 doi:10.20944/preprints202207.0456.v1

Article

Effectiveness of Adherence to a Mediterranean Diet in the Management of Overweight Women: the Prospective Interventional Cohort Study

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Abstract: Evidence indicates that unhealthy eating habits constitute multilevel obstacles threatening our health and well-being—studies suggesting that consumer choices turn irremovably towards Western diets. Mediterranean diets (MD) have been identified as one of the most effective in preventing and treating overweight and obesity. Considering this scientific substantiation in prevention and treatment activity, the purpose of this investigation is to verify this evidence. In our prospective interventional study, we examined the effect of MD on body weight in a female cohort sample. The analyzed group consisted of (n=181) females divided into three distinct groups based on their age (tricenarian, quadragenarian, and quinquagenarian). Anthropometric (weight, BMI, FATP, VFATL, FFM, TBW, and BMR), biochemical examinations (urea, creatinine, uric acid, ALT, AST, GGT, CHOL, HDL-CH, non-HDL, LDL-CH, TAG, GLU, and CRP) and comprehensive, personalized three months MD program was completed on the examined subjects. We didn't establish convincing evidence of MD on weight reduction and its magnitude of correlation with a positive correspondence on selected determinants in all groups combined. There is a challenge to construct more robust prospective cohort studies that will incorporate add-on critical integrands that will be appropriate to monitor, evaluate and predict weight management in experimenting.

Keywords: Mediterranean Diet; weight loss; determinants of health; healthy lifestyle; clinically significant weight loss

1. Introduction

The current lifestyle of people in economically developed societies is characterized by the high availability of food and an increasing rate of physical inactivity. Unhealthy dietary patterns have been associated with the development of multiple age-related diseases [28, 2]. Some investigators [6, 8, 27, 5] asserts that the Mediterranean diet (MD) acts as hindering means for impeding overweight and obesity-related undesirable consequences of hypertension, hyperglycemia, dyslipidemia [9, 23].

MD impacts fatty acid and antioxidants profile (phenolic compounds such as hydroxytyrosol, tyrosol, phenyl alcohols, and flavonoids). The MD emphasizes eating fruits, root vegetables, grains, legumes, nuts, seeds, and olive oil, which provides a high content of monounsaturated fatty acids and reduced intake of saturated fatty acids [1]. Furthermore, MD is characterized by a moderate intake of red wine after meals, a moderate intake of seafood, poultry, and dairy products, and low consumption of red meat and sweets. MD is a food philosophy inspired by the eating habits of the population who live in coun-

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tries bordering the Mediterranean Sea that differ slightly means we can encounter different versions of the MD diets. MD does not emphasize specific amounts of foods and portion size. A combination of MD foods appears protective against disease, as the benefits are not as substantial when looking at single foods or nutrients included in the MD [4]. Two additional aspects to be included compasses the MD's daily physical activity (activities of daily living) and adequate sleep and hydration [11]. The purpose of this examination is to evaluate MD intervention and its outcome on selected cohort sample.

2. Materials and Methods

2.1. Study Participants

A total of (n=181) overweight females residing in Slovakia, ages ranging from 30Y-60Y, participated in this study over the three months, May-July 2022. The representative sample was branched into three distinct clusters. Cohorts A consisted of 59 females from 30-39-y-old, B 62, 40-49-y-old, and C 60, 50-60-y-old.

2.2. Ethics

Ethical approval for the study was obtained from University Ethics Committee (UEC) of the University of Prešov in Prešov, Slovakia.

2.3. Biochemical examination

Comprehensive biochemical examination at the baseline incorporated LDL markers (low-density lipoproteins), HDL (high-density lipoproteins), CHOL (total cholesterol), TAG (triacylglycerides), GLU (glucose), non-HDL, urea, uric acid, ALT (alanine aminotransferase), AST (aspartate aminotransferase), GGT (gamma-glutamyltransferase) and CRP (c-reactive protein). Blood collection: a venous blood sample was taken voluntarily in the morning on an empty stomach in the presence of a medical person at the University of Prešov. Biochemical analysis was executed using a fully automated biochemical analyser Cobas Integra 400 plus. Biochemical analysis of the blood dichotomizes the subjects to be accepted or decline to participate in the study (i.e., without metabolic and cardiovascular risk).

2.4. Anthropometric analysis

Were performed using bioelectrical impedance (Quadscan 4000 Touch Screen) Bodystat QuadScan 4000 Touch Screen for measuring body weight, percentage of total body fat (FATP), visceral fat (VFATL), muscle mass (FFM), and total body water (TBW). Other monitored parameters included BMI and basal metabolism rate (BMR). Participants were measured morning at the beginning of each month during the three months of the experimentation.

2.5. Questionnaire of preferences

The personalized questionnaire was implemented on the participants at the first consultation by professional nutritionists. The questionnaire consisted of 3 distinct parts. In the first, the proband filled in personal data. In the second, the researcher measured the proband's basic anthropometric parameters (body weight, body height, waist, chest, hip, neck, thigh, and arm circumference; blood pressure and blood pulse). Consequently gave them an identification code under which the actual measurement was performed by the bioimpedance method using the BodyStat QuadScan 4000 TouchSreen instrument. The third part of the questionnaire focused on family history, previous and current diseases, and treatment. The third part included questions concerning the probands' dietary preferences and frequency of physical activity.

2.6. Personalized diet plan

Participants adhere to a three-month personalized diet plan executed in the center of weight loss by the three certified nutritionists. The MD diet was individualized to every partaker based on the biochemical blood analysis anthropometric assessment and a questionnaire where they indicated an individual dietary preference. Probands with higher cholesterol values were given a personalized low-fat diet. Probands with higher blood glucose levels suggested a diet emphasizing a balanced intake of carbohydrate/glucose units throughout the day with a consequent effect of lowering glycemia. With elevated liver test values, a sparing diet was indicated. All individuals explained the purpose of the investigation. With signature and confirmed their agreement with the terms and conditions of the examination. Participants that had or are currently suffering from metabolic or cardiovascular disease were excluded from the research. An investigation was conducted anonymously with unrecorded personal data.

2.7. Data Analyses

All data were analysed using SPSS (version 20.0, SPSS). Results are presented as mean ± SD. Change in body weight, FFM and TBW were calculated and expressed in kg, BMI in (kg.m2), FATP in percentage, VFATL in scale level, and BMR in (kcal). The values of the variables were normally distributed. Descriptive statistics were broken down into measures of central tendency and variability (spread). Paired t-tests have been used to test for differences between baseline, each month of three months, and the end of the three months. Differences were considered significant at $p<0.05$.

3. Results

3.1. Participants' Characteristics

At the inclusion, there were no differences in ethnicity, background, culture, and dwelling. No significant disparity in education was also observed, which altogether creates the assumption of a more homogeneous representation. The participants' main objective was voluntary decrease in body weight (diet plan) the incidence of civilization diseases (obesity, diabetes mellitus, cardiovascular diseases), emeliorate health and well-being.

3.2. Biochemical Indicators

Screening of (urea, creatinine, uric acid, ALT, AST, and GGT) revealed optimal kidney and liver functioning and a normative level of triglycerides, HDL, Non-HDL, and LDL. There were no significant differences between biochemical characteristics of the subjects at the baseline, excluding total CHOL linking group C 5,4 mmol/l borderline level A 4.7mmol/l B 4.8 mmol/l desirable. The blood glucose level was in the normal range. Plasma C-reactive protein did not hit inflammation risk thresholds. From the above, we can extrapolate reasonable health and homogeneity of the sample that can support a determination of causality (cause and effect).

3.3. Anthropometric Characteristics

Reduction of body weight was observed progressively in groups B and C (-3.4 kg-4% / -2.1 kg-3%); body weight reduction was not detected in group A after the completion of the 3 months intervention. According to [21], small weight gains or losses seem insignificant among normative and overweight individuals and potentially harmful only among those who are well into the obese range. Modest weight loss of 5-10 percent of total body weight over six months is likely to produce health benefits, such as normalization of blood glucose and cholesterol concentration [15]. The population averages for phase angle according to sex, age, and BMI is relatively stable between the (30-60-y-old) period [32]. All cohorts (all three groups) were overweight during the entire investigation. BMI in the A group was 26,7 kg.m-2 with no improvement detected, B 27,9 kg.m-2 improvement 5%

respectively C 27,8 kg.m-2 enhancement of BMI by 2,5% which was in congruence with weight losses of our sample. FATP did not change convincingly all along the experimentation in all cohorts, more specifically A group approximately 1%, B 2% respectively C 3% were higher than desirable for their age group category.

The VFATL should be below level 13, and the recommendation suggests maintaining a visceral fat lower than ten or a visceral fat area under 100 square centimetres. Our examination detected A 4,3 - B 7 and C 9 at the baseline did not change throughout the investigation (Table 1.). We did not detect any modification of VFATL. That can be correlated to insulin resistance GLU in group A 5mmol/l vs. group C 5,4 mmol/l (borderline) presented in (Table 4.). Some studies have shown that a low-carb diet is more effective at reducing visceral fat than low-fat diets [25, 13]. MD is considering a more balanced eating plan than the keto diet.

Moreover, regular aerobic exercise can decrease visceral fat, and enough sleeping and reduced stress can stand out as one the potential contributing factors influencing the possible outcome. A healthy percentage of FFM in women represents 68 - 80 percent. FFM remains relatively stable until approximately age 50 with a slower rate of decline (about 16% between the ages 25 and 70 at a rate of -0,16kg/year. We observed relatively stable FFM with an insignificant drop-in group C throughout the investigation (Table 1.), which can be attributed to the changes in TBW.

There is a small but not significant negative linear association of TBW to weight decline with age in females. The mean ratio of TBW to weight declined with age as a function of an increase in body fatness. The findings indicate that TBW volume, on average, maintains a reasonable degree of stability in women through a large portion of adulthood [3]. The average healthy range of TBW for women is 40-45%. Our observation points to the middle range from 35,7-37,7%, which was below average across the entire examination, and corresponds with an accumulation of adipose tissue in our cohort samples. An average female has a BMR of around 1410 kcal or 5,900 kJ. The BMR of our selection ranged from 1538-1497 (kcal).

Daily calorie needs based on activity level showed that sedentary (little or no exercise) is 1869 kcal. (Table 1.). A more accurate Mifflin-St Jeor equation of RMR showed that the average BMR of our entire sample was 1323 kcal which is about 200 kcal lower than a standard calculation of BMR. BMR is usually slightly lower than RMR measurement. Moreover, the average metabolic age (Harris-Benedict formula) of our entire sample was about five years higher than the actual age throughout the investigation (46 vs. 51), which indicates a need for lifestyle modification. During weight loss, tissue loss and metabolic adaptations contribute to the reduction in RMR.

Contrary to popular belief, it is not skeletal muscle but rather adipose tissue losses that seem to drive RMR reduction following weight loss [18]. FFM, TBW, and BM values decreased during a three-month program in each group (Table 1.). BMI values slightly dicreased in sub-groups B,C. no change in A group. Body fat decreased in cohorts B and C but increased in cohorts A, and visceral fat values remained unchanged.

The optimal proportion of total body fat in young females is 18-25%. In older females, physiologically, it can reach 30% of the total body weight. From the measured values before and after the 3-month program, we can state that our sample had an above-average body fat percentage. Visceral fat is closely linked to overweight, obesity, and hypertension, hyperlipidaemia, which can lead to serious chronic diseases, specifically diabetes and acute diseases such as myocardial infarction. The ideal value of visceral fat ranges from 1 to 3. In our analysed groups, visceral fat values were not lower than 4. While adhering to a proper lifestyle in the form of an MD concerning weight reduction, the resulting bioelectric impedance measurement showed that cohorts B and C reduced their body weight by (-3.4 kg / -2.1 kg). No changes were observed in group A. As mentioned above, we did not observe substantial differences in BMI measurements. Overweight was observed continuously through the entire duration of intervention in all three cohort groups.

Table 1. Results of the bioelectrical impedance during 3-months of the experimentation in all three groups.

parameters	Total (N = 181)			Group A (N = 59)			Group B (N = 62)			Group C (N = 60)		
Measurements	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.
AGE	46	46	46	30,5	30,5	30,5	45,5	45,5	45,5	57	57	57
WEIGHT (kg)	79,1	77,1	76,6	73,65	73,55	74,2	81,35	79,85	77,95	78,9	77	76,8
BMI ($kg.m^{-2}$)	27,8	27,4	27	26,9	26,65	26,6	28,45	28,25	27	28,3	27,5	27,6
FATP (%)	36,1	35,9	35,4	32,75	33,5	33,85	36,45	35,9	34,9	38,5	37,5	38,2
VFATL (level)	7	7	7	4,5	4	4,5	7	7	7	9	9	9
FFM (%)	50,7	50,2	49,5	50,7	50,45	50,15	51,6	50,7	49,75	49,9	49,4	48,8
TBW (%)	37,1	36,8	36,2	37,1	36,9	36,75	37,75	37,15	36,45	36,5	36,2	35,7
BMR (kcal)	1538	1523	1497	1543	1534	1516	1568	1530	1503	1502	1492	1471

Abbreviations: BMI – body mass index; FATP – body fat; VFATL – visceral fat; FFM – muscle fat; TBW – total body water; BMR – basal metabolism rate

Table 2. Correlation analysis of individual significant parameters for the overall data (N = 181) at the baseline of three-month intervention.

Parameters	*P* value	Difference between the groups
FATP	0,032	C – A (0,0291776)
VFATL	$1,49*10^{-9}$	A – B (0,0000274) C – A (0,000000)
CHOL	$7,59*10^{-5}$	C – A (0,0001434) C – B (0,0015425)
non - HDL	0,000497	C – A (0,003301)
LDL	0,00412	C – A (0,0029018)
GLU	0,000257	C – A (0,0001445)

Abbreviations: * $p < .05$ level of significance; FATP – body fat; VFATL – visceral fat; CHOL – total cholesterol; non – HDL - total cholesterol minus HDL cholesterol level; LDL- low density lipoproteins; GLU- glucose

Table 3. Correlation analysis of individual parameters for the overall data (N = 181) at the baseline and the end of a three-month intervention.

Parameters	*P* value
BMI 1 – BMI 3	0,2744
TBW 1 – TBW 3	0,04238*
BM 1 – BM 3	0,07668
FATP 1 – FATP 3	0,9018
VFATL 1 – VFATL 3	0,0001416*
WEIHGHT 1 – WEIGHT 3	0,2718

Abbreviations: * $p < .05$ level of significance

Table 4. Biochemical analysis of the blood samples.

Parameters	**Total (N = 181)**	**Group A (N = 59)**	**Group B (N = 62)**	**Group C (N = 60)**
UREA (mmol/l)	4,4	4,1	4,3	5,35
CREATININ (mmol/l)	68	67,5	69	67,5
URIC ACID (μmol/l)	280,5	262	275	290,5
ALT (μkat/l)	0,33	0,31	0,33	0,4
AST (μkat/l)	0,35	0,35	0,32	0,36
GGT (μkat/l)	0,3	0,26	0,34	0,35
CHOL (mmol/l)	4,9	4,7	4,8	5,4
HDL (mmol/l)	1,6	1,65	1,48	1,65
Non-HDL (mmol/l)	3,29	2,96	3,26	3,73
LDL (mmol/l)	2,98	2,67	2,93	3,23
TAG (mmol/l)	1,09	0,99	1,18	1,11
GLU (mmol/l)	5,1	5	5,1	5,4
CRP (mg/l)	2	1,6	2,3	2,25

Abbreviations: ALT- alanine aminotransferase; AST- aspartate aminotransferase; GGT- gamma-glutamyltransferase; CHOL- total cholesterol; non-HDL-total cholesterol minus HDL cholesterol level; LDL- low density lipoproteins; TAG- triacylglycerides; GLU- glucose; CRP-c-reactive protein; Data are expressed as mean (SD) unless otherwise indicated.

4. Discussion

Based on our findings, it can be argued that additional factors contributed to the reduction of body weight of our cohort sample. Healthy weight loss and its maintenance may not be entirely about nutritional therapy. There are additional integrands (Table 5) that we need to consider that may explain the process, strength, and direction of that relationship.

Table 5. Factors contributing to body weight management.

Combination of foods	Crous-Bou M et al. 2014
Sleep pattern	Eugene A, Masiak J 2015
Bedtime procrastination	Kroese FM et al. 2014
Physical environment	Ding D, Gebel K 2011
Physical activity	Swift DL et al. 2018
Stress management	Ornish D. 2021
Interoception	Robinson E et al. 2021
Higher education	Vranes AJ, Mikanovic VB 2012

We can utter that MD it's more of a guideline than a diet in contemporary society (it doesn't exclude any food groups) but is more akin to plant-based eating [4]. Although the pyramid shape advocates the proportion of foods to eat, it does not define portion sizes or determined amounts. It is up to the individual to choose how much food to eat at each meal. By contrast, there is a risk of excess calorie intake as a specific portion of foodstuffs which could lead to weight gain [30] made a distinction between "Hunger and Appetites" author claim that we think and behave in a certain way. To make a change, we must implement our perspective into practice. It was granted that our subjects were instructed on what and how much to eat (to satisfy hunger).

Nevertheless, it was up to the proband how she interpreted physical hunger or emotional cravings that can ultimately influence the outcome. Where perceive accuracy depends on interoception, which refers to the processes by which we sense, interpret, and integrate signals originating from within the body. A growing body of research suggests

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 29 July 2022 doi:10.20944/preprints202207.0456.v1

that the interoceptive process (relating to emotional regulation) may play an essential role in shaping our health. Deficits in interoception have been linked to higher BMI and may contribute to weight gain [24].

Yet, it remains unclear whether deficit or sensibility to interoception contributes to or is a consequence of weight gain of our sample that needs further investigation.

Müller et al. (2016) provide evidence that a higher BMI of 5 kg.m-2 is associated with an increase in overall mortality. Even though being overweight is a risk factor for specific medical conditions, including coronary heart disease, diabetes, and some forms of carcinomas, the relative risk for mortality from these conditions among the overweight is not necessarily as high as the relative risk for incidence. We have the so-called "obesity paradox." Research suggests that for people with various conditions, survival may be slightly better for heavier subjects. [12]. Still, the underlying reasons for the increased survival among overweight have not been well elucidated. Potential indications incorporate both physiological and behavioral influences. That led to the conclusion that the average value of BMI of 27 in our samples may have modest survival benefits of being overweight in a variety of adverse situations (chronic, acute illness, and medical procedures). However, that may not agree with a self-related health (SRH) and general life satisfaction (LS), which is more strongly related to perceived weight status and the motivation to join our program.

Irrespectively visceral fat (active fat) is strongly linked to metabolic disease. Subcutaneous fat doesn't carry those same risks (some may even be protective). A study by [19] showed that losing 6-7% of total body weight can reduce both subcutaneous and visceral fat. According to the Center for Disease Control and Prevention [17], losing around 0,5 kilos of body weight in a week is ideal, which makes it 2 kilos in a month. Losing body weight can be surprisingly simple and unusually challenging at the same time. A decrease in body weight in groups B and C (4%-3%) after the completion of the program resulted in voluntary circumstances (MD diet), presumably due to the loss of FFM, TBW, and BMR. No weight loss was detected in group A.

Further [33] asserts that cortisol can increase how much visceral fat our body stores so that stress reduction may influence fat loss. VFATL in our samples was a rating between 1-12, indicating a healthy (above average) visceral fat level.

Higher education attainment and socioeconomic status can be associated with better functional, healthy literacy, i.e., an individual's capacity to obtain, process, and understand basic health information and services sufficiently to make appropriate health decisions [29]. Our sample included women with higher education and economic security. That may favor participation but not guaranteed the outcome of our intervention. Further, poor sleep quality is linked to a higher risk of various chronic conditions, from heart disease to depression [10]. Kroese et al. (2014) claim that bedtime procrastination may also lead to unhealthy behavior as an essential factor related to getting insufficient sleep and consequently affecting individual health and well-being. We did not investigate this relationship, which could appear as a potential contributor to the result of our investigation. Lastly, physical activity and exercise participation are associated with healthy outcomes [26]. Undoubtedly, physical activity and a regulated exercise regimen can reduce alimentary obesity by increasing total energy expenditure, thus promoting a negative energy balance when caloric intake is lower than energy expenditure. Weiss et al. (2016) assert that minimum levels of physical activity (150 min of moderate-intensity exercise training) without dietary restriction may induce modest weight loss (≥5%weight loss). However, Johns (2014) asserts that there is no significant difference in weight loss programs from 3 to 6 months between the diet-only and exercise-only. But a more pronounce weight loss was detected after completion of 12 months combined program. In sum, the optimal strategy for promoting weight loss is the combination of a behavioral weight management program and adherence to adequate (continuous) amounts of physical activity or exercise regimen. Considering our 3-month program based on the above findings, we may conclude that omitting physical training may not be a factor in our research conclusions.

 doi:10.20944/preprints202207.0456.v1

Given that lifestyle modification (its domains) is challenging to initiate and maintain [14]. Weight loss possible, although difficult to conceptualize, is that weight loss it's not entirely about the diet (eating less). Instead, one can realize the lower calories as a consequence of the effective strategies in lifestyle midification brought about to achieve the goal of weight management. We focus on a holistic approach grounded in bio-psycho-social and environmental determinants. In that effect, healthy, sustainable eating should prevail and exceed a particular diet plan.

Our study has potential limitations. Evaluation of diet using any method will link to measurement error. This error is related to be random and would tend to under evaluate the connection between intake of products and body weight modification. Furthermore, compliance with the MD regime can be modified. We can't rule out the possibility of residual confounding contributable to personal, social, and environmental influences. Our study population comprised educated, affluent individuals. Even though it is improbable that the biological processes underlying this association are dissimilar in other people, our results may not be generalizable.

The strength of our study incorporates the repeated measurements of anthropometric and biochemical characteristics. The monthly structured observation provides a view of reliable markers. We found coherent results across three cohorts group delineating a particular range of female ages.

5. Conclusions

This study provides a platform for further research to provide better understanding through prospectively planned cross-sectional, longitudinal studies. It offers an innovative paradigm to consider before embarking on monitoring and evaluating an MD or similar dietary plans. Due to the limitations of the data, anthropometric characteristics, biochemical indicators, and personalized MD plan, the future studies should take into consideration further integrants (interoception, sleeping patterns, emotional health, environmental integrants, etc.) to elucidate further the complex interplay between diet regiments and their efficacity in confronting weight management. We can argue that a combination of physiological, psychological, and socioeconomic factors (holistic view) contributes (initiate, modify and sustain) to habitual changes. Future research ought-to target personalized strategies addressing the predominant causes of overweight and its treatment. In this framework to established complex conceptual and statistical models that include moderators and mediators, improve objective and perceived measures of the built environment, and strengthen evidence of causality through more comprehensive research design.

Author Contributions: Study concept and design: I.U., H.V., M.K., M.B; Methodology: I.U., H.V., J.P.; Formal analysis: I.U., H.V., J.P., V.S; Resources: H.V., J.P., M.K., M.B., V.S; Writing original draft preparation: I.U., H.V., J.P.; Writing review and editing: I.U., H.V., J.P. All authors read and approved the final manuscript.

Funding: KEGA 002PU – 4/2021.

Data Availability: The authors have full access to all specific material used in this paper and take responsibility for the use and accuracy of the information provided.

Conflict of Interest: The authors declare that there are no conflicts of interest regarding the publication of thispaper.

Institutional Review Board Statement: The study was approved by the Ethics Committee of the University of Prešov in Prešov, Slovakia. 20-04-2022 No: ECUPO42022PO-1/7

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Conflict of Interest: The authors declare no conflict of intertest.

 doi:10.20944/preprints202207.0456.v1

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