (120 mg/kg) followed by streptozotocin (65 mg/kg) after 15 min. 18 animals were divided into three groups of six animals each: normal control, STZ–NA diabetic control, and STZ–NA diabetic rats treated with Lactobacillus acidophilus probiotic at 1×10^9 CFU/day, orally, every morning for 28 days. Individual body weights were measured at baseline and weekly for 4 weeks. Weight gain from baseline to week 4 was assessed. Data are shown as mean ± SEM and analyzed by one-way ANOVA with multiple comparisons.

Outcome: The control group increased from 150.00 ± 1.95 g at baseline to 229.50 ± 4.37 g at week 4. The STZ-NA group decreased from 159.33 ± 4.11 g to 149.50 ± 7.46 g. In the probiotic group, it increased from 169.50 ± 5.33 g to 228.83 ± 10.68 g. The mean changes in weight from baseline to week 4 were +79.50 ± 3.39 g, −9.83 ± 10.68 g and +59.33 ± 14.26 g respectively. One-way ANOVA indicated a significant group effect ($F=20.03$, $p<0.001$). Untreated STZ–NA animals significantly gained less weight compared to probiotic treated animals ($p<0.001$).

Conclusion: Probiotic supplementation resulted in significant recovery of body weight in STZ–NA-induced diabetic rats. The body weight of probiotic treated group at 4 weeks was comparable to normal controls and significantly higher than untreated diabetic animals.

Keywords: body weight; body-weight gain; diabetes mellitus; streptozotocin; nicotinamide; Lactobacillus acidophilus; probiotic; Wistar rat

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INTRODUCTION

Diabetes mellitus is a chronic metabolic disorder caused by defective regulation of glucose. Type 2 diabetes mellitus is mainly caused by insulin resistance. Impaired body weight progression is often associated with diabetes. [1–3] The streptozotocin-nicotinamide (STZ-NA) model is commonly used as an experimental model for type 2 diabetes-like metabolic abnormalities. Nicotinamide partly protects against streptozotocin-induced pancreatic beta-

**Author for Correspondence: maddiballack@gmail.com*

cell injury and provides a reproducible diabetic phenotype for assessment of metabolic interventions. [4–6]

Loss of body weight or failure to gain weight is a known feature of experimental diabetes . Earlier experimental studies have reported impaired body weight progression in diabetic animals and have demonstrated metabolic effects of probiotic interventions in diabetic models . [7–9]

The intestinal microbiota participates in metabolic homeostasis, energy regulation, integrity of the intestinal barrier and inflammatory signaling. Dysbiosis has been implicated in type 2 diabetes and insulin resistance. Reviews of probiotic-based interventions describe potential mechanisms including intestinal permeability, short chain fatty acids, immune regulation and oxidative stress. [10–13]

Experimental studies with Lactobacillus species, including L. acidophilus and other probiotic strains have been shown to be beneficial for metabolic effects in diabetic models. Clinical systematic reviews and meta-analyses indicate that probiotics might affect glycemic control and anthropometric outcomes, but the effects differ depending on the strain, dose, duration and population. [14–17]

Moreover, recent experimental studies advocate further investigation of probiotics in diabetic animals. L. acidophilus supplementation has been associated with improved metabolic and tissue outcomes in diabetic models, and recent work using lactic-acid-bacterial preparations has reported improved body-weight retention in streptozotocin-diabetic rats. These data support the need for investigation of body weight recovery as a distinct outcome. [18–20]

MATERIALS AND METHOD

Experimental Animals

Adult male albino Wistar rats (6 weeks old, 150–200 g) were kept in well-ventilated temperature-controlled animal facility in clean polypropylene cages on a 12-h light/dark cycle. Standard rat pellet diet and water for drinking were freely available. The experimental procedure provided states that animal procedures were performed in accordance with the ethical committee approval and the recommendations for proper care and use of laboratory animals.

Ethical Approval

The study was conducted as part of the project approved by the Institutional Animal Ethical Committee (IAEC), KMCH College of Pharmacy, Coimbatore under Project Proposal No. KMCRET/ReRc/Ph.D/125/2025

Experimental Groups

Three groups comprising of normal control, STZ–NA diabetic control and STZ–NA + L. acidophilus probiotic were were grouped for the study. Each group had six rats (n=6).

(Table 1)

Table 1. Experimental groups

Group	Designation	n
I	Normal control	6
II	STZ–NA diabetic control	6
III	STZ–NA + L. acidophilus probiotic	6

Induction of Experimental Diabetes

Animals were starved overnight. Nicotinamide was administered intraperitoneally at a dose of 120 mg/kg body weight. Fifteen minutes later, streptozotocin was administered intraperitoneally (65 mg/kg body weight). Streptozotocin was freshly prepared in sodium citrate buffer (pH 4.5) and nicotinamide was freshly prepared in 0.9% sodium chloride immediately prior to administration. Animals with blood glucose >250 mg/dL were selected 72 h after induction of fasting blood glucose according to the supplied protocol.

Treatment with probiotics

The probiotic intervention was Lactobacillus acidophilus 1 x 10^9 CFU/day, given orally (p.o.) every morning for 28 consecutive days.

Measurement of Body Weight

Body weights were recorded at baseline and at weeks 1, 2, 3 and 4 (by a digital precision weighing balance)

Body Weight Gain Calculation

Absolute body weight gain was calculated as: body weight at week 4 − baseline body weight. The percent change was calculated as: [(Week-4 body weight – baseline body weight) / baseline body weight] × 100.

Statistical Analysis

Data are expressed as mean ± SEM (n=6). One-way ANOVA was used to compare baseline to week 4 body-weight gain for the three groups. Normal control comparisons were made using Dunnett's test and direct pairwise comparisons using Tukey's multiple-comparison test. $p<0.05$ was considered significant. Descriptive statistics of weekly repeated measurements are presented. The main inferential endpoint was individual baseline to week 4 change.

Results

The control group experienced progressive weight gain. The STZ–NA untreated group showed persistent impairment of weight gain and ended up below their weight baseline. The probiotic group had an initial decrease and then a major recovery from week 2. (Table 2,Table 3)

Table 2. Weekly body weight of experimental animals (g)

Group	Baseline	Week 1	Week 2	Week 3	Week 4
Control	150.00 ± 1.95	158.17 ± 2.89	175.67 ± 2.40	213.50 ± 4.09	229.50 ± 4.37
STZ–NA	159.33 ± 4.11	153.50 ± 2.73	158.67 ± 1.86	159.83 ± 5.83	149.50 ± 7.46
STZ–NA + Probiotic	169.50 ± 5.33	155.50 ± 2.25	191.00 ± 7.60	215.50 ± 10.56	228.83 ± 10.68

Table 3. Baseline-to-week-4 body-weight change

Group	Baseline (g)	Week 4 (g)	Change (g)	Percentage change
Control	150.00 ± 1.95	229.50 ± 4.37	+79.50 ± 3.39	+53.00%
STZ–NA	159.33 ± 4.11	149.50 ± 7.46	−9.83 ± 10.68	−6.17%
STZ–NA + Probiotic	169.50 ± 5.33	228.83 ± 10.68	+59.33 ± 14.26	+35.00%

Statistical Comparisons

Probiotic-treated diabetic animals showed significantly higher weight gain than untreated STZ–NA rats. One-way ANOVA, $F(2,15)=20.03$, $p<0.001$.(Table 4)

Table 4. Statistical comparison of baseline-to-week-4 body-weight change

Comparison	Mean difference (g)	p value	Interpretation
Control vs STZ–NA	89.33	<0.001	Significant
Control vs Probiotic	20.17	0.199	Not significant
STZ–NA vs Probiotic	69.17	<0.001	Significant

DISCUSSION

The present study was designed to evaluate the effect of supplementation of Lactobacillus acidophilus probiotic on the progression of body weight in STZ-NA-induced diabetic rats. Body weight was the primary outcome since changes in body mass provide a composite indicator of the metabolic perturbations associated with experimental diabetes and the net response to intervention. The results showed three different types of patterns of body-weight development: a steady increase in body-weight in normal control animals, a failed maintenance of body weight in untreated STZ-NA diabetic animals, and a remarkable recovery of body weight after probiotic supplementation.

The normal control animals demonstrated progressive increase in body weight during the 4 weeks of observation period from 150.00 ± 1.95 g at baseline to 229.50 ± 4.37 g at week 4. This was an absolute increase of 79.50 ± 3.39 g, or 53.0% from baseline. This gradual increase in body weight is consistent with normal growth and maintenance of nutritional status of healthy young rats under standard experimental conditions.

In contrast, the body-weight pattern in the untreated STZ-NA diabetic group was unfavorable. The mean body weight decreased from 159.33 ± 4.11 g at baseline to 149.50 ± 7.46 g at week 4, i.e. a mean loss of 9.83 ± 10.68 g or 6.17 % of the baseline weight. However, the second and third weeks showed a small increase in STZ–NA group, which was not sustained and the body weights of the animals remained lower than their initial weight. This pattern is suggestive of persistent impairment of normal body-weight gain after induction of diabetes.

The decrease in body weight of the diabetic control group is consistent with the metabolic disturbances associated with experimental diabetes . The STZ–NA model was initially developed to induce a reproducible diabetic phenotype in adult rats, and subsequent studies have described the model and its use for studying diabetes-associated metabolic abnormalities. [1–4] Experimental diabetes is commonly associated with impaired body-weight gain, which is a consequence of problems with glucose use and overall energy metabolism. [4–6]

The major finding in the present study was the significant improvement in body-weight progression after probiotic supplementation. Animals treated with L. acidophilus initially decreased in body weight from 169.50 ± 5.33 g at baseline to 155.50 ± 2.25 g in the first week. However, this initial reduction was followed by a significant recovery with body weight increasing to 191.00 ± 7.60 g in week 2, 215.50 ± 10.56 g in week 3 and 228.83 ± 10.68 g in week 4. Thus, the probiotic treated group achieved a body weight very similar to the normal control group.

The difference between untreated and probiotic treated diabetic animals was especially evident when considering baseline to week 4 changes. The STZ-NA diabetic control group lost 9.83 ± 10.68 g whereas the probiotic-treated group gained 59.33 ± 14.26 g. Thus, the mean body weight change in the probiotic group was 69.17 g higher than that of untreated diabetic animals. The difference was statistically significant ($p<0.001$) and overall one-way ANOVA revealed a significant effect of treatment group on body weight change ($F(2,15)=20.03$, $p<0.001$).

The final comparison of body-weight also demonstrates the extent of recovery. It was observed that although probiotic treated animals had a higher mean body weight at the start of the experiment than controls, body weight at week 4 (228.83 ± 10.68 g) was comparable to body weight at week 4 of the control group (229.50 ± 4.37 g). Overall weight gain was not statistically different between the control and probiotic groups ($p=0.199$), further suggesting that probiotic supplementation was associated with restoration toward the normal pattern of body-weight gain rather than a simple transient increase in body mass.

The observed response can be explained in terms of the proposed metabolic effects of probiotics. The intestinal

microbiota is involved in metabolic homeostasis, energy regulation, intestinal barrier integrity and inflammatory signaling. Changes in gut microbiota have been linked to diabetes and insulin resistance, and probiotic interventions have been examined for their possible impacts on metabolic and inflammatory pathways.[10–13]

The present observation is in general agreement with previous experimental evidence. Yadav et al. reported that probiotic preparations containing L. acidophilus and L. casei on the course of streptozotocin-induced diabetes in rats.[7] Other experimental studies have shown beneficial effects of probiotic Lactobacillus strains in diabetic models, including effects on inflammation and intestinal function.[9] Multi-strain probiotic supplementation has also been reported to attenuate streptozotocin-induced type 2 diabetes abnormalities, including inflammatory changes and β-cell injury.[10] Such findings lend experimental support to the investigation of probiotics as an adjunctive approach in diabetes.

Evidence for L. acidophilus also supports the biological plausibility of the current findings. Delivery of L. acidophilus has been studied in streptozotocin-induced diabetic animals reporting improved metabolic and pancreatic outcomes. [16] Moreover, studies of other lactic-acid-bacterial preparations have demonstrated beneficial effects in experimental diabetes, suggesting that probiotic-related metabolic effects may extend beyond a single bacterial strain. [12,18–20]

Several interrelated biological processes may underlie the possible link between probiotic supplementation and body-weight recovery. Probiotic organisms may influence metabolic homeostasis by affecting the balance of intestinal microbes, intestinal barrier function, microbial metabolites, and inflammatory signaling.[10–13] Thus, the observed improvement in body weight should be considered as an important physiological outcome associated with probiotic treatment.

The present data are also in line with broader evidence on probiotic supplementation in metabolic disorders . Probiotic or synbiotic interventions may affect metabolic outcomes in people with diabetes, but the size and direction of effects vary according to probiotic strain, dose, duration, and study population characteristics.[14,15] Clinical systematic reviews and meta-analyses have shown this. Experimental evidence also suggests that probiotic effects may be strain- and experimental model-dependent.[9–13]

Another important aspect is the temporal pattern of the probiotic response. The initial decline in the first week was followed by rapid and sustained recovery in weeks [2–4]. This points out that the response was not rapid and the possible role of ongoing supplementation in the later improvement. However, since the present study was limited to a 28-day treatment, studies with a longer treatment duration would be required to determine whether the improvement in body weight is maintained over time.

The present findings should therefore be mainly interpreted in relation to body weight progression. L. Acidophilus supplementation in STZ–NA-induced diabetic rats showed a significant improvement in body-weight change, in which animals treated with acidophilus gained 59.33 ± 14.26 g, whereas untreated diabetic animals lost 9.83 ± 10.68 g. The extent of this difference and the close approximation of final body weight to that of normal controls indicate a significant recovery of body-weight progression following probiotic supplementation.

To summarize, the current results show a clear distinction between untreated diabetic animals and diabetic animals treated with probiotics. Failure to maintain normal body-weight progression was associated with STZ-NA-induced diabetes, while daily oral administration of L. Acidophilus at 1 × 10 9 CFU/day was associated with significant recovery of body weight The marked improvement compared with the untreated diabetic group ($p<0.001$), coupled with the close approximation of final body weight to normal controls, supports the potential value of probiotic supplementation as an adjunctive intervention in experimental diabetes. Further studies including glycemic, biochemical, inflammatory and gut-microbiota parameters would help to elucidate the mechanisms underlying this beneficial effect.

SUMMARY

STZ–NA induced diabetes was associated with a marked impairment of normal body-weight gain.Significant recovery was related to Lactobacillus acidophilus probiotic supplementation (1×10^9 CFU/day, p.o., every morning for 28 days). Normal controls gained 79.50 ± 3.39g, untreated STZ–NA rats lost 9.83 ± 10.68g and probiotic-treated rats gained 59.33 ± 14.26g. Probiotic treated animals had a significant increase in weight gain compared to untreated STZ–NA animals ($p<0.001$) and reached a final body weight close to normal controls.

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Statement of Ethics

Animal experimentation was carried out with the approval of the IAEC, KMCH College of Pharmacy, Coimbatore, Project Proposal No. KMCRET/ReRc/Ph.D/125/2025

Competing Interest

The authors have no conflicts of interest to disclose in relation to this study.

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Data Sharing Statement

The body-weight data analyzed in this manuscript were procured during the approved animal experiment .

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