University "St. Kliment Ohridski" - Bitola, Republic of North Macedonia
Faculty of Technology and Technical Sciences - Veles

Book of proceedings of the 1st International Scientific Conference - Food Science, Nutrition, Innovative Technologies and Sustainability

Veles, North Macedonia
February 2026

University "St. Kliment Ohridski" - Bitola, Republic of North Macedonia

Faculty of Technology and Technical Sciences - Veles

Book of proceedings of the 1st International Scientific Conference - Food Science, Nutrition, Innovative Technologies and Sustainability

Veles, North Macedonia
February 2026

Publication Title: Book of Proceedings of the 1st International Scientific Conference - Food Science, Nutrition, Innovative Technologies and Sustainability

Publisher: University "St. Kliment Ohridski" - Bitola, Faculty of Technology and Technical Sciences - Veles

Editor-in-chief: Assoc. Prof. Dr. Sc Vezirka Jankuloska, Faculty of Technology and Technical Sciences - Veles, University “St. Kliment Ohridski” – Bitola, Republic of North Macedonia

Editor: Prof. Dr. Sc Vesna Knights, Faculty of Technology and Technical Sciences- Veles, University “St. Kliment Ohridski” – Bitola, Republic of North Macedonia

Technical Editor and Graphic Design: Tanja Stojanovska, Jordan Martinovski, Faculty of Technology and Technical Sciences - Veles, University "St. Kliment Ohridski" - Bitola, Republic of North Macedonia

All papers included in this volume were peer-reviewed by members of the Scientific Committee and Reviewers from a relevant scientific field.

Edition: e-edition

Year of publication: 2026

CIP - Каталогизација во публикација
Национална и универзитетска библиотека "Св. Климент Охридски", Скопје

613.2(062)
616-083.2(062)
606:663/664(062)

INTERNATIONAL Scientific Conference - Food Science, Nutrition, Innovative Technologies and Sustainability (1 ; 2025 ; [Veles])
Book of proceedings of the 1st International Scientific Conference - Food Science, Nutrition, Innovative Technologies and Sustainability [Електронски извор] / [editor-in-chief Vezirka Jankuloska]. - Veles : University "St. Kliment Ohridski" - Bitola, Faculty of Technology and Technical Sciences, 2026

Начин на пристапување (URL): https://ttfv.uklo.edu.mk/2026/02/20/book-of-proceedings-of-the-1st-international-scientific-conference-food-science-nutrition-innovative-technologies-and-sustainability/.
- Текст во ПДФ формат, содржи 193 стр., илустр. - Наслов преземен од екранот. - Опис на изворот на ден 09.03.2026. - Фусноти кон текстот. - Библиографија кон трудовите

ISBN 978-608-67527-0-5

а) Храна -- Квалитет -- Собири б) Исхрана -- Здравствени аспекти -- Собири в) Храна -- Биотехнологија -- Собири

COBISS.MK-ID 68355333

ORGANIZING COMMITTEE

Vezirka Jankuloska, PhD, Dean, University “St. Kliment Ohridski” – Bitola, Faculty of Technology and Technical Sciences – Veles, Republic of North Macedonia

Vesna Knights, PhD, Vice-Dean for Science and International Cooperation, University “St. Kliment Ohridski” – Bitola, Faculty of Technology and Technical Sciences - Veles, Republic of North Macedonia

Aleksandar Stanković, PhD, Vice-Dean for Science and International Cooperation, Faculty of Applied Sciences – Niš, University of Economics Academy in Novi Sad, Serbia

INTERNATIONAL SCIENTIFIC COMMITTEE

Vesna Knights, PhD, University "St. Kliment Ohridski" - Bitola, Faculty of Technology and Technical Sciences – Veles, Republic of North Macedonia

Anka Trajkoska Petkoska, PhD, University "St. Kliment Ohridski" - Bitola, Faculty of Technology and Technical Sciences – Veles, Republic of North Macedonia

Vezirka Jankuloska, PhD, University "St. Kliment Ohridski" - Bitola, Faculty of Technology and Technical Sciences – Veles, Republic of North Macedonia

Gorica Pavlovska, PhD, University "St. Kliment Ohridski" - Bitola, Faculty of Technology and Technical Sciences – Veles, Republic of North Macedonia

Valentina Velkovski, PhD, University "St. Kliment Ohridski" - Bitola, Faculty of Technology and Technical Sciences – Veles, Republic of North Macedonia

Tatjana Kalevska, PhD, University "St. Kliment Ohridski" - Bitola, Faculty of Technology and Technical Sciences – Veles, Republic of North Macedonia

Daniela Nikolovska Nedelkoska, PhD, University "St. Kliment Ohridski" - Bitola, Faculty of Technology and Technical Sciences – Veles, Republic of North Macedonia

Viktorija Stamatovska, PhD, University "St. Kliment Ohridski" - Bitola, Faculty of Technology and Technical Sciences – Veles, Republic of North Macedonia

Tatjana Blazhevska, PhD, University "St. Kliment Ohridski" - Bitola, Faculty of Technology and Technical Sciences – Veles, Republic of North Macedonia

Nevena Gruevska, PhD, University "St. Kliment Ohridski" - Bitola, Faculty of Technology and Technical Sciences – Veles, Republic of North Macedonia

Sanja Sazdovska, PhD, University "St. Kliment Ohridski" - Bitola, Faculty of Technology and Technical Sciences – Veles, Republic of North Macedonia

Namik Durmishi, PhD, University of Tetova, Faculty of Food Technology and Nutrition, Tetovo, Republic of North Macedonia

Saša Savić, PhD, University of Niš, Faculty of Technology – Leskovac, Serbia

Arber Hyseni, PhD, University "Isa Boletini" – Mitrovica, Faculty of Food Technology, Kosovo

Indrit Loshi, PhD, University "Haxhi Zeka" – Peja, Faculty of Agribusiness, Kosovo

Joanna Harasym, PhD, University of Economics – Wrocław, Faculty of Production Engineering, Department of Biotechnology and Food Analysis, Poland

Agnieszka Orkusz, PhD, University of Economics – Wrocław, Faculty of Production Engineering, Department of Biotechnology and Food Analysis, Poland

Amrita Poonia, PhD, Banaras Hindu University, Institute of Agricultural Sciences – Department of Dairy Science and Food Technology, Varanasi, India

Nishant Kumar, PhD, National Institute of Food Technology Entrepreneurship and Management, New Delhi, India

Velitchka Gocheva, PhD, University of Food Technology-Plovdiv, Department of Biotechnology, Bulgaria

Mersiha Suljkanović, PhD, University of Tuzla, Faculty of Natural Sciences and Mathematics, Bosnia and Herzegovina

Zoltán Kovács, PhD, Hungarian University of Agriculture and Life Sciences, Institute of Food Science and Technology, Hungary

Gokhan Durmaz, PhD, Inonu University, Department of Food Engineering, Malatya, Turkey

Deniz İnnal, PhD, Burdur Mehmet Akif Ersoy University, Faculty of Arts and Sciences, Department of Biology, Burdur, Turkey

Didem Cinkilic, PhD, Aydin Adnan Menderes University, Department of Food Engineering, Turkey

Rigerta Sadikaj, PhD, University of Tirana, Faculty of Natural Sciences, Department of Biotechnology, Albania

Dritan Arapi, University of Tirana, Faculty of Natural Sciences, Department of Biotechnology, Albania

UDK: 613.25.03

BODY MASS REDUCTION WITH THE KETOGENIC DIET: COMPARATIVE STATISTICAL ANALYSIS USING THE WISHNOFSKY MODEL

Gordana Markovik[1], Vesna Antoska Knights[2][0000-0003-1768-2231], Tatjana Blazevska[2][0009-0000-9019-3616], Jasenka Gajdoš Kljusurić[3][0000-0001-6657-7337]

[1]PROTEKAL – Medical Keto Diet, 1000 Skopje, Republic of North Macedonia
[2]Faculty of Technology and Technical Sciences - Veles, University "St. Kliment Ohridski" - Bitola, Republic of North Macedonia
[3]Faculty of Food Technology and Biotechnology, University of Zagreb, Croatia
E-mail: gordana-goca@hotmail.com;

Abstract
The overweight and obesity represent major global health challenges associated with numerous chronic diseases. This study evaluates body mass reduction achieved through a ketogenic diet and examines the predictive performance of the Wishnofsky weight-loss model. A cohort of 200 participants following a ketogenic diet was analyzed using anthropometric and biochemical data collected at clinical centers in Skopje and Pristina. Comparative statistical analyses were conducted to assess differences in weight loss outcomes across regions and sexes using independent-sample *t*-tests ($p < 0.05$). Principal component analysis (PCA) was applied to explore relationships between baseline anthropometric parameters, biochemical markers (glucose and cholesterol), and pre-diet lifestyle habits.The results confirm the effectiveness of the ketogenic diet for body mass reduction and support the applicability of the Wishnofsky model as a reliable predictive tool in structured dietary interventions. The Wishnofsky model demonstrated strong agreement with observed body mass reduction during the diet period, confirmed by quantitative regression analysis with a high coefficient of determination (R^2=0.98).

Key words: weight loss; keto diet; Wishnofsky method; Mathematical models; overweight.

Introduction

Overweight and obesity are becoming an increasingly global issue, linked to various diseases and negative health effects such as coronary heart disease, type 2 diabetes, various types of cancer, hypertension, disorders of the colon and gallbladder, respiratory problems, osteoarthritis, and others (CDC, 2017). (Poščić, A. 2020).

Excess body mass develops when energy intake chronically exceeds energy expenditure, leading to a positive energy balance and progressive weight gain (Westerterp KR. 2013). The treatment of obesity therefore requires the establishment of a negative energy balance , most effectively achieved through the application of an energy-restricted diet (Westerterp-P, MS. et al., 2009). However, this typically results in an increased sense of hunger and desire to eat, and a decrease in the feeling of fullness, implying a risk poor long-term adherence to reduced energy intake.

Weight loss is a complex physiological process involving reductions in both fat mass and fat-free mass (FFM), which in turn trigger decreases in resting energy expenditure and overall energy requirements . These adaptive responses may counteract the intended negative energy balance induced by an energy-restricted diet. Consequently, weight loss should be accompanied by a reduction in energy intake without increasing appetite, while maintaining energy expenditure while preserving FFM (fat-free mass). (Drummen M. et al., 2018).

Predicting weight loss is critical for designing effective weight loss interventions (Rickman AD. et al., 2011; Rochon J. et al., 2011), providing accurate weight loss prescriptions for patients (Alison DB. et al., 2014; Hall KD. et al., 2018; Thomas DM. et al., 2014), and evaluating the components of the post hoc energy balance (Thomas DM. et al., 2012; Thomas DM. et al., 2010; Hall KD & Chow CC. 2011). This need leads to a wide collection of different models for predicting weight loss, differing in how they separate changes in energy storage and energy expenditure (Thomas D. et al., 2019). Therefore, various mathematical models are developed to attempt to analyze and define key variables for successful weight loss and maintenance (Poščić, A. 2020).

In nutrition science, mathematical models are primarily applied as predictive tools to describe and simulate body weight dynamics under different dietary conditions. Their application in nutrition can be of great significance, primarily to predict the dynamics of body weight change. Generally, models approximately represent a system or process and serve for a better understanding of it. They are useful for planning various experiments and their rapid and safe repetition, as well as for prediction, contributing to a better understanding of the system.Their value lies in capturing the most relevant physiological mechanisms while remaining sufficiently simple for practical application (Gajdoš, 2020). Additionally, predictive models reduce experimental costs and time requirements and allow safe testing of multiple dietary scenarios (Seila et al., 2003; Gajdoš Kljusurić, 2020).

Recent studies have emphasized the significance of mathematical modeling in understanding the dynamics of body weight change and the development of effective weight loss strategies. Knights et al. (2023) discussed the integration of artificial intelligence techniques into mathematical modeling frameworks for dietary optimization, demonstrating how data-driven methods can support personalized weight management strategies.

The utilization of specific dietary regimens, such as the ketogenic diet, has gained popularity for weight reduction among overweight and obese individuals. In their work, "Ketogenic Diet Applied in Weight Reduction of Overweight and Obese Individuals with Progress Prediction by Use of the Modified Wishnofsky Equation" (Markovikj et al., 2023), the authors explore the application of the modified Wishnofsky equation in predicting progress during ketogenic diet interventions. This research sheds light on the practical implementation of dietary strategies for weight loss.

Furthermore, sustainable diet indicators play a pivotal role in the optimization of dietary choices and their environmental impact. In "Model of optimization of the sustainable diet indicators" (Markovikj & Knights, 2022), the authors propose a model that optimizes sustainable diet indicators, contributing to the promotion of both personal health and environmental sustainability. This holistic approach considers not only individual well-being but also the broader ecological implications of dietary decisions.

To assess the effectiveness of these dietary strategies and models, it is crucial to analyze and interpret the results comprehensively. Markovik et al. (2020) conducted a statistical analysis of outcomes in patients applying sustainable diet indicators, using descriptive statistics, hypothesis testing, and multivariate analysis methods, underscoring the importance of rigorous quantitative evaluation in nutrition research. This study underscores the importance of evidence-based practices in nutrition and highlights the need for rigorous evaluation of dietary interventions. In a related comparative study, Knights et al. (2024) analyzed obesity-related factors using both statistical design of experiments and machine learning methods, demonstrating that classical statistical models and ML approaches can yield complementary insights into key metabolic and anthropometric predictors of obesity, thereby reinforcing the value of integrated quantitative modeling frameworks in nutrition research.

The aim of this study is to evaluate body mass reduction achieved through a ketogenic diet and to assess the predictive performance of the Wishnofsky model in a clinical population. The scientific contribution of this work lies in the combined application of comparative statistical analysis, principal component analysis, and regression modeling to validate the applicability of the Wishnofsky model as a reliable predictive tool for body mass reduction in contemporary dietary practice.

Materials and methods

This study was conducted at two clinical centers: Venustas Medical Polyclinic in Skopje (North Macedonia) and Prodieta Polyclinic in Pristina (Kosovo). A total of 200 patients who sought professional consultation for body mass reduction were included in the study. All participants followed a ketogenic diet under medical supervision during their weight loss process.

The study population consisted of 44 males and 156 females. Throughout the dietary intervention, participants were continuously monitored, and their progress was systematically recorded in medical documentation. Data collection included anthropometric measurements, specifically height, body weight, body mass index (BMI), chest circumference, and umbilical (waist) circumference. In addition, individual dietary logs were collected to document adherence to the ketogenic diet.

Statistics:

In our comparative analysis encompassing region, sex, and anthropometric values, we utilized a t-test to evaluate the statistical significance of the observed differences across various indicators. This test served as a crucial component in guaranteeing the reliability and validity of our research findings. Notably, we established a significance level of $p<0.05$, signifying that differences with a p-value below this threshold were regarded as statistically significant.

All collected data were processed and organized using XLStat statistical software, which was employed for subsequent statistical and multivariate analyses.

Model:

We conducted an examination of a mathematical model rooted in Wishnofsky's equation, which was adapted to the dynamics of weight reduction in accordance with the principles of the ketogenic diet. This adaptation was carried out across diverse gender categories and varying initial levels of obesity. All calculations based on the Wishnofsky model were performed using XLStat software (version 2023, Addinsoft, Paris, France).

Our study drew upon the Wishnofsky equation, initially conceived by Max Wishnofsky in 1958 for the purpose of forecasting the trajectory of body mass loss.

$$W(t) = W_0 - 0{,}454 * \Delta EB * \qquad [\text{kg}] \qquad (1)$$

W, represents body weight (TM), expressed in kilograms (kg).
W_0. represents the first TM expressed in kilograms (kg).
W(t), represents the expected weight gain after reducing energy intake for t days expressed in kilograms (kg).
t, is the number of days when the energy balance is negative and energy consumption decreases , expressed in days (d).
ΔEB, represents the difference between energy intake and consumption. expressed in kilocalories per day (kcal/day).
The equation was employed for all individuals who were engaged in a ketogenic diet to achieve weight reduction.

Data collection and preparation:

Dietary habits were assessed by recording the number of meals consumed per day, as reported in participants' dietary logs.

Results

The following section presents the results of the research. The first part of the study examined the similarities and differences between the above indicators based on gender, age, BMI and various anthropometric measurements between regions.

31 men and 69 women from North Macedonia and 13 men and 87 women from Kosovo participated in the research. Figure 1a shows the distribution of participants by region and gender, and Figure 1b shows the age distribution of participants by region and gender.

a) b)

Figure 1. Participants by region and sex; a) percentage of participants; b) average age

From our comparison between North Macedonian participants and Kosovo participants in the written study, it is clear that there is participation in North Macedonia (100) and Kosovo (100), but the difference between participants by gender (Figure 1a), only 7% male participant from Kosovo.

The age difference between the two groups is also significant (Figure 2). The average age of participants from North Macedonia (male) was 35.3 years, with an age range of 18 to 56 years. In comparison, the average age of (male) participants in Kosovo was 41.8 years, with a very similar age range of 18 to 57 years.

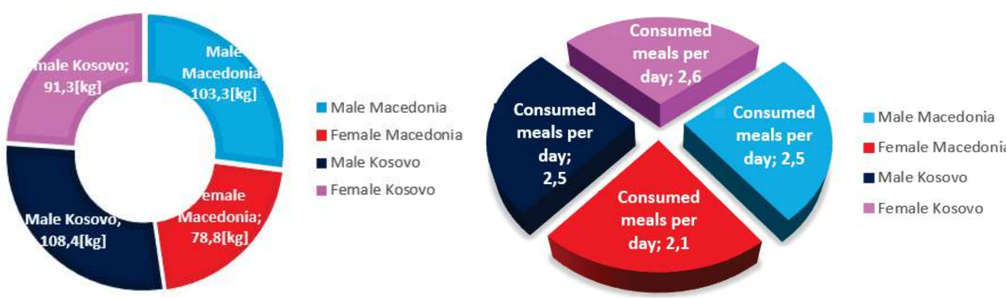

Figure 2. Participants by region and sex; a) body mass (kg); b) consumed meals per day.

When we analyzed body weight (kg), we found a difference between the average weights of females from North Macedonia was 78.8 kg, ranging from 50.7 kg to 152.5 kg. On the other hand, the average weight of female participants from Kosovo was 91.3 kg, with a weight range between 62.5 kg and 161.2 kg. All comparisons of anthropometric variables (body weight, height, and BMI) were based on baseline measurements, and statistical significance between groups was assessed using independent-sample t-tests ($p < 0.05$).

Data shows that height is no significant difference between male and female participants from Macedonia and Kosovo. The group of males from North Macedonia with an average height of 1.76 meters and the height of the group of males from Kosovo was 1.74 meters. In comparison, the average height of a group of females from Kosovo is 1.65 meters, with a group from North Macedonia having 1.64 meters.

Body Mass Index (BMI) shows the differences between groups. For the males from North Macedonia, the mean BMI was 38.3 kg/m2 and the BMI range was 26.3 kg/m2 to 64.3 kg/m2. Males from Kosovo had a mean BMI of 35 kg/m2. In the female group, there was no significant difference between the female group from North Macedonia (the mean BMI was 33.6 kg/m2) and the female group from Kosovo (mean BMI was 32.8 kg/m2).

Our data shows (Figure 2) that there are no significant differences in daily nutritional intake, in male group from North Macedonia and Kosovo. Both groups' participants ate an average of 2.5 meals per day (ranging from 1 to 4 meals). In comparison, group of female in Kosovo, they ate an average of 2.6 meals per day (ranging from 1 to 5 meals); and group of female from North Macedonia eat 2.1 meals. This indicates a difference in daily meal frequency between the female groups.

Information on the difference between waist circumferences. The average waist circumference of males from North Macedonia was 110.7 cm, with a range between 80 cm and 164 cm. In contrast, the average waist circumference of males from Kosovo was slightly lower at 105.4 cm, with a range between 77 cm and 138 cm. This suggests that, on average, males from North Macedonia had a larger waist circumference compared to males from Kosovo.

A comprehensive analysis was performed to determine the status of obese individuals in the data set. This classification consists of many factors that contribute to body weight. These factors include genetics, underlying health, consumption of sodas, nuts and salty foods, and eating habits that involve being active and consuming large meals. In addition, the tendency to overeat, the effects of sugary foods and many other important factors are also taken into account in the evaluation. The results of this classification are shown in Figure 3, which illustrates different categories of factors contributing to excessive body mass, including lifestyle-related behaviors and dietary habits. The term "extreme events" refers to unfavorable behavioral patterns such as frequent consumption of sugar-sweetened beverages, high intake of salty and processed foods, and overeating, which may disproportionately contribute to increased body mass.

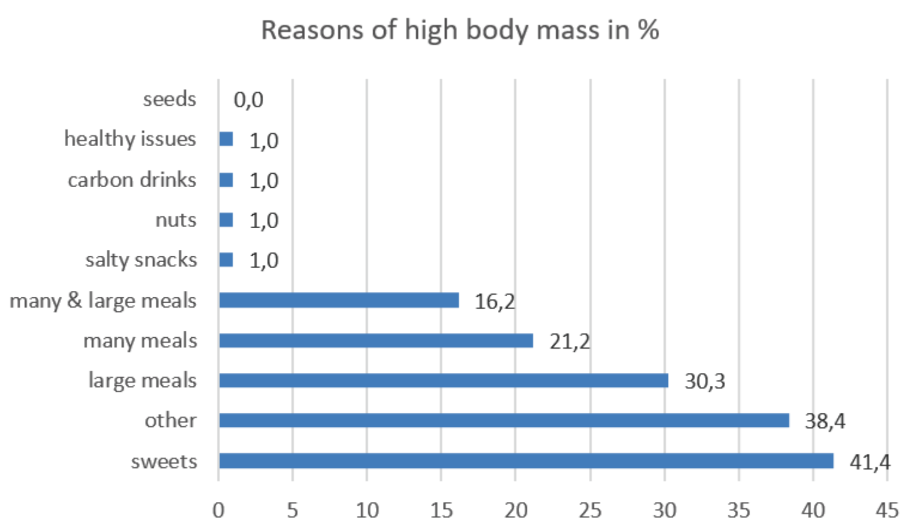

Figure 3. Gradation of the Cause of Excessive Weight

In this study, Principal Component Analysis (PCA) was conducted to examine the relationships between lifestyle habits related to eating before starting the diet and certain fundamental biochemical parameters. This analysis incorporated information about the frequency of meals and snacks between meals, including items such as crisps, seeds, nuts, fruits, carbonated soft drinks, sweets, etc., as supplementary variables, as illustrated in Figure 4.

Additionally, the study explored the connection between the initial BMI (baseline body mass index) and two key biochemical parameters, namely glucose and cholesterol, as active variables.

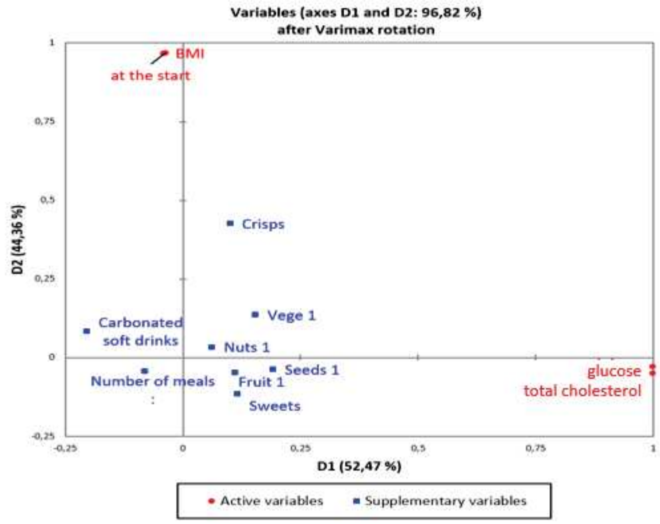

Figure 4: PCA relationship between baseline body mass index (BMI) and life habits of eating before diet and fundamental biochemical parameters

When the PCA was performed, it resulted in two principal components (D) that explained a substantial portion of the variance in the data. The first principal component (D1) explained 52.47% of the variance, while the second principal component (D2) explained 44.36% of the variance. Together, these two components (D1 and D2) accounted for 96.82% of the total variance in the data. Overall, the results suggest that the lifestyle habits related to eating before the diet, as well as the baseline BMI, are associated with a substantial portion of the variation in the biochemical parameters (glucose and cholesterol) that were examined in this study. A closer inspection of the PCA biplot reveals that baseline BMI, glucose, and cholesterol, treated as active variables, exhibit strong loadings along the first principal component (D1), indicating that this component primarily reflects metabolic and anthropometric status. In contrast, dietary and lifestyle habits, such as the number of meals, consumption of sweets, carbonated soft drinks, crisps, fruits, seeds, and nuts, were included as supplementary variables and are distributed around the origin or along the second principal component (D2). This suggests that these habits modulate, rather than dominate, the variability explained by the core biochemical parameters. The observed spatial proximity between certain dietary habits and baseline BMI further indicates potential associations between pre-diet eating behavior and metabolic profile, although these relationships are exploratory and descriptive in nature. Overall, the PCA highlights the dominant role of biochemical and anthropometric variables while illustrating how lifestyle habits contribute to the underlying structure of variability in the dataset.

Using the keto diet, all participants successfully achieved their goal of reducing their body mass. In Figure 5, we have a graphical representation in the form of a box plot that illustrates the BMIs of individuals of different genders at the beginning (BMI start) and end (BMI end) of the diet in both Skopje and Pristina. It's noteworthy that significant reductions in female body weight and BMI were attained. On average, the post-diet BMI was 23 [kg/m^2]. A similar effect of BMI reduction was observed in men, with an average post-diet BMI of 26 [kg/m^2].

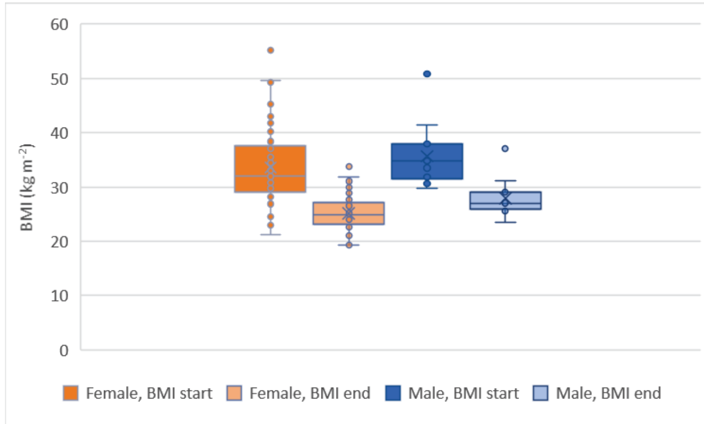

Figure 5. Box plot for body mass index (BMI) at the beginning of the diet (BMI start) and at the end (BMI end) for both genders, for all participants

Data was used to determine the significance of the prediction model for body weight. Wishnofsky model (1) was adopted and analysis was carried out to determine the significance of the model. Comparison of BMI changes during dieting and assumed BM loss according to the Wishnofsky model aimed to determine the relationship between the theoretical weight loss model and weight loss.

Figure 6. Comparing of actual body mass (TM) during the diet and the expected TM loss based on the Wishnofsky model.

Figure 6 displays the individual body mass (TM, total mass) changes during the dietary intervention, comparing experimentally observed values with model-predicted values obtained using the Wishnofsky model. Experimental body mass measurements are presented using discrete symbols, while the model-predicted TM loss is shown as a continuous smooth line, emphasizing the agreement between measured data and theoretical predictions The red line in the graph represents the predicted loss of body mass according to the Wishnofsky model, while the blue line represents the actual body mass loss (TM loss).

What's noteworthy in this comparison is the remarkable similarity between the two lines. In other words, the actual body mass loss, as observed in the blue line, closely aligns with the predictions made by the Wishnofsky model, represented by the red line.

Figure 7 presents the scatter plot of individual data points on the graph (TM) corresponds almost precisely to the predictions generated by the Wishnofsky model. This alignment between the observed outcomes and the model's predictions indicates that the Wishnofsky model is a robust and accurate tool for estimating body mass loss in this particular context. This consistency between the model's projections and the real-world results suggests that the model is effective in predicting how individuals in the study are losing body mass.

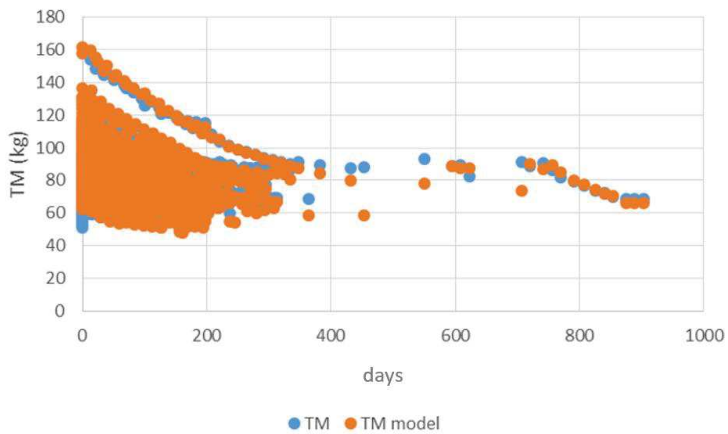

Figure 7. Individual body mass (TM, total mass) changes for each patient during the dietary intervention. Blue dots represent experimentally measured TM values for individual participants, while orange dots correspond to TM values predicted by the Wishnofsky model, illustrating the overall smooth trend of model-based weight loss dynamics .

The scatter representation emphasizes inter-individual variability, while the model-predicted values collectively illustrate a smooth weight loss trajectory consistent with the Wishnofsky framework.

Figure 8 presents the regression-based relationship between experimentally measured body mass (TM) and model-predicted values, demonstrating a very strong agreement between observed and predicted data. The high coefficient of determination ($R^2 = 0.985$) confirms the strong explanatory power of the regression model in capturing body mass changes during the dietary intervention.

Although the regression analysis demonstrates a very strong overall agreement between experimentally measured and model-predicted body mass values, Figure 8 also reveals a limited dispersion of individual data points outside the confidence interval, particularly at higher TM values. This deviation may reflect increased inter-individual variability at higher levels of initial body mass, as well as simplifications inherent in energy-balance–based models that do not fully capture metabolic heterogeneity in extreme cases. Such deviations suggest that, while the Wishnofsky-based model provides high predictive accuracy at the population level, its precision may be slightly reduced for individuals with very high baseline body mass. Nevertheless, these discrepancies do not substantially affect the overall explanatory power of the model, as confirmed by the high R^2 value.

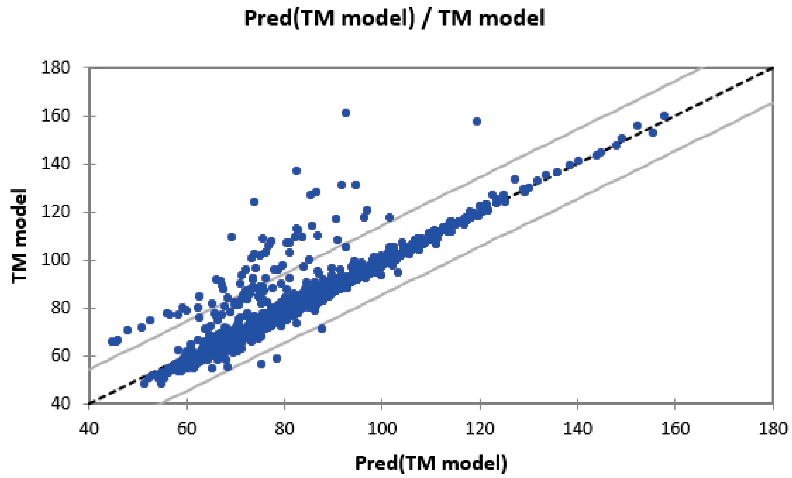

Figure 8. Quantitative regression, R-squared =0,98

Discussion

The observed reductions in body mass index and body weight in this study are consistent with findings reported in previous investigations of ketogenic and low-carbohydrate dietary interventions. Controlled studies have demonstrated that ketogenic diets can induce significant body mass reduction in overweight and obese individuals by promoting sustained negative energy balance and alterations in substrate utilization (Hall et al., 2018; Markovikj et al., 2023a). The post-diet BMI values observed in both male and female participants in the present study fall within ranges reported in comparable clinical settings, confirming the effectiveness of the ketogenic dietary approach for body mass reduction.

From a physiological perspective, the results align with the energy balance framework described by Alison et al. (2014) and Hall and Chow (2011), who showed that sustained negative energy imbalance leads to predictable reductions in adipose tissue mass. These findings support the biological plausibility of the weight loss patterns observed in our cohort and reinforce the relevance of energy balance as a central mechanism underlying dietary weight reduction. Moreover, the preservation of fat-free mass observed in ketogenic diet studies reported by Hall et al. (2018) is consistent with the present findings, where substantial body mass reduction was achieved without evidence of disproportionate loss of lean tissue.

An important contribution of this study lies in the validation of the Wishnofsky model as a predictive tool for body mass reduction under ketogenic dietary conditions. The strong agreement between predicted and observed body mass changes corresponds closely with earlier work by Thomas et al. (2014, 2019), who demonstrated that energy-balance–based mathematical models can reliably predict weight loss trajectories when dietary intake and energy expenditure are adequately characterized. Similar conclusions were reported by Markovikj et al. (2023b), who applied a modified Wishnofsky equation to ketogenic diet interventions and observed high concordance between model predictions and clinical outcomes.

Beyond individual model performance, the present results support broader perspectives on the role of mathematical modeling in nutrition science. Previous work has emphasized that mathematical and statistical models provide valuable tools for integrating anthropometric, biochemical, and dietary variables into coherent predictive frameworks (Gajdoš Kljusurić, 2020; Poščić, 2020). The consistency between our findings and those reported in earlier modeling studies suggests that relatively simple energy-balance–based models, when appropriately contextualized, remain useful for both clinical practice and research applications.

Taken together, the agreement between the present findings and existing literature confirms that ketogenic dietary interventions can produce predictable and substantial body mass reduction, and that mathematical models such as the Wishnofsky framework remain relevant for describing and forecasting weight loss dynamics. These results reinforce the importance of combining empirical clinical data with established mathematical modeling approaches to improve the understanding and prediction of body weight changes in overweight and obese populations.

Conclusion

This comprehensive study delved into the multifaceted realm of body mass reduction, focusing on the ketogenic diet as a practical approach. It conducted a meticulous comparative analysis using the Wishnofsky Model, an established predictive framework. The findings and insights derived from this research contribute substantially to the field of weight management and dietary interventions.

This study included a sample of 200 participants who started the ketogenic diet under professional training in clinics in Skopje and Pristina. It integrates quantitative anthropometric measurements and dietary intake information collected through structured dietary logs, providing a comprehensive assessment of the weight loss process.

One of the positive results of this study is the successful modification of the Wishnofsky model for different levels of weight loss for the ketogenic diet. This variable increases confidence in the estimate by accounting for the difference between gender and baseline adiposity. An important result is the excellent agreement between the prediction model and the participants' loss accuracy, confirming its accuracy and validity.

Principal Component Analysis (PCA) adds depth to this study by revealing the relationship between life habits of meal, snakes and drinks, and two key biochemical parameters, namely glucose and cholesterol. This holistic perspective helps better understand the interplay of these factors, providing a path for personalized nutritional advice.

Quantitative regression analysis strengthens findings by providing weighted estimates and predictions. The model showed unique explanatory power with an R-squared value of 0.985, indicating strong fit of the Wishnofsky model and ketogenic diet. The information obtained from this study is useful for individual leadership and intervention in the field of weight management. Combining practical applications with theoretical models, this research provides a valuable blueprint for proven strategies for achieving and maintaining body weight. It is important to investigate these methods to increase the accuracy of weight estimation and its impact on the individual.

Reference

Alison D. B. 2014. "Quantifying the effect of energy imbalance on human adipose tissue." Science 334 (6058): 306-311. CDC. 2017. "Overweight & Obesity." https://www.cdc.gov/obesity/index.html.

Drummen, Marieke et al. 2018. "Long-term effects of increased protein intake after weight loss on intrahepatic lipid content and implications for insulin sensitivity: a PREVIEW study." American Journal of Clinical Nutrition 108 (5): 962-972.

Gajdoš Kljusurić, Jasenka. 2020. "Basics of Mathematical Modeling in Food Science and Nutrition." Springer.

Gajdoš Kljusurić, Jasenka. 2020. "Mathematical models in human nutrition." In Proceedings of the European Federation of Food Science and Technology (EFFoST) 2020 International Conference, 38.

Hall, Kevin D., and Chow, Carson C. 2011. "Estimating changes in free-living energy intake and its confidence interval." American Journal of Clinical Nutrition 94 (1): 66-74.

Hall, Kevin D., et al. 2018. "Energy expenditure and body composition changes after an isocaloric ketogenic diet in overweight and obese men." American Journal of Clinical Nutrition 104 (2): 324-333.

Knights, V., M. Kolak, G. Markovikj, and J. Gajdoš Kljusurić. 2023. “Modeling and Optimization with Artificial Intelligence in Nutrition.” *Applied Sciences* 13 (13). https://doi.org/10.3390/app13137835.

Knights, V., Blazevska, T., Markovic, G., & Kljusurić, J. (2024). Mathematical Analysis of Statistical Design of Experiment and Machine Learning Methods in Identifying Factors Influencing Obesity. *Medical Research Archives, 12*(9). doi:10.18103/mra.v12i9.5790

Markovikj, G., V. Knights, and J. Gajdoš Kljusurić. 2023. “Body Weight Loss Efficiency in Overweight and Obese Adults in the Ketogenic Reduction Diet Program—Case Study.” *Applied Sciences* 13 (19): 10704. https://doi.org/10.3390/app131910704.

Markovikj, G., V. Knights, and J. Gajdoš Kljusurić. 2023. “Ketogenic Diet Applied in Weight Reduction of Overweight and Obese Individuals with Progress Prediction by Use of the Modified Wishnofsky Equation.” *Nutrients* 15 (4): 927. https://doi.org/10.3390/nu15040927.

Markovikj, Gordana, Vesna Knights, Dijana Nikolovska Nedelkovska, and Dimitar Damjanovski. 2020. "Statistical analysis of results in patients applying the sustainable diet indicators." Journal of Hygienic Engineering and Design 30: 35–39.

Markovikj, Gordana, and Vesna Knights. 2022. “Model of Optimization of the Sustainable Diet Indicators.” Journal of Hygienic Engineering and Design 39: 169–175.

Markovikj, Gordana. 2024. *Reduction of Excess Body Weight and Optimization of Healthy and Normal Body Weight through the Example of a Medical Keto Diet: Presentation of a Mathematical Model and Simulation*. PhD diss., University “St. Kliment Ohridski” – Bitola, Faculty of Technology and Technical Sciences – Veles. Available at https://ttfv.uklo.edu.mk/wp-content/uploads/sites/12/2024/03/Doktorska-GM.pdf

Poščić, Ana. 2020. "Mathematical modeling in weight management." In Current Topics in Weight Management. IntechOpen.

Rochon, Justine et al. 2011. "Design and conduct of the CALERIE study: Comprehensive assessment of the long-term effects of reducing intake of energy." The Journals of Gerontology Series A: Biological Sciences and Medical Sciences 66 (1): 97-108.

Seila, Andrew et al. 2003. "Applications of mathematical models to animal science." Journal of Animal Science 81 (2): E28-E38.

Thomas, Diana M., et al. 2012. "The effect of diet composition on weight change during a 6-month weight loss intervention: A randomized controlled trial." The American Journal of Clinical Nutrition 95 (3): 614-625.

Thomas, Diana M., et al. 2014. "Time to correctly predict the amount of weight loss with dieting." Journal of the Academy of Nutrition and Dietetics 114 (6): 857-861.

Thomas, Diana M., et al. 2019. "Mathematical models of weight loss, maintenance, and regain: From body compartments to populations." Diabetes 68 (9): 1851-1860.

Westerterp, Klaas R. 2013. "Physical activity, food intake, and body weight regulation: Insights from doubly labeled water studies." Nutrition Reviews 71 (Suppl 1): S210-S220.

Westerterp-P, Marieke S., et al. 2009. "Dietary fat oxidation as a function of body fat." American Journal of Clinical Nutrition 90 (2): 427-432.