Original Research Report

# EFFECT OF SHORT-TERM EXTRA MALTODEXTRIN DURING A DIET BREAK ON THE RESISTANCE TRAINING PERFORMANCE OF *Rattus norvegicus*

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## ABSTRACT

Poor diet with a purpose to lose a certain body weight or body fat can impair muscle protein synthesis. This results in muscle loss and poor performance in physical training, particularly resistance training. This study aimed to determine the short-term effect of extra carbohydrates, specifically in the form of maltodextrin, during a diet break on the resistance training performanced by rats. This study was an experimental laboratory study with a randomized posttest-only control group design. Twenty-seven male rats, aged 3 months with a weight range of 140–165 g, were randomly and equally assigned into three groups: KN (standard diet), KP (75% calorie intake), and K1 (65% calorie intake with a diet break and extra maltodextrin every week). These diets were administered for four weeks, during which the rats had *ad libitum* feeding. Additionally, the rats underwent ladder-climbing training three times a week. The body weight was measured pre- and post-treatment, while the performance in resistance training was evaluated post-intervention using a ladder climbing platform. There was no significant difference in the weight before and after treatment, with $p>0.05$ for the increments (Δ) among KN (14.00±9.89 g), KP (13±9.5 g), and K1 (20.89±14.77 g). According to the posttest assessment results, only 17 out of 27 rats succeeded in the maximum weightlifting test. This study showed that a short-term high-carbohydrate diet break does not improve the resistance training performance of rats. Further research is necessary to ascertain the outcomes of the treatment implemented over an extended period of time.

**Keywords:** Diet break; carbohydrates; ladder-climbing exercise; calorie restriction; human and health

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**Highlights:**
1. The ongoing advancement of dietary research has significant importance in the exploration of strategies to optimize the impact of nutrition on performance during resistance training.
2. This study provides a prompt for future research to explore the effectiveness of incorporating an additional dietary strategy that may enhance resistance training performance.

## INTRODUCTION

According to the most recent guidelines of the World Health Organization and the American College of Sports Medicine, regular resistance training can provide comprehensive health benefits. These advantages include a reduction in mortality associated with cardiovascular disease, hypertension incidence, type 2 diabetes, various forms of cancer, and adiposity. Additionally, regular resistance training has been found to improve mental health by reducing depressive and anxiety symptoms (Pranoto et al. 2023). The goal of maintaining muscle size and strength during a prolonged period of energy restriction is to achieve a leaner physical profile. In individuals who do not use anabolic agents, it is exceedingly challenging to maintain or even progress a load due to a lack of energy during the prolonged period of energy restriction (Anstey et al. 2018).

The ketogenic dietary regimen was initially used as an alternative to medication for people with epilepsy. However, it has now become a widely utilized therapeutic approach for patients with obesity, diabetes mellitus, and cancer. According to current cancer research, it has been observed that the addition of tumor necrosis factor (TNF) and interleukin-6 (IL-6) inhibitors to high-fat diets can reduce inflammation and mucosal damage in the colons of mice. Consequently, this preventive measure hinders the growth of tumors (Kern et al. 2018). The aforementioned dietary regimen has evolved and become a method that is incorporated into everyday life. The typical macronutrient distribution for a ketogenic diet consists of 75% fat, 20% protein, and 5% carbohydrate (Laksana et al. 2021).

The combination of chronic energy restriction and low-carbohydrate intake has been observed to impair anaerobic exercise performance. This may lead to muscle atrophy and a decrease in the number of calories burned during exercise, ultimately resulting in a reduction in the total daily energy expenditure (TDEE). A decrease in TDEE might lead to a stagnation in the pace of weight loss. If individuals are unable to make practical adjustments, their weight loss progress may stall. This can cause a decrease in motivation that ultimately results in failure to achieve weight loss goals (Hall 2018). Recent research has investigated intermittent energy restriction as a potential strategy to mitigate the negative effects associated with prolonged and extreme energy restriction. Intermittent energy restriction has been demonstrated to be superior compared to continuous energy restriction in terms of weight reduction efficiency, metabolic adaptation, conserved lean body mass, and training performance (Byrne et al. 2018).

The implementation of a carbohydrate-rich diet in the short term has the potential to improve performance during training sessions by increasing stored muscle glycogen and delaying the onset of fatigue. However, until recently, most diet break or intermittent energy restriction research primarily focused on body composition, compensatory metabolic response, and related indicators such as insulin (Henselmans et al. 2022, Kim et al. 2022). There is a dearth of studies on the impact of a diet break or intermittent energy restriction on exercise performance, specifically in the context of resistance training. Consequently, there is a pressing need for further study in this area. This concept pertains to those who adhere to calorie restriction, such as athletes who are preparing for competitive weight requirements or obese patients undergoing strict energy restriction. The foregoing background outlines the objective of this study, which was to examine the effect of a high-carbohydrate diet on the performance of calorie-restricted *Rattus norvegicus* during resistance training.

## MATERIALS AND METHODS

This study was experimental laboratory research with a randomized posttest-only control group design. Wistar strain rats (*Rattus norvegicus*) were used as animal models due to their anatomical and physiological similarities to humans (Santana et al. 2019). This study used 27 male rats aged 3 months within the weight range of 140–165 g. During the four-week treatment, the rats were randomly divided into three groups consisting of nine rats each: KN, KP, and K1. The KN group was provided with a standard diet equivalent to 5 grams per 100 grams of body weight. The KP group was given 75% of the standard diet, while the K1 group received 65% of the standard diet. However, the diet of the K1 group included a two-day break and extra maltodextrin intake (2.25 g) every week until equal calorie consumption with the KP group was achieved. The animal models were acclimatized for one week, during which they were provided with *ad libitum* feeding and were familiarized with ladder-climbing exercise. The research was conducted for five weeks in the Biochemistry Laboratory for Experimental Animals, Faculty of Medicine, Universitas Airlangga, Surabaya, Indonesia.

The bodyweight of the rats was measured pre- and post-intervention using a digital scale (Harnic HL-3650 Heles, China), with a maximum capacity of 5 kg and a graduation of 1 g. The ladder-climbing training equipment was constructed using wooden materials. The dimensions of the equipment were measured to be 110 cm in height and 18 cm in width. There was a 2 cm gap between each staircase, and the equipment had an inclination angle of 80 degrees. Located at the top of the ladder, a shelter in the form of a box with dimensions of 20 x 20 x 20 cm was provided as a resting area for the exercising rats (Figure 1). The maximum weightlifting test was conducted post-treatment. The rats climbed the ladder while carrying a load that was equivalent to 75% of their own weight. This procedure was repeated until the animals failed to climb, hence obtaining the maximum capacity in the weightlifting training. The maximum capacity was established after the rats demonstrated consistent failure to climb the ladder for three consecutive attempts. The resistance training was performed twice per week, utilizing loads that were reduced to 50% of those used in the previous weightlifting test. Each resistance training session consisted of three sets and three repetitions. This exercise conformed to the recommendations offered by the American Heart Association, which advocate for two sessions of resistance training per week. Notably, the training put more emphasis on strengthening the lower body muscles than the upper body muscles, given their essential function in carrying out everyday tasks (Fauzi et al. 2022).

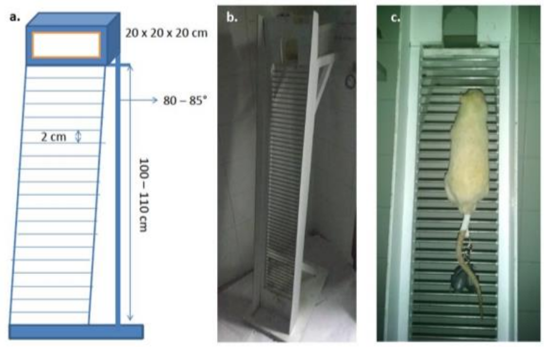


Figure 1. Vertical ladder-climbing platform for resistance training (Neto et al. 2016).

In accordance with the study carried out by Petrie & Watson (2013), the data analysis in this study was performed with the assistance of IBM SPSS Statistics for Windows, version 25.0 (IBM Corp., Armonk, N.Y., USA). The data were presented in numerical values and percentages. Numerical data were presented as mean (standard deviation) and standard error if a normal distribution was present. The posttest data for Groups KN, KP, and K1 were analyzed using the Chi-square test. However, it was found that the necessary criteria for this test were not met. As a result, a follow-up statistical analysis method, the Fisher's exact test, was employed to examine the differences between the groups. The Shapiro-Wilk test was employed to determine normality. The mean difference for a normal distribution was determined using an independent t-test, while the Mann-Whitney test was employed for a skewed distribution. The statistical significance was set at $p<0.05$.

## RESULTS

A total of twenty-seven male rats of the Wistar strain, with an overall age of 3 months and a weight range of 140–165 g, were distributed into three distinct groups: KN, KP, and K1. The bodyweight measurements pre- and post-intervention exhibited a normal distribution ($p>0.05$).

Since there is a connection between bodyweight and strength, a bodyweight analysis was performed between groups, which revealed normally distributed differences ($p>0.05$). Furthermore, a Mann-Whitney comparative test was performed. The characteristics of the body weight of subjects are reported in Table 1.

Table 1. The rats' weight post-intervention according to the ANOVA results.

| Groups | Mean±SD | n | p (Fisher's exact test) |
|---|---|---|---|
| KN | 182.33±23.61 | 9 | 0.875 |
| KP | 181.56±24.23 | 9 | |
| K1 | 177.44 ±15.46 | 9 | |

Note: ANOVA=Analysis of variance.

The statistical analysis of the maximum weightlifting test resulted in p=0.069. This value indicated that there was no significant relationship between the difference in body weight and ladder-climbing performance in all groups, regardless of the presence or absence of calorie restriction. The results shown in Table 2 demonstrate that there is no statistically significant difference between rats that succeeded in the maximum weightlifting test and those that did not.

Table 2. Results of the post-intervention maximum weightlifting test.

| Groups | Success | Failure | Total |
|---|---|---|---|
| KN | 3 (33.3%) | 6 (66.7%) | 9 |
| KP | 8 (88.9%) | 1 (11.1%) | 9 |
| K1 | 6 (66.7%) | 3 (33.3%) | 9 |
| Total | 17 (63.0%) | 10 (37.0%) | 27 |
| p (Fisher's exact test) | 0.069 | | |

## DISCUSSION

In this study, the rat models were distributed into three groups, consisting of one control group and two treatment groups. The first treatment group was subjected to a calorie restriction, whereas the second treatment group underwent the same regimen but included a diet break and extra carbohydrate intake. The treatment was implemented using a food-rationing procedure tailored to each group. This dietary treatment aligns with research conducted on human subjects (Campbell et al. 2020). The variables assessed in response to the intervention were the results of the maximum weight lifting test. The assessment was performed to evaluate the muscular strength of the rats engaged in resistance training, specifically ladder climbing.

The observed pattern of body weight changes among the rats in this study showed a noticeable weight increase, albeit without a significant difference. This finding demonstrates that an increase in body weight does not consistently affect performance during ladder-climbing resistance training. Individuals classified as obese may have higher muscle mass but lower muscle quality compared to those with a normal weight (Cava et al. 2017). The observed weight gain in the rats, while being subjected to a 25% reduction in food intake, contradicts prior research findings on the effects of food restriction on body weight. This research analyzed the effect of extending the duration of calorie restriction by introducing maltodextrin supplementation to a specific group, which may potentially produce variations in athletic performance during ladder-climbing resistance training. It is noteworthy that the rats in this study had never received any form of resistance training intervention, hence allowing for the initiation of early muscle growth.

According to prior research, it has been demonstrated that an increase in muscle strength may become evident within three weeks of resistance training. Hypertrophy has been identified as an important factor that contributes to the increase in muscle strength (Loenneke et al. 2019). The muscles that have a role in hypertrophy are the flexor hallucis longus, soleus, extensor digitorum longus, and triceps brachialis. Additionally, several studies have reported a growth in the size of the gastrocnemius and flexor digitorum longus muscles (Neto et al. 2013, Cassilhas et al. 2013). In a study with an 8-week treatment, the flexor hallucis longus muscle was dissected and weighed after the completion of ladder climbing training. The measurement of the wet weight showed a 23% increase compared to both the non-trained and control groups (Cassilhas et al. 2013). According to these findings, it may be inferred that the observed weight gain in the rats might be attributed to early-phase hypertrophy. A study conducted in the field of bodybuilding found that adult males can gain up to 7.2 kg of lean mass within the first year of training (Benito et al. 2020).

This study demonstrated muscle gain or hypertrophy in rats, even when in a calorie deficit. This finding supported a study conducted by Barakat et al. (2020) who found the occurrence of hypertrophy in non-trained individuals. During a calorie-restricted diet period, skeletal muscle hypertrophy may manifest in individuals belonging to several categories: individuals who are untrained and initiating resistance training, obese individuals, detrained athletes, or those who quit resistance training and eventually start out again. The prerequisites for this occurrence are nitrogen balance or a surplus through increased consumption of dietary protein, a well-structured resistance training plan, and a calorie intake that is equivalent to or slightly below the TDEE (Krzysztofik et al. 2019). A full comprehension of this subject matter requires further research that includes a thorough examination of the gastrocnemius, flexor hallucis longus, soleus, and flexor digitorum longus muscles. This will enable a comprehensive analysis of the differences between the groups under study.

During the treatment period of this study, the rats were provided with feed in accordance with the predetermined quantity for each group. Both the KP and K1 groups received the same weekly calorie intake (75% of the KN group's standard diet), but with different timing and food sources. The results of this study showed that weight gain was observed in all groups following the treatment. Surprisingly, the KP group demonstrated superior performance in the post-treatment maximum weight lifting test. The KP group involved the heaviest rat, weighing 227 g, despite the similarity in average weight across all groups. However, the phenomenon counters our hypothesis, which predicted that the KP group might exhibit the poorest performance in the post-treatment maximum weight lifting test, while the KN group could be the highest performing group due to the absence of calorie restriction. Compared to the KP group, the K1 group supposedly exhibited superior performance as a result of increased glucose intake, albeit with the same net weekly calories. There was evidence suggesting that the calorie restriction encouraged the rodents to nibble on the bedding material composed of rice husk, as observed in this experimental study. The nutritional value of rice husk is comparatively suboptimal when compared to BR-1 feed, which is composed of 3.1% protein, 2.7% fat, 12.5% water, and 17.5% ash (Partama et al. 2019). Furthermore, a low-protein diet has been shown to potentially have an adverse effect on the composition and function of gut bacteria. Wu et al. (2022) found that mice subjected to a low-protein diet had a decreased abundance of cecal bacteria, specifically *Alistipes* sp., *Roseburia* sp., and *Muribaculaceae*. This composition is assumed to be ideal for promoting muscle hypertrophy, hence making the post-treatment maximum weightlifting test suboptimal.

**Strength and limitations**

The publication of this study holds significance as it enables interested researchers to further investigate this subject matter with an improved experimental design, an extended time frame, and the inclusion of additional variables to yield more robust outcomes. One of the limitations of this study pertained to the absence of a maximum weightlifting test before the administration of the treatment. Future studies should carefully consider the aforementioned factors and develop a refined research design according to the findings presented in this paper.

## CONCLUSION

A short-term weekly diet break with additional carbohydrate intake in the form of maltodextrin has no significant difference in the performance of resistance training, despite the presence or absence of calorie restriction.

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**Conflict of interest**

None.

**Ethical consideration**

This study was approved by the Health Research Ethics Committee, Faculty of Medicine, Universitas Airlangga, Surabaya, Indonesia, with reference No. 68/EC/KEPK/FKUA/2022 on 31/3/2022.

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None.

**Author contribution**

MII contributed to the conceptualization and design, analysis and interpretation of the data, drafting of the article, final approval of the article, provision of study materials, and collection and assembly of the data. II contributed to the collection and assembly of data, critical revision of the article for important intellectual content, and final approval of the article. LL contributed to the conceptualization and design, collection and assembly of data, critical revision of the article for important intellectual content, and final approval of the article. A contributed to the analysis and interpretation of the data, the drafting of the article, a critical revision of the article for important intellectual content, and the final approval of the article.

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