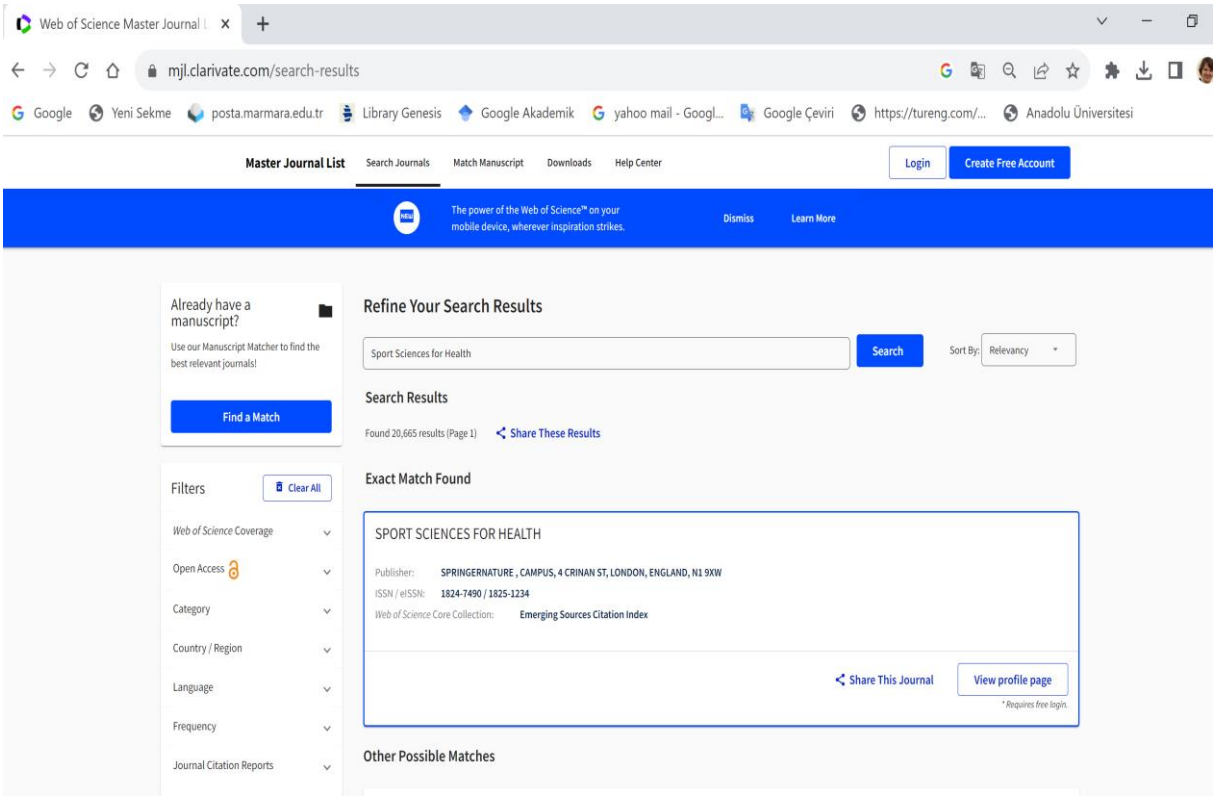



Sport Sciences for Health

Founded by the Faculty of Exercise Science - University of Milan, official journal of the Italian Society of Exercise and Sport Sciences

SISMES

Editorial board | Aims & scope | Journal updates

The journal Sport Sciences for Health publishes reports of experimental and clinical research on the physiology and pathophysiology of physical exercise. The journal places a special focus on mechanisms through which exercise can prevent or treat chronic-degenerative disease, contributing to prevention and personalized treatment of specific diseases and health maintenance with a translational perspective. — show all

Editors-in-Chief
Federico Schena, Fabio Esposito

Publishing model
Hybrid (Transformative Journal). How to publish with us, including Open Access

1.5 (2022)	6 days	194,667 (2022)
Impact factor	Submission to first decision (Median)	Downloads

For authors

Submission guidelines
Language editing services
Ethics & disclosures
Open Access fees and funding
Contact the journal
Calls for papers

Submit manuscript

Working on a manuscript?
Avoid the most common mistakes and prepare your manuscript for journal editors.
Learn more →



Sport Sciences for Health

Founded by the Faculty of Exercise Science - University of Milan, official journal of the Italian Society of Exercise and Sport Sciences

Editors

Editors-in-Chief

Fabio Esposito, MD, PhD, Professor, *Department of Biomedical Sciences for Health, University of Milan, Milan, Italy*

Federico Schena, MD, PhD, Professor, *Research Centre in Mountain Sport and Health (CeRiSM), University of Verona, Rovereto, Italy*

Section Editors

Biomechanics, Musculoskeletal: Emiliano Cè, PhD, *Department of Biomedical Sciences for Health, University of Milan, Milan, Italy*

SPRINGER NATURE

Do you publish research?

If so, would you be willing to take 2 minutes to answer a few questions about your experience of publishing in the last year or so?

Provide Feedback No Thanks

Sport traumatology, rehabilitation, injury prevention: Marco Bigoni, *University of Milano-Bicocca, Milan, Italy*

Associate Editors

Danilo Iannetta, PhD, *University of Utah – Veterans Affairs, Salt Lake City, USA* **(Sport Physiology)**

Rogerio N. Soares, PhD, *Joslin Diabetes Center, Harvard Medical School, Boston, USA* **(Sport Physiology)**

Editorial Board

Braulio H. M. Branco, PhD, *University Center of Maringá - Unicesumar, Paranà, Brazil*

Pasqualina Buono, PhD, Professor, *Department of Movement Sciences, Parthenope University of Naples, Naples, Italy*

Jose A Calbet, MD, PhD, *Department of Physical Education, Universidad de Las Palmas de Gran Canaria (ULPGC), Las Palmas de Gran Canaria, Spain*

Attilio Carraro, PhD, *Professor of Sport and Exercise Sciences, Faculty of Education, Free University of Bozen-Bolzano, Bolzano, Italy*

Paul D. Chantler, PhD, *Assistant Professor Division of Exercise Physiology, West Virginia University – School of Medicine, Director of Clinical Research, Center for Cardiovascular and Respiratory Sciences, Morgantown, WV, USA*

Pierpaolo De Feo, MD, PhD, Professor, *Endocrinology, Department of Medicine, University of Perugia, Perugia, Italy*

Giuseppe De Vito MD, PhD, FFSEM RCPI, RCSI, Professor, *Head of School of Public Health, Physiotherapy and Sport Science , CD Dean of Performance Science, University College Dublin Health Science Centre, Belfield, Dublin 4, Ireland*

Luigi Di Luigi, MD, PhD, Associate Professor of Endocrinology, *Chief of Department Section of Health Sciences, Chief of Endocrinology Unit, University of Rome "Foro Italico", Rome, Italy*

Clara Fitzgerald, Director, *Canadian Centre for Activity and Aging, University of Western Ontario, London, ON, Canada*

Laura Guidetti, MD, PhD, FACSM, Professor, *Department of Movement, Human and Health Sciences, University of Rome "Foro Italico",*

Rome, Italy
Thomas Hureau, *Université de Strasbourg, France*
Md. Anamul Islam, PhD, *Stony Brook University, New York, USA*
Michael Kellmann, PhD, *Ruhr-Universitat Bochum, Bochum, Germany*
Sylvain Laborde, PhD, *German Sport University, Institute of Psychology, Department of Performance Psychology, Koln, Germany*
Moh H. Malek, Ph.D., FACSM, FNSCA, CSCS*D, Associate Professor, *Integrative Physiology of Exercise Laboratory Wayne State University Eugene Applebaum College of Pharmacy & Health Sciences, Detroit, MI, USA*
Giampiero Merati, MD, PhD, Associate Professor in Exercise Science, *Department of Biomedical Sciences for Health, University of Milan, Milan, Italy*
Laurent D. Mourot, PhD, Associate Professor, *Head of the Master Training, Management and Sport engineering Head of the research platform dedicated to human researches Exercise, Performance, Health, Innovation, Univ. Franche Comté, Plateforme Exercice Performance Santé innovation (EPSI) , Besançon, France*
Fabio Nakamura, PhD, Professor, *Universidade Estadual de Londrina and Nucleus of High Performance, São Paulo, Brazil*
Mark Olfert, PhD, FAHA, *West Virginia University School of Medicine, Center for Cardiovascular & Respiratory Sciences, West Virginia Clinical and Translational Science Institute, Division of Exercise Physiology, Morgantown, WV, USA*
Antonio Paoli M.D., B.Sc. FECSS, *Human Movement Sciences School Department of Biomedical Sciences, University of Padua, Padua, Italy*
Antonio Palma, MD, PhD, Professor, *Sport and Exercise Sciences Research Unit, University of Palermo, Palermo, Italy*
Leonardo A. Peyré-Tartaruga, PhD, Associate Professor, *Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil*
Alberto Rainoldi, MD, PhD Professor, *Department of Medical Sciences, Motor Science Research Center, NeuroMuscularFunction research Group, SUISM, University of Turin, Turin, Italy*
Claudio Robazza, PhD, Professor, *BIND-Behavioral Imaging and Neural Dynamics Center, Department of Medicine and Aging Sciences, "G. d'Annunzio" University of Chieti-Pescara, Chieti, Italy*

oza, Argentina
ducation and Sports, Ordu, Turkey

SPRINGER NATURE

Do you publish research?

If so, would you be willing to take 2 minutes to answer a few questions about your experience of publishing in the last year or so?

ience, Syracuse University, Syracuse, NY, USA
Department of Physical Performance, Oslo, Norway
ology Laboratory, University of Cagliari, Cagliari, Italy
Asterios Deligiannis, MD, PhD, Professor, *Laboratory of Sports Medicine, Aristotle University of Thessaloniki, Thessaloniki, Greece*
Pietro Enrico di Prampero, MD, PhD, Professor, *Department of Medical and Biological Sciences, University of Udine, Udine, Italy*
Giorgio Fanò Illic, PhD, Professor, *U.O. Medical Biotechnology,CeSI- "G. d'Annunzio" Foundation, University "G. d'Annunzio" Chieti-Pescara, Italy*
Guido Ferretti, MD, PhD, Professor, *University of Brescia, Health and Wealth, Brescia, Italy*
Timothy P. Gavin, PhD., FACSM, *Professor and Department Head, Department of Health and Kinesiology, Faculty Associate, Center on Aging and the Life Course, Purdue University, West Lafayette, IN, USA*
Bruno Grassi, MD, PhD, Professor, *Department of Medical and Biological Sciences, University of Udine, Udine, Italy*
Hanns-Christian Gunga, MD, PhD, Professor, *Center for Space Medicine Berlin, Berlin, Germany*
Andrea Lenzi, MD, PhD, Professor, *Department of Medical Physiopathology and Endocrinology, Department of Experimental Medicine, University of Rome La Sapienza, Rome, Italy*
Marco V. Narici, MSc PhD, Professor of *Clinical Physiology, Faculty of Medicine & Health Sciences, University of Nottingham, School of Medicine, Nottingham, United Kingdom*
Russel S. Richardson, PhD, *Department of Internal Medicine, University of Utah Health Care, Salt Lake City, USA*
Alfred Rütten, PhD, Professor, *Friedrich-Alexander-Universität Erlangen-Nürnberg, Institute of Sport Science and Sport, Erlangen, Germany*
Peter Wagner, MD, PhD, Professor Emeritus, *University of California San Diego, Medicine Department, La Jolla (CA) USA*

For authors

Submission guidelines

Language editing services

Ethics & disclosures

Open Access fees and funding

Contact the journal

Calls for papers

Submit manuscript



Working on a manuscript?

Avoid the most common mistakes and prepare your manuscript for journal editors.

Learn more →

SPRINGER NATURE

Do you publish research?

If so, would you be willing to take 2 minutes to answer a few questions about your experience of publishing in the last year or so?

rts

Librarians (Springer Nature)

Societies and Publishing Partners

Advertisers

Shop on Springer.com

About Springer

About us

Help & Support

Contact us

Press releases

Impressum

Legal

General term & conditions

Your US state privacy rights

Rights & permissions

Privacy

How we use cookies

Your privacy choices/Manage cookies

SPRINGER NATURE

Do you publish research?

If so, would you be willing to take 2 minutes to answer a few questions about your experience of publishing in the last year or so?

Sport Sciences for Health
https://doi.org/10.1007/s11332-023-01059-7

RESEARCH

The effect of a nutrition program for weight loss during the pre-competition period on the body composition, hydration, and mood profile of elite Greco–Roman wrestlers

Muttalip Ayar[1] · **Meral Kucuk Yetgin**[2] · **Ani Agopyan**[3] · **Funda Elmacioglu**[4]

Received: 16 August 2022 / Accepted: 10 March 2023
© The Author(s), under exclusive licence to Springer-Verlag Italia S.r.l., part of Springer Nature 2023

Abstract

Objective The study aimed to investigate the effect of a nutrition program introduced among elite Greco–Roman wrestlers during the weight-loss period before the competition on the athletes' body composition, hydration, and mood.

Methods The experimental group comprised the Greco–Roman Wrestling National Team (U23) of different weights ($n=8$) and the control group consisted of substitute athletes ($n=8$) with the same weights as the experimental group. To achieve the target weight, the experimental group followed a personalized weight loss program under the supervision of a dietitian, whereas the control group lost weight using their own methods. The athletes completed a mood profile questionnaire, food and fluid consumption, urine density evaluation, anthropometric measurements, and body composition assessments were performed.

Results The athletes who followed a balanced diet under the guidance of a dietician had decreased body mass index, body weight, body fat rates (%), and urine density compared to the athletes who used traditional methods ($P<0.05$). Negative changes in the control group and positive changes in the experimental group were observed in the mood profile scores ($P<0.05$). There was a higher decrease in variables, including energy (kcal), carbohydrate (g/kg), protein (g/kg), fat (g/kg), and micronutrient consumption, in the control group ($P<0.05$).

Conclusion Change in nutritional intake at the macro and the micro level was found to be more balanced among male athletes who followed a regular and planned nutrition program under a dietitian's supervision. In addition, the experimental group had decreased body fat percentages and urine density and underwent a positive change as confirmed by their mood profile.

Keywords Wrestling · Mood profile · Nutrition · Body composition · Hydration

✉ Meral Kucuk Yetgin
meral.kucukyetgin@marmara.edu.tr

Muttalip Ayar
mttlp_ayr@hotmail.com

Ani Agopyan
aniagopyan@marmara.edu.tr

Funda Elmacioglu
fundael@gmail.com

[1] MSc Program of Physical Education and Sports, Institute of Health Sciences, Marmara University, Istanbul, Türkiye

[2] Department of Coaching Education, Sports Health Sciences, Faculty of Sports Sciences, Marmara University, Istanbul, Türkiye

[3] Department of Coaching Education, Movement and Training Sciences, Faculty of Sports Sciences, Marmara University, Istanbul, Türkiye

[4] Department of Nutrition and Dietetics, Faculty of Health Sciences, Istinye University, Istanbul, Türkiye

Introduction

Wrestling is an individual combat sport at the Olympic level, and participating athletes are grouped into certain weight classes based on their body weight to create equal competition [1, 2]. Therefore, the majority of athletes seek to maintain their weight within the predetermined limits of their weight class [3]. Accordingly, athletes are known to follow rapid weight loss (RWL) as a strategy few weeks before the competition to achieve their target weight [1, 4]. RWL is defined as losing ≥ 5% of a person's body weight within a week [5]. Athletes often resort to traditional methods, including sauna, excessive exercise, and reducing fluid and food intake to achieve RWL [6, 7]. The replacement of the body fluids lost due to these unhealthy methods takes 24–48 h, whereas at least 17 h are required to replenish the muscle glycogen stores [8]. As these methods are associated

Published online: 29 March 2023

with losses in athletic performance as well as dehydration and muscle cramps that might have a detrimental effect on health [5], following these methods should be avoided to prevent the risk posed to athletes' health [9].

Athletes follow RWL methods as early as 12 and 14 years of age, and 3–6% resort to such methods several times during a season [5]. Although some athletes and coaches are aware of the adverse effects of RWL on performance, they do ignore these effects. Inadequate fluid intake, which causes RWL, and the frequency thereof, induces dehydration [10] as well as fluid loss of 1–3% of the body weight and can have an adverse effect on performance. Furthermore, an undesirable fluid balance may lead to impaired psychomotor performance, prolonged decision-making time, and decreased perceptional capacity [11]. This further indicates the need for determining the fluid intake and dehydration levels for protecting the athletes' health and monitoring the progression of their performance.

It was reported that RWL among elite athletes was also associated with negative mood, including tension, anger, fatigue, and confusion [9]. Mood alterations are important determinants of athletic performance; therefore, it is necessary to regularly monitor the mood of athletes during the intense training process before the competition [12].

Athletes spend a wealth of energy during training and competition; thus, the consumed energy should be replaced in an adequate and balanced manner as soon as possible [8]. Accordingly, athletes need a planned nutrition program to achieve weight that is within the appropriate weight class by preserving their body composition based on scientific methods during the period before the competition. Today, there are new rules governing the weighing process before the start of the competition [13, 14].

In addition, athletes should replace the high amounts of energy spent during training and competition in an adequate and balanced way as soon as possible [8]. Accordingly, athletes need a planned nutrition program to achieve the range of the weight class by preserving their body composition based on scientific methods during the period before the competition. Today, there are new rules governing the weighing process to be introduced 2 h before the start of the competition [13].

Nevertheless, it is noteworthy that there are a limited number of studies on monitoring weight before a competition, which has multilaterally investigated the effect of dietitian-supervised nutrition programs on body composition, urine density, and mood profile among elite athletes. Accordingly, the present study aimed to compare the effect of weight loss following traditional methods and under the supervision of a dietitian during the three-week camp period before the commencement of the U-23 World Greco–Roman wrestling championship on elite athletes' nutritional status, body composition, urine density, and mood profile.

Materials and methods

Participants

The study population included permanent ($n=8$) and reserve ($n=8$) athletes, who participated in the U-23 World Championship training camp of the Turkish Greco–Roman wrestling national team. The study was conducted with a total of 16 elite athletes aged between 19 and 23 years who started their weight control at 13.50 ± 2.35 years. The experimental group consisted of 8 athletes from each weight class (59 kg, 66 kg, 71 kg, 75 kg, 80 kg, 88 kg, 98 kg, and 130 kg) who were competing. The control group consisted of reserve athletes from the same weight classes.

All the athletes were physically examined by a physician at the beginning of the study. Written consent was obtained from each athlete, confirming that they were willing to participate in the study.

Study design and procedures

This study was designed as a single-blinded, pre-test–post-test study that included experimental and control groups and was performed during a 23-day period at the Wrestling National Team Camp Center. All the athletes completed a personal information form and the mood profile questionnaire on the first day of the camp where anthropometric measurements were taken, urine samples were collected, and body compositions were analyzed.

All the athletes participated in the same training program, including conditioning in the morning (90 min/day) and technical workout in the evening (60 min/day), during the first 2 weeks (4 days/week) and basic technical workout (90 min/day) during the last week (5 days/week) before the competition under the supervision of the national team coaches. The experimental group followed a nutrition program under the supervision of a dietitian, whereas the control group did not receive the dietitian's support. All the measurements and questionnaires were repeated at the end of the camp.

Nutrient and fluid consumption record

The dietitian completed the food and liquid consumption forms pertaining to the athletes included in both groups for a total of 14 days, including consecutive days of the first and last weeks of the camp. The daily dietary energy and nutrient intake based on the data from the above forms were analyzed using Nutrition Information System (BeBiS 8-Ebispro for Windows, Germany; Turkish version), a food analysis software. Neither athlete was allowed to use any medications or support products during the study.

Nutrition program

Athletes included in the experimental group were required to follow a nutrition program developed by the team dietitian and no other methods were allowed for weight control. The athletes in the control group lost weight by following traditional methods (including sauna, excessive exercise, and reduced fluid and food intake) [6]. In the present study, the nutrition programs were personalized for each athlete in consideration of the training program. Upon calculation of daily energy expenditure (Fig. 1), nutrition programs were developed on the basis of a 15–20% energy restriction to meet the weight class criteria. ISSN 2018 data [15] were considered as a reference for carbohydrate, protein, and fat intake, whereas the Nutrition Guide Specific to Turkey 2015 data [16] were used for determining the micronutrient intake.

Anthropometric measurements and assessment of body composition

All the anthropometric parameters of the participants (height, body weight, and skinfold thickness) were measured by a specialist according to the "International Society for the Advancement of Kinanthropometry" [20] protocol. Body length was measured using a stadiometer (SECA, Germany) with a sensitivity rating of 0.01 m, and body weight was measured using an electronic scale (CAS-PB, China) with a sensitivity rating of 0.01 kg. Skin fold thickness was measured at 3 different locations on the body, including subscapular, triceps, and abdominal areas, using a skinfold caliper (Holtain, Crosswell, Crymych, UK). Each measurement was repeated 3 times on the participants' right side and the mean value was obtained [21]. Lohman's [22] body density formula, which was found [21] to be valid and reliable ($r = 0.82$) in predicting body fat percentages in athletes was used to find the body composition using the following formula: [Body Density (BD) = 1.0982 − 0.000815 (triceps + subscapular + abdominal skinfold thickness (mm)) + 0.00000084 (triceps + subscapular + abdominal skinfold thickness (mm))^2].

The body fat percentage was determined using the Brozek formula: [Body fat = (4.57/body density − 4.142) × 100] [23].

The following equations by VanItallie et al. [24] were utilized to assess the proportion of fat mass (FM) and fat-free mass (FFM).

FM (kg) = PBF (percent of body fat)/100) × weight (kg); FFM (kg) = Weight (kg) − FM (kg);

As a result, the components of body composition, such as body mass index [BMI = body weight/length^2 (kg/m^2)], body FM (kg), body fat percentage (%), fat-free body mass (kg), and fat-free body mass ratio (%) were calculated.

Hydration

Athletes provided a urine sample for immediate analysis of the urine specific gravity (USG) using a hand-held refractometer and a pen refractometer (Atago Pen Wrestling Refractometer, Japan) for cross-comparison of the same sample. The measurements were taken on an empty stomach in the morning on the first and last days of the camp (07:00–08:00 am). Hydration status was assessed based on the USG measurements. Hypo-hydration was defined as a USG of > 1.020 (g/ml), whereas severe hypo-hydration was defined as a USG of > 1.030 (g/ml) [10].

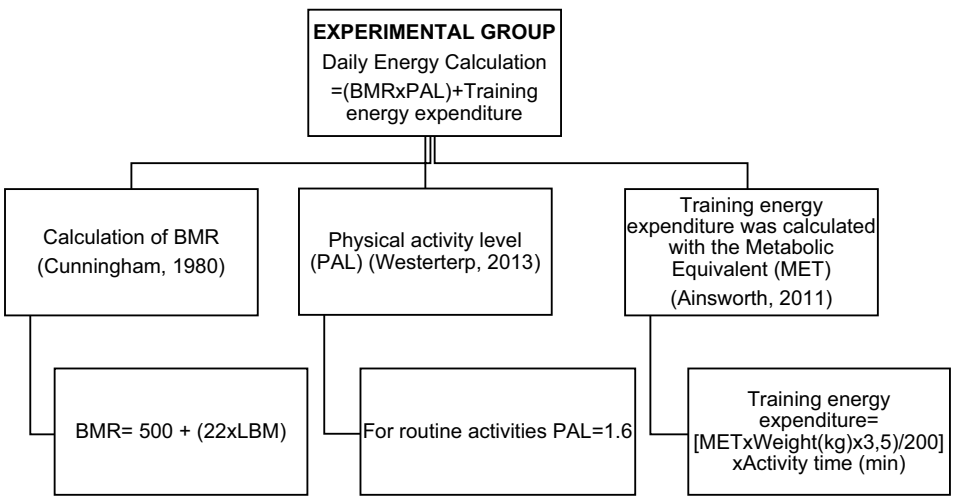

Fig. 1 Experimental group daily energy calculation [17–19]. *BMR* basal metabolic rate, *PAL* physical activity level, *MET* metabolic equivalent

Abbreviations: BMR:Basal Metabolic Rate, PAL:Physical activity level, MET: Metabolic Equivalent.

Profile of mood states (POMS)

In the present study, the mood state profile of the athletes was assessed using the POMS questionnaire developed by McNair et al. [25] POMS Manual for the Profile of Mood States. San Diego, CA: Educational and Industrial Testing Service. The reliability and validity of the Turkish version of POMS were assessed by Selvi and his colleagues [26] who reported that the reliability coefficient of the scale was in the range of 0.81–0.91. The Turkish form of the POMS scale consists of 58 items that describe the current emotional state of individuals [25]. The results consistently indicated the following 6 dimensions: "depression–dejection" − 15, "tension–anxiety" − 9, "anger–hostility" − 12, "confusion–bewilderment" − 7, "fatigue–inertia" − 7, and "vigor–activity" − 8. POMS scale is a five-point Likert-type scale with the following responses: 0 = not at all; 1 = a little; 2 = moderately; 3 = quite a bit, and 4 = extremely. According to the scores obtained on POMS, the scores obtained in the vigor–activity subscale indicate a positive mood, whereas scores from other subscales indicate a negative mood. In addition, the total score average of the five sub-dimensions is the vigor–activity sub-dimension is considered as an indicator of negative mood.

The POMS survey was completed twice, including on the first and the last day of the camp. Athletes were asked to state their mood within the last week (the week before the first day of the camp and the last week of camp), including the day the questionnaire was completed.

Statistical analysis

The Number Cruncher Statistical System 2007 (Kaysville, Utah, USA) program was used for the statistical analysis of the data collected in the study. Descriptive statistical methods were described using mean, standard deviation, median, minimum and maximum scores. The fit to a normal distribution was examined using the Kolmogorov–Smirnov Test. Intra-group pre- and post-test evaluations were performed using the Wilcoxon Signed Ranks Test, while the Mann–Whitney *U* Test was used for inter-group pre-and post-test evaluations which could not be determined using the Kolmogorov–Smirnov. A p level of < 0.05 was considered statistically significant. Effect size (ES) was calculated using Cohen's d test to determine the meaningfulness of the difference. The magnitude of the ES was classified according to the Hopkins' Scale as trivial (< 0.2), small (> 0.2–0.6), moderate (> 0.6–1.2), large (> 1.2–2.0), and very large (> 2.0–4.0) [27].

Results

Analysis results of the intergroup pre-test differences

The participants included in the experimental and control groups had similar body composition, energy intake (kcal), carbohydrate and protein components (g, g/kg), micronutrient consumption values, urine density, and mood profiles along with similar ages ($P > 0.05$). There were differences between the groups regarding the intake of fat (g), the fat intake per kg (g/kg), and water consumption, unlike the carbohydrate, protein, and fat % values ($P < 0.05$) (Tables 1, 2, 3, 4 and 5).

Analysis results of the intragroup pre- and post-test differences

Anthropometric measurements and the components of body composition

There was a statistically significant decrease in the body weight; BMI; triceps, subscapular, and abdominal skinfold thicknesses; and body fat percentage and mass and an increase in FFM (kg) in the experimental group ($P < 0.05$), whereas there was a statistically significant decrease in BMI and FFM (kg) in the control group ($P < 0.05$) (Table 1).

Nutrition program components

There was a statistically significant decrease in all values (%, g, g, and g/kg) pertaining to energy (kcal), protein (g) and protein (g/kg), CHO, and fat components of the athletes in both the experimental and control groups, whereas there was an increase in the protein (%) ($P < 0.05$; Table 2). There was a statistically significant decrease in water intake (ml) in the experimental group ($P < 0.05$; Table 2), whereas the decrease in the control group was not significant ($P < 0.05$; Table 2). There was a significant decrease in the vitamin B6, calcium, magnesium, iron, sodium, and potassium intake in both groups ($P < 0.05$; Table 3). There was no change in vitamin D intake in the experimental group ($P < 0.05$); however, there was a statistically significant decrease in the control group ($P < 0.05$; Table 3).

Hydration values

The urine density statistically significantly decreased in the experimental group and increased in the control group ($P < 0.05$; Table 4).

Table 1 Anthropometric and body composition characteristics of experimental and control groups

Variables	Experimental group ($n=8$)			Control group ($n=8$)			Baseline differences between groups	Pre–post-test differences between groups	Effect size
	Pre	Post	p^a	Pre	Post	p^a	p^b	p^c	
Age (years)	22.10 ± 1.14 19.7–23.3 (22.04)	22.17 ± 1.14 23.8–20.2 (22.1)	0.18	21.63 ± 0.92 23.3–20.6 (21.37)	21.69 ± 0.92 23.4–20.6(21.44)	0.19	*0.141*	*1.000*	–
Height (cm)	175.6 ± 6.6 165–186 (177.5)	175.7 ± 6.6 165.1–186.1 (177.5)	0.160	177.5 ± 7.8 169.7–192.6 (175.3)	177.7 ± 7.7 169.7–192.7 (175.3)	0.260	0.875	0.956	–
Body mass (kg)	84.9 ± 18.8 62.6–120 (81.2)	81.9 ± 19.2 59.2–119 (77.8)	0.012*	84.9 ± 17.5 63.5–116 (82)	83.5 ± 18.6 61.1–118 (80.4)	0.080	0.834	0.012*	1.285
BMI (kg/m^2)	27.3 ± 4.4 23–34.7 (27)	26.3 ± 4.5 21.7–34.4 (26)	0.012*	26.7 ± 3.2 22.1–31.3 (26.8)	26.2 ± 3.5 21.2–31.8 (26.2)	0.036*	0.834	0.016*	1.472
Triceps skinfold (mm)	9.7 ± 2.9 6.6–14.2 (8.2)	8.5 ± 2.3 6.2–12.2 (7.7)	0.012*	9.9 ± 5.9 5.8–23.6 (8.4)	10.3 ± 6.4 5.8–25.6 (8.8)	0.249	0.599	0.003**	1.904
Subscapular skinfold (mm)	15.1 ± 5.3 9–23.7 (13.5)	13.8 ± 4.8 8–21.2 (12)	0.012*	14.5 ± 8.4 8.6–34.2 (11.3)	14.2 ± 8.7 8.4–34.6 (11.3)	0.236	0.401	0.020*	1.359
Abdominal skinfold (mm)	13.8 ± 10.2 6.3–35.2 (8.9)	12.9 ± 10.3 6.2–35.8 (7.8)	0.048*	12.8 ± 10.4 6.2–35.2 (7.2)	13.2 ± 10.6 6.2–36.2 (7.4)	0.206	0.317	0.027*	1.205
Percent Body Fat (%)	14.0 ± 5.2 9.4–23.8 (11.3)	13.0 ± 4.9 9–22.4 (10.3)	0.012*	13.6 ± 7.2 8.7–30 (10.6)	13.7 ± 7.5 8.9–31 (10.7)	0.401	0.401	0.001**	2.247
Body Fat Mass (kg)	12.7 ± 7.9 6.6–28.6 (8.9)	11.4 ± 7.8 6.03–26.7(7.8)	0.012*	12.5 ± 8.9 5.5–34.8 (8.9)	12.5 ± 8.8 5.5–36.6 (8.8)	0.674	0.753	0.002**	2.293
Fat Free Mass (%)	85.96 ± 5.21 76.2–90.6(88.7)	87.00 ± 4.90 77.5–91 (89.7)	0.012*	86.4 ± 7.24 70–91.3(89.4)	86.30 ± 7.50 69–91.1(89.3)	0.401	0.401	0.001**	2.268
Fat Free Mass (kg)	72.20 ± 11.41 55.7–91.5(72.1)	70.40 ± 12.30 53.2–92.3 (70)	0.017*	72.40 ± 9.50 58–84.9(73.4)	70.90 ± 10.10 55.6–83.9(70.5)	0.017*	0.753	0.208	0.303

BMI body mass index, Values are presented as mean ± SD and min–max (median), *$p<0.05$; **$p<0.01$

[a]Wilcoxon signed ranks test was performed to compare within groups

[b]Mann–Whitney *U* test was performed to compare baseline differences between Experimental and Control groups

[c]Mann–Whitney *U* test was performed to compare pre–post-test differences between Experimental and Control groups

POMS There was a statistically significant decrease in the Fatigue–Stillness and Total Mood Disturbance (TMD) scores in the experimental group along with a significant increase in the Vigor–Activity score ($P<0.05$; Table 5). In the control group, there was a statistically significant increase in Tension–Anxiety, Depression–Dejection, Anger–Hostility, Fatigue–Stillness, and TMD scores ($P<0.05$; Table 5).

Comparison results of the intergroup pre- and post-test differences

Anthropometric measurements and the components of body composition

The decrease in body weight; BMI; triceps, subscapular, and abdominal skinfold thicknesses; and body fat percentage and mass and the increase in FFM (%) benefited the experimental group ($P<0.05$). The magnitude of the effect of BMI, triceps, subscapular, and abdominal changes was large ($d=1.2$–2.0). Moreover, % Fat, Fat mass (kg), and

Table 2 Statistical comparisons of energy and macronutrient consumption of the experimental and control groups

Variables	Experimental group ($n=8$)			Control group ($n=8$)			Baseline differences between groups	Pre–post-test differences between groups	Effect size
	Pre	Post	[a]p value	Pre	Post	[a]p value	[b]p value	[c]p value	
Energy (kcal)	3130.8 ± 956.5 2298.1–5282.3 (2819.8)	2605.4 ± 1140.2 1760.2–5221.5 (2221.1)	0.012*	3575.9 ± 643.9 2951.9–4961 (3515)	2053.7 ± 1286.8 1408–5205.9 (1589.9)	0.017*	0.115	0.012*	1.848
Carbohydrate (%)	47.13 ± 1.8 45–50 (47)	45.0 ± 2.4 42–49 (44.5)	0.031*	43.9 ± 2.8 39–47 (44)	39.6 ± 2.9 37–4 (38.5)	0.018*	0.023*	0.279	0.660
Carbohydrate (g)	362.28 ± 110.28 269.3–601,.7 (327.4)	289.59 ± 131.65 191.6–580.7 (232.4)	0.012*	384.30 ± 78.86 311.4–566.8 (368.7)	204.29 ± 146.69 127.1–563.1 (148.4)	0.012*	0.248	0.012*	1.891
Carbohydrate (g/kg)	4.24 ± 0.58 3.37–5.01 (4.23)	3,31 ± 0.78 2.76–4.84 (2.96)	0.012*	4.56 ± 0.51 3.55–5.31 (4.52)	2.28 ± 1.06 1.72–4.85 (1.96)	0.012*	0.208	0.012*	3.262
Protein (%)	21.88 ± 1.64 20–24 (21.5)	25.13 ± 2.53 20–28 (26)	0.018*	21.88 ± 1.64 20–28 (26)	23.50 ± 2.07 19–26 (24)	0.011*	0.001**	0.0151	0.844
Protein (g)	165.17 ± 40.10 126.4–254.6 (153.7)	153.04 ± 42.81 118.5–249.9 (140)	0.012*	162.02 ± 21.43 136–200.7 (159.2)	112.52 ± 52.38 81.3–238.2 (96.2)	0.017*	0.834	0.012*	1.435
Protein (g/kg)	1.95 ± 0.1 1.68–2.12 (1.97)	1.87 ± 0.2 1.55–2.10 (1.85)	0.012*	1.93 ± 0.2 1.60–2.22 (1.97)	1.3 ± 0.3 1.13–2.02 (1.20)	0.017*	1.000	0.009**	1.915
Fat (%)	31.0 ± 1.6 29–34 (30.5)	29.6 ± 2.7 27–35 (29)	0.040*	37.6 ± 2.6 34–43 (37)	37.0 ± 2.3 33–40 (37)	0.671	0.001*	0.958	0.250
Fat (g)	110.39 ± 39.74 77.6–202.7 (96.5)	88.81 ± 49.17 53.1–205.3 (72.1)	0.017*	151.36 ± 30.22 113–205.8 (146.5)	85.34 ± 54.21 57.8–218.5 (65.6)	0.017*	0.012*	0.012*	1.694
Fat (g/kg)	1.28 ± 0.21 0.95–1.69 (1.23)	1.0 ± 0.31 0.72–1.71 (0.89)	0.017*	1.78 ± 0.44 1.75–1.88 (1.77)	0.96 ± 0.38 0.75–1.88 (0.83)	0.017*	0.001**	0.012*	1.325
Water (ml)	3051.8 ± 707.8 2100–4214.3 (3021.42)	2628.6 ± 617.3 1842.9–3657.1 (1971.42)	0.025*	2002.7 ± 545.9 2857.1–1221.4 (2635.41)	1633.4 ± 542.6 1028.6–2871.4 (1500)	0.050	0.009**	0.563	0.125

[a]Wilcoxon Signed Ranks test was performed to compare within group

[b]Mann–Whitney U test was performed to compare baseline differences between Experimental and Control groups

[c]Mann–Whitney U test was performed to compare pre–post-test differences between Experimental and Control groups

*$p<0.05$

**$p<0.01$

FFM (%) changes were very large ($d=2.0$–4.0). There was no difference in FFM (kg) between the intergroup pre-and post-test results ($P<0.05$), and the magnitude of the effect was small ($d=0.303$) (Table 1).

Nutrition program components

With large magnitudes of effects ($d=1.2$–2.0), the decrease in energy (kcal), CHO (g), protein (g), protein (g/kg), fat (g), and fat (g/kg) intake was higher in the control group ($P<0.05$; Table 2). The decrease in CHO (%) and the increase in protein (%) were greater in the control group, and the magnitude of the effect was moderate ($d=0.6$–1.2) ($P<0.05$; Table 2). In terms of the water (ml) levels, there was no intergroup difference in the pre- and post-test results ($P<0.05$), and the magnitude of the effect was trivial ($d=0.125$; Table 2). The decrease in micronutrient consumption was higher in the control group ($P<0.05$). The effects of the magnitude of the changes in vitamin B6 (mg), calcium (mg), and potassium (mg) levels were moderate ($d=0.6$–1.2), Vitamin D (µg), magnesium (mg) and iron (mg) were large ($d=1.2$–2.0) and Sodium (mg) was very large ($d=2.0$–4.0; Table 3).

Table 3 Statistical comparisons of the micronutrient consumption status of the experimental and control groups

Variables	Experimental group ($n=8$)			Control group ($n=8$)			Baseline differences between groups	Pre–post-test differences between groups	Effect size
	Pre	Post	[a]p value	Pre	Post	[a]p value	[b]p value	[c]p value	
B_6 Vitamin (mg)	3.0 ± 0.5 2.4–4.1 (3)	2.6 ± 0.9 1.7–4.4 (2.3)	0.035*	3.2 ± 0.4 2.6–4 (3.1)	2.3 ± 0.9 1.4–4.5 (2.1)	0.017*	0.401	0.046*	0.693
D vitamin (µg)	4.9 ± 1.4 2.78–7.11 (4.95)	4.3 ± 1.5 2.97–7.11 (3.74)	0.063	5.7 ± 1.5 3.7–8.4 (5.62)	3.4 ± 1.3 1.9–6.3 (3)	0.012*	0.529	0.016*	1.383
Calcium (mg)	1641.3 ± 357.1 1227.1–2376.2 (1624.2)	1391.1 ± 457.4 938.4–2319.4 (1250.2)	0.012*	1685.8 ± 167.8 1449.8–2015.9 (1668.4)	1095.6 ± 631.4 713.7–2629.2 (880.5)	0.025*	0.401	0.016*	0.913
Magnesium (mg)	624.7 ± 121.4 495.5–890.4 (612.7)	511.5 ± 180.9 369–922.5 (453.5)	0.017*	645.5 ± 78.0 533.2–793 (641.4)	396.4 ± 206.0 241.1–890.9 (327.8)	0.017*	0.294	0.012*	1.280
Iron (mg)	21.2 ± 4.4 15.6–30.3 (20.6)	17.5 ± 4.8 13–28.8 (16.6)	0.012*	21.6 ± 3.6 16.4–27.7 (21.3)	12.9 ± 6.9 9.2–29.9 (10.2)	0.017*	0.834	0.012*	1.453
Sodium (mg)	4837.7 ± 1719.9 3584.6–8702.6 (4190.2)	3913.9 ± 1706.1 2609.6–7838.9 (3277.9)	0.012*	5887.1 ± 1257.1 4372.2–8258.1 (5742.4)	3187.2 ± 1806.7 1659.9–7547 (2678.4)	0.012*	0.317	0.006**	2.361
Potassium (mg)	5656.7 ± 931.2 4657–7441.6 (5542.9)	4844.1 ± 1313.5 3370.1–7568.9 (4536.5)	0.017*	5713.8 ± 587.4 4858.7–6826.1 (5723.6)	3876.2 ± 1733.4 2232.2–7907.3 (3482.2)	0.017*	1.000	0.012*	1.086

[a]Wilcoxon Signed Ranks test was performed to compare within group

[b]Mann–Whitney U test was performed to compare baseline differences between Experimental and Control groups

[c]Mann–Whitney U test was performed to compare pre–post-test differences between Experimental and Control groups

*$p<0.05$

**$p<0.01$

Table 4 Statistical comparisons of the urine density values of the experimental and control groups

Variables	Experimental group ($n=8$)			Control group ($n=8$)			Baseline differences between groups	Pre-post test differences between groups	Effect size
	Pre	Post	[a]p value	Pre	Post	[a]p value	[b]p value	[c]p value	
Urine density (g/ml)	1.016 ± 0.005 1.008–1.023 (1.016)	1.013 ± 0.004 1.006–1.019 (1.013)	0.012*	1.018 ± 0.008 1.005–1.027 (1.018)	1.032 ± 0.007 1.023–1.043 (1.032)	0.017*	0.401	0.006**	2.608
	Normal ($n=6$) (%75)	Normal ($n=8$) (%75)		Normal ($n=5$) (%62.5)	Normal ($n=0$) (%0)				
	Hypo-hydration ($n=2$) (%25)	Hypo-hydration ($n=0$) (%0)		Hypo-hydration ($n=3$) (%37.5)	Hypo-hydration ($n=2$) (%25)				
	Serious hypo-hydration ($n=0$) (%0)	Serious hypo-hydration ($n=0$) (%0)		Serious hypo-hydration ($n=0$) (%0)	Serious hypo-hydration ($n=6$) (%75)				

[a]Wilcoxon Signed Ranks test was performed to compare within group

[b]Mann–Whitney U test was performed to compare baseline differences between Experimental and Control groups

[c]Mann–Whitney U test was performed to compare pre–post-test differences between Experimental and Control groups

*$p<0.05$

**$p<0.01$

Table 5 Comparison of mood profile scores by groups

Variables	Experimental group ($n=8$)			Control group ($n=8$)			Baseline differences between groups	Pre–post-test differences between groups	Effect size
	Pre	Post	[a]p value	Pre	Post	[a]p value	[b]p value	[c]p value	
Tension-Anxiety	12.38 ± 3.2 6–16 (14)	10.75 ± 3.85 6–16 (11)	0.074	11.13 ± 5.89 2–20 (10)	17.88 ± 4.79 12–25 (17.5)	0.012*	0.711	0.001**	2.411
Depression—Dejection	6.38 ± 5.37 0–15 (5)	3.13 ± 2.23 0–6 (3)	0.141	9.38 ± 8.02 1–24 (7.5)	19.63 ± 13.23 5–44 (19.5)	0.012*	0.429	0.002**	1.998
Anger—Hostility	10.88 ± 5.44 3–16 (12)	7.75 ± 5.52 3–17 (5.5)	0.058	9.50 ± 9.90 0–26 (5)	22.88 ± 10.62 11–36 (21.5)	0.012*	0.370	0.001**	2.304
Fatigue—Stillness	5.63 ± 2.62 2–10 (6)	3.63 ± 2.83 0–8 (4)	0.041*	7.63 ± 4.78 1–14 (6)	15.13 ± 4.22 10–22 (16)	0.012*	0.457	0.001**	3.360
Confusion-Bewilderment	8.00 ± 3.46 4–14 (7.5)	8.13 ± 4.70 3–14 (7.5)	1.000	8.38 ± 4.03 3–13 (8.5)	9.88 ± 5.62 5–19 (7)	0.246	0.833	0.387	0.502
Vigor-Activity	18.75 ± 3.37 13–23 (19)	21.63 ± 3.29 17–27 (22)	0.021*	17.38 ± 6.05 8–26 (17)	13.50 ± 6.12 7–25 (11.5)	0.205	0.563	0.065	1.141
Total Mood Disturbance (TMD)	24.50 ± 17.03 1–51 (25.5)	11.75 ± 12.04 − 5–31 (7.5)	0.017*	28.63 ± 30.70 0–70 (14.5)	71.88 ± 37.26 21–123 (74)	0.012*	0.958	0.001**	2.773

[a]Wilcoxon Signed Ranks test was performed to compare within group

[b]Mann–Whitney U test was performed to compare baseline differences between Experimental and Control groups

[c]Mann–Whitney U test was performed to compare pre–post-test differences between Experimental and Control groups

*$p<0.05$

**$p<0.01$

Hydration values

There was a statistically significantly higher increase in the urine density in the control group compared to the decrease in the experimental group, and the magnitude of the effect was very large ($d=2.608$; $P<0.01$; Table 4).

POMS The decrease in the Tension–Anxiety, Depression–Dejection, Anger–Hostility, Fatigue–Stillness, and TMD scores was statistically significant in favor of the experimental group ($P<0.01$). The effect of the magnitude of the decrease Tension–Anxiety, Anger–Hostility, Fatigue–Stillness, and Total Mood Disturbance (TMD) was very large ($d=2.0$–4.0) and Depression–Dejection was large ($d=1.2$–2.0; Table 5). The anthropometric measurements, body composition, macro, and micronutrient values, urine density, and descriptive statistics for pre-and post-test results (mean, standard deviation, median, minimum, and maximum values) of mood profile components, and the intra- and inter-group analyses are presented in tabular form (Tables 1, 2, 3, 4 and 5).

Discussion

The results of our study suggested that elite Greco–Roman wrestlers who followed a dietitian-supported personalized balanced diet during the three-week camp period had decreased body weight, BMI, skin fold thickness, body fat and FM, and urine density and demonstrated a positive change in mood profiles (a medium to the large magnitude of effect) compared to the controls who followed the traditional method. Moreover, the change in the macro- and micro-nutrient intake was more balanced in favor of the experimental group.

The approximate weekly weight loss of athletes during short periods was reportedly 3–7 kg [28]. At the beginning of the study, the body weight of the athletes in both groups was found to be similar and exceeded the targeted weight (by 3.5–4.5 kg). Athletes who received dietitian support lost more weight and attained a weight that was very close to the target weight in the competition (− 0.25 kg). Athletes who did not receive dietician support failed to reach their target weight by an average deviation in weight of 2.12 kg. This

result is suggestive of the importance of seeking dietitian support in cases where the weight should be lost over a relatively short period among athletes.

Excessive training during the pre-competition period is a traditional method that is followed to ensure RWL among athletes. Cutrufello et al. [29] reported that male wrestlers might lose 1.5 ± 0.2 kg of body weight after 2 h of wrestling training [28]. However, it was also reported that the acute weight loss that occurs following training before the weigh-in on the day of the competition was attributable to fluid loss and was an unhealthy method for RWL [28]. It is a remarkable result of our study that although all the athletes underwent the same training program, those that received dietitian support achieved better results concerning achieving their target weight based on weight class. Athletes in the control group, which did not receive dietitian support, did not achieve the target weight based on their weight class, despite visiting a sauna and undergoing extra training in thick clothes before the weigh-in. These results are consistent with the results of studies [28] that suggested that RWL was often sought through traditional methods before the competition in combat sports and athletes participating in competitions that necessitate the use of weight classes. Furthermore, it was also emphasized that upon RWL, the athletes might not be able to attain replacement in terms of energy and fluid over a short duration and that their performance might be adversely affected [30]. Ultimately, it was suggested that following a weight-control method spanning the entire duration of the annual training period under the supervision of a dietitian would be much more useful for maintaining the athletes' health and improving their performance.

Concerning sports performance, body composition characteristics constitute the primary factor in the development of conditioning programs during the competition season [31]. In the present study, the group that received dietitian support had a higher decrease in skinfold thickness as well as in fat percentage (− 1.01%) compared to the group that resorted to the traditional method. Studies on elite athletes reported a body fat percentage range of 7.4–13% [32, 33]. The weight classes, age categories, and measurement methods may account for the differences in the distribution reported by relevant studies. In the present study, the fat percentage values varied across a wide range owing to weight class differences (8.88–30.98%). On the other hand, the average fat percentage values of the athletes in both groups were similar to the results reported in similar studies [32, 33].

Some of the RWL owing to the high amount of energy restriction may manifest in the form of FFM [34]. In the present study, the average decrease in FFM level (kg) in both groups suggested that athletes might have undergone RWL over a short duration. Nevertheless, it is remarkable that there was an increase in the percentage of FFM in parallel with the decrease in fat weight in the experimental group compared to the control group. The FFM rate of the athletes who received dietitian support increased (1.04%), whereas the same slightly decreased in those who did not receive support. In similar studies, the FFM rate in athletes who lost weight gradually using a nutrition program increased by 2% in 20 days [35] and by 2.98% in 6 weeks [36]; these results are consistent with the results of our study. Although it is possible to lose FM while potentially maintaining the FFM, the intervention must comply with scientific dietary guidelines [34]. Slower weight loss will help better maintain the FFM in athletes. However, it was reported that a protein-rich diet (1.6 to 2.2 g/kg/day) might reduce the FM, while maintaining the FFM [37].

It was reported in a study with young elite athletes that the average daily energy intake was 4958 kcal during the period without any attempt to lose weight [38]. In weight-class sports, the daily energy consumption of athletes decreases during weight-reduction periods compared to the normal periods [35, 39]. The daily energy consumption of both groups of athletes was decreased to induce a change in body composition during the study period; this indicates that the restriction on the energy consumption of athletes who lose weight without dietitian intervention is greater than that of athletes under dietician supervision and that traditional methods fail to regulate energy intake in a balanced manner.

Proteins, carbohydrates, and fats, i.e. the macronutrients required to provide energy daily, are especially important in meeting the daily energy needs of athletes. The carbohydrate consumption among athletes was suggested to be within the range of 3–4 g/kg before performing short-term high-intensity exercises [38] and 5–7 g/kg before performing medium-intensity exercises [40]. Furthermore, a review of the published guidelines on the nutrition of athletes indicated that carbohydrate consumption between 3 and 12 g/kg was necessary [15]. In our study, the energy and nutrient (carbohydrate, protein, and fat) consumption of the athletes included in the experimental group was planned considering their body weight. The pre- and post-test carbohydrate consumption of athletes in the experimental group was 4.24 g/kg and 3.31 g/kg, respectively, and these values were considered to be sufficient for high-intensity short-term exercises. In contrast, the mean pre- and post-test levels in the control group were 4.56 g/kg and 2.28 g/kg, respectively. In a study that ensured a weight loss of 6% over a 3-day period, Kondo et al. found that the athletes had a carbohydrate intake of 6.9 ± 1.9 g/kg during the normal period and 2.1 ± 1.0 during the weight-control period [39].

A protein intake of 1.2–1.7 g/kg was suggested to be sufficient for athletes, whereas in cases where energy is restricted for weight loss purposes, an increase in the same to 2.0–2.5 g/kg was recommended [40]. Published guidelines generally recommend that protein consumption should

range between 1.2 and 2.0 g/kg [15]. The daily protein intake of the athletes in both groups was similar and within the recommended range (1.2–2.0 g/kg) at the beginning of the present study [15]. However, the significant decrease in the post-test protein levels in the control group compared to that at the beginning of the study (1.3 g/kg) might be attributable to the subconscious weight loss program without dietitian intervention followed by the athletes in this group. The protein intake was 1.7 ± 0.4 g in the normal period compared to 0.5 ± 0.2 g during the weight-loss period among the athletes, who lost 6% of their body weight in 3 days by following traditional methods for RWL [38]. The radical decrease in protein intake reported in the study by Kondo et al. might have been attributable to the short duration of the weight loss period [39]. In the present study, the decrease in protein (g/kg) consumption in the experimental group was lower compared to that in the control group. This is indicative of the fact that a qualified nutrition program under the supervision of a dietitian will ensure that even the decreases in macronutrient consumption occur in a controlled manner. Moreover, the macronutrient intake of the group that received dietitian support appeared to be in line with the current sports nutrition guidelines [15].

In our study, the decrease in the fat (g/kg) intake (78.1%) in the group of athletes who received dietitian support was higher compared to that in those who did not receive support (54%), but this decrease was within the recommended daily limits for athletes.

An assessment of micronutrient consumption showed that all except for vitamin D and potassium were compliant with the TÜBER 2015 reference values in the experimental and control groups (vitamin D (15 µg–400 IU), potassium (4.7 g/day)) [16]. The fact that the potassium intake of the control group was lower compared to the reference values at the end of the camp may be attributed to the imbalances in the energy intake.

One of the irrational nutrition strategies that athletes follow to meet the weight class requires to significantly reducing fluid intake a few days before the competition. In our study, the fact that the duration and frequency of training conducted 1 week before the competition was decreased by half compared to the pre-test values may account for the fact that water consumption was decreased in the athletes from both groups as observed during the post-test evaluation. In our study, the fact that the water consumption of athletes who received dietitian support was lower compared to that at the onset of the study, but higher compared to the control group ensured that the urine density was maintained at optimal levels. Relevant studies that investigated hydration based on urine density on the day of competition in athletes participating in competitions requiring weight classes reported that the hydration status was impaired in groups that lost weight by following traditional methods [41]. The fact that better hydration conditions are associated with higher muscle contraction time in athletes can also have a positive impact on performance [42]. Another important finding of the present study is that upon the post-test hydration measurements, 25% of the group that lost weight without dietitian support had hypo-hydration and 75% had severe hypo-hydration, whereas all the athletes who received dietitian support during weight loss were within the normal hydration range. These results are suggestive of the fact that the qualified nutrition programs implemented with dietitian support contribute to the healthy control of dehydration in athletes, especially when RWL is required.

Several studies in the relevant literature investigated the relationship of mood profiles with RWL among athletes across different sports [10, 43, 44]. These studies suggested that RWL caused short-term memory loss, decreased concentration, and increased anger, fatigue, and depression scores among athletes [42]. It was reported that an average of 5% RWL in boxers and judokas was associated with increased anger, fatigue, and tension scores, and weightlifters also had depression in addition to the above manifestations [10]. Negative emotions, including anger, fatigue, tension, depression, and confusion may increase after exercise or RWL over a short period [43]. In the present study, dietitian support had a positive effect on the mood profile of athletes.

Conclusions

As a result, it was found that a regular and planned nutrition program under the supervision of a dietitian during the three-week camp period among elite Greco–Roman wrestlers was effective in decreasing body weight, BMI, skinfold thickness, body fat ratio, and urine density, and induced a positive change in the mood profile. It was concluded that the change in energy and micro and macronutrient intake was more balanced among the elite male athletes who were supported by a regular and planned nutrition program specific to each athlete, and a certain extent of positive changes in body composition, mood profile, and urine density was observed. Supporting weight loss over a longer period through nutrition programs provided by athlete nutrition specialists instead of incorrect short-term weight loss methods used in wrestling and similar weight-class sports is important for maintaining and improving athletes' health and performance. Following the wrong strategies during the weight-loss period may be associated with adverse effects on health in the future. The results of the present study generally demonstrated the importance of providing dietitian support for the entire season covering non-camp periods that the athletes attend to the camps with body weight above the limitations of their weight class.

Limitations

The study was designed as a single-blinded study. Although the researchers knew which athletes would be on the national team's permanent list, to determine which athletes would be included in the experiment and control groups, the athletes were not informed. The fact that the athletes did not know the use of different nutrition programs between the experimental and control groups had a limited effect on the conduct of the study. The study was limited to a 23-day training camp period of the Greco–Roman wrestling national team.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s11332-023-01059-7.

Acknowledgements The authors would like to thank all athletes who participated in the study, and Turkish Wrestling Federation for their collaboration.

Author contributions All authors contributed to the research design. MA and MKY designed the questionnaire. MA and AA analysed the data. MA initiated the study and recruited elite wrestlers for the study. FE and MKY supervised the study. All authors prepared and approved the final manuscript.

Data Availability Due to the nature of this research, participants of this study did not agree for their data to be shared publicly, so supporting data are not available.

Declarations

Conflict of interest The authors declare that they have no competing interests.

Ethical approval The ethical approval of the study was gathered from the Clinical Trials Ethics Committee of Marmara University Faculty of Medicine (No. 09.2017.545) and was by ethical principles stated in the Declaration of Helsinki.

References

1. Castor-Praga C, Lopez-Walle JM, Sanchez-Lopez J (2021) Multilevel evaluation of rapid weight loss in wrestling and taekwondo. Front Sociol 6:637–671. https://doi.org/10.3389/fsoc.2021.637671
2. Ulupınar S, Özbay S, Gençoğlu C, İnce İ (2021) Performance differences between Greco-Roman and freestyle wrestlers: a systematic review and meta-analysis. J Strength Cond Res 35(11):3270–3279. https://doi.org/10.1519/jsc.0000000000004129
3. Zaccagni L (2012) Anthropometric characteristics and body composition of Italian national wrestlers. Eur J Sport Sci 12(2):145–151. https://doi.org/10.1080/17461391.2010.545838
4. Özbay S, Ulupınar S (2022) Strength-power tests are more effective when performed after exhaustive exercise in discrimination between top-elite and elite wrestlers. J Strength Cond Res 36(2):448–454. https://doi.org/10.1519/jsc.0000000000003456
5. Nishimaki M, Kondo E, Teo C, Nakajima K, Yamashita D (2020) Prevalence, methods of rapid weight loss among elite Japanese wrestlers based on a questionnaire-based study of the 2016 Japanese Wrestling Championship. J High Perform Sport 6:12–27. https://doi.org/10.32155/jissjhps.6.0_12
6. Coutinho LA, Porto CP, Pierucci AP (2016) Critical evaluation of food intake and energy balance in young modern pentathlon athletes: a cross-sectional study. J Int Soc Sports Nutr 13:15. https://doi.org/10.1186/s12970-016-0127-x
7. Ulupinar S, Özbay S, Gençoğlu C (2020) Siklet Sporlarında Dehidrasyon ve Hiponatremi. (Dehydration and Hyponatremia in Weighing), Sports Ulusal Spor Bilimleri Dergisi 4(2):103–115. https://doi.org/10.30769/usbd.782358
8. Case SH, Horswill CA, Landry GL, Oppliger RA, Shetler AC (2016) Weight loss in wrestlers. American College of Sports Medicine, Indianapolis
9. Sundgot-Borgen J, Meyer NL, Lohman TG, Ackland TR, Maughan RJ, Stewart AD, Müller W (2013) How to minimise the health risks to athletes who compete in weight-sensitive sports review and position statement on behalf of the Ad Hoc Research Working Group on Body Composition, Health and Performance, under the auspices of the IOC medical commission. Br J Sports Med 47(16):1012–1022. https://doi.org/10.1136/bjsports-2013-092966
10. Durguerian A, Bougard C, Drogou C, Sauvet F, Chennaoui M, Filaire E (2016) Weight loss, performance and psychological related states in high-level weightlifters. Int J Sports Med 37(3):230–238. https://doi.org/10.1055/s-0035-1555852
11. Pettersson S, Berg CM (2014) Hydration status in elite wrestlers, judokas, boxers, and taekwondo athletes on competition day. Int J Sport Nutr Exerc Metab 24(3):267–275. https://doi.org/10.1123/ijsnem.2013-0100
12. Karimi M, Keshavarz S, Ansari MJ, Etaati A (2013) Mood changes during a period of incremental training and following tapering strategies in elite male wrestlers. Int J Wrestl Sci 3(1):48–57. https://doi.org/10.1080/21615667.2013.10878969
13. International Wrestling Rules (IWR) (2020) https://unitedworldwrestling.org/sites/default/files/2020-03/wrestling_rules.pdf Accessed 01 Aug 2020
14. Ulupınar S, Özbay S, Gençoğlu C, Özkara A (2020) Attitudes towards nutritional sport supplement of national and international kickboxers. Ambient Sci. https://doi.org/10.21276/ambi.2020.07.sp1.oa04
15. Kerksick CM, Wilborn CD, Roberts MD, Smith-Ryan A, Kleiner SM, Jäger R, Collins R, Cooke M, Davis JN, Galvan E, Greenwood M, Lowery LM, Wildman R, Antonio J, Kreider RB (2018) ISSN exercise & sports nutrition review update: research & recommendations. J Int Soc Sports Nutr 15(1):38. https://doi.org/10.1186/s12970-018-0242-y
16. Turkey Nutrition Guide TÜBER 2015, 2016. Ankara, T.C. Ministry of Health Publication No: 1031.
17. Cunningham JJ (1980) A reanalysis of the factors influencing basal metabolic rate in normal adults. Am J Clin Nutr 33(11):2372–2374. https://doi.org/10.1093/ajcn/33.11.2372
18. Westerterp KR (2013) Physical activity and physical activity induced energy expenditure in humans: measurement, determinants, and effects. Front Physiol 4:90. https://doi.org/10.3389/fphys.2013.00090
19. Ainsworth BE, Haskell WL, Herrmann SD, Meckes N, Bassett DR, Tudor-Locke C, Greer JL, Vezina J, Whitt-Glover MC, Leon AS (2011) 2011 Compendium of physical activities: a second update of codes and MET values. Med Sci Sports Exerc 43(8):1575–1581. https://doi.org/10.1249/MSS.0b013e31821ece12
20. Marfell-Jones MJ, Stewart AD, Olds T, de Ridder JH (2011) International Standards for Anthropometric Assessment (ISAK). Lower Hutt, New Zealand ISBN 9780620362078.
21. Clark RR, Oppliger RA, Sullivan JC (2002) Cross-validation of the NCAA method to predict body fat for minimum weight in

collegiate wrestlers. Clin J Sport Med 12(5):285–290. https://doi.org/10.1097/00042752-200209000-00005
22. Lohman TG, Roche F, Martorell R (1991) Anthropometric standardization reference manual. Human Kinetics, Champaign
23. Brožek J (1966) Body composition: models and estimation equations. Am J Phys Anthropol 24(2):239–246. https://doi.org/10.1002/ajpa.1330240212
24. VanItallie TB, Yang MU, Heymsfield SB, Funk RC, Boileau RA (1990) Height-normalized indices of the body's fat-free mass and fat mass: potentially useful indicators of nutritional status. Am J Clin Nutr 52(6):953–959. https://doi.org/10.1093/ajcn/52.6.953
25. McNair DM, Lorr M, Droppleman LF (1971) Manual for the profile of mood states. San Diego, CA: Educational and Industrial Testing Services. p. 27
26. Selvi Y, Gulec M, Aydin A, Besiroglu L (2011) Psychometric evaluation of the Turkish language version of the Profile of Mood States (POMS). J Mood Disorders 1(4):152–161. https://doi.org/10.5455/jmood.20110902072033
27. Hopkins W, Marshall S, Batterham A, Hanin J (2009) Progressive statistics for studies in sports medicine and exercise science. Med Sci Sports Exerc 41(1):3–13. https://doi.org/10.1249/MSS.0b013e31818cb278
28. Yousef Abadi HA, Mirzaei B, Habibi H, Barbas I (2018) Prevalence of rapid weight loss and its effects on elite cadet wrestlers participated in the final stage of national championships. Int J Sport Stud Health 1(1):e64316. https://doi.org/10.5812/intjssh.64316
29. Cutrufello PT, Dixon CB (2014) The effect of acute fluid consumption following exercise-induced fluid loss on hydration status, percent body fat, and minimum wrestling weight in wrestlers. J Strength Cond Res 28(7):1928–1936. https://doi.org/10.1519/jsc.0000000000000339
30. Kukidome T, Shirai K, Kubo J, Matsushima Y, Yanagisawa O, Homma T, Aizawa, (2008) MRI evaluation of body composition changes in wrestlers undergoing rapid weight loss. Br J Sports Med 42(10):814–818. https://doi.org/10.1136/bjsm.2007.044081
31. Masanovic B, Vukasevic V (2020) Differences in anthropometric characteristics between junior handball and volleyball players. J Anthr Sport Phys Educ 4(1):9–14. https://doi.org/10.26773/jaspe.200102
32. Devrim-Lanpir A, Badem EA, Işık H, Çakar AN, Kabak B, Akinoglu B, Kocahan T, Hasanoglu A, Rosemann T, Knechtle B (2021) Which body density equations calculate body fat percentage better in Olympic wrestlers?-comparison study with air displacement plethysmography. Life (Basel) 11(7):707. https://doi.org/10.3390/life11070707
33. Moghanlou AE, Gursoy R, Aggon E (2021) Examining the relationship between body composition values and performance indicators in wrestlers at the World Cup. Ido Mov Cult J Martial Arts Anthrop 21(3):23–28. https://doi.org/10.14589/ido.21.3.4
34. Willoughby D, Hewlings S, Kalman D (2018) Body composition changes in weight loss: strategies and supplementation for maintaining lean body mass, a brief review. Nutrients 10(12):1876. https://doi.org/10.3390/nu10121876
35. Miranda KA, Gheller RG, da Silva IM, PicanÇo LA, Dos Santos JO (2021) Effects of gradual weight loss on strength levels and body composition in wrestlers athletes. J Sports Med Phys Fitness 61(3):401–406. https://doi.org/10.23736/s0022-4707.20.11254-4
36. Bakońska-Pacoń E, Dziubek W, Forgiel G, Murawska-Ciałowicz E, Zatoń M, Witkowski K (2017) Effects of gradual weight loss on anaerobic capacity and muscle strength in elite taekwondo ITF athletes. Arch Budo 13:117–130
37. Morton RW, Murphy KT, McKellar SR, Schoenfeld BJ, Henselmans M, Helms E, Aragon AA, Devries MC, Banfield L, Krieger JW, Phillips SM (2018) A systematic review, meta-analysis and meta-regression of the effect of protein supplementation on resistance training-induced gains in muscle mass and strength in healthy adults. Br J Sports Med 52(6):376–384. https://doi.org/10.1136/bjsports-2017-097608
38. Teacher NK (2021) Study and analysis of energy consumption of the macronutrients and energy expenditure of the highly qualified freestyle wrestlers. Cent Asian J Edu 6(1):1–14
39. Kondo E, Sagayama H, Yamada Y, Shiose K, Osawa T, Motonaga K, Ouchi S, Kamei A, Nakajima K, Higaki Y, Tanaka H, Takahashi H, Okamura K (2018) Energy deficit required for rapid weight loss in elite collegiate wrestlers. Nutrients 10(5):536. https://doi.org/10.3390/nu10050536
40. Stanzione JR, Volpe SL (2019) Nutritional considerations for wrestlers. Nutr Today 54(5):207–212. https://doi.org/10.1097/NT.0000000000000362
41. Ceylan B, Baydil B, Aydos L (2021) Weigh-in time affects hydration status and acute weight gain in combat sports: a comparison of judo and wrestling. Rev Artes Marciales Asiáticas 16(2):80–88
42. García JM, Rico BC, Massuça LFM, Yabar LJP, Vicen JA (2016) Impact of hydration on muscle contraction properties of elite competitive wrestlers. Arch Budo 12:25–34
43. Franchini E, Brito CJ, Artioli GG (2012) Weight loss in combat sports: physiological, psychological and performance effects. J Int Soc Sports Nutr 9(1):52. https://doi.org/10.1186/1550-2783-9-52
44. Selmi O, Khalifa WB, Zouaoui M, Azaiez F, Bouassida A (2018) High intensity interval training negatively affects mood state in professional athletes. Sci Sports 33(4):e151–e157. https://doi.org/10.1016/j.scispo.2018.01.008

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Springer Nature or its licensor (e.g. a society or other partner) holds exclusive rights to this article under a publishing agreement with the author(s) or other rightsholder(s); author self-archiving of the accepted manuscript version of this article is solely governed by the terms of such publishing agreement and applicable law.