

Article

Effectiveness of Resistance Training Program on Body Composition in Adults Following Vegan Diet versus Omnivorous Diet; Developed in Mobile Health Modality

Richar Cárcamo-Regla ¹, Rafael Zapata-Lamana ^{2,3,*}, Carolina Ochoa-Rosales ^{4,5}, Miquel Martorell ^{1,6},
Fernanda Carrasco-Marín ¹ and Guillermo Molina-Recio ^{7,8}

- ¹ Centro de Vida Saludable, Universidad de Concepción, Concepción 4070386, Chile; ricarcamo@udec.cl (R.C.-R.); mmartorell@udec.cl (M.M.); fercarrasco@udec.cl (F.C.-M.)
 - ² Escuela de Kinesiología, Facultad de Salud, Universidad Santo Tomás, Los Ángeles 4440000, Chile
 - ³ Escuela de Educación, Campus Los Ángeles, Universidad de Concepción, Los Ángeles 4440000, Chile
 - ⁴ Latin American Brain Health Institute (BrainLat), Adolfo Ibáñez University, Santiago 7941169, Chile; caroochoa.r@gmail.com
 - ⁵ Department of Human Genetics, Radboud University Medical Center, 6525 GA Nijmegen, The Netherlands
 - ⁶ Departamento de Nutrición y Dietética, Facultad de Farmacia, Universidad de Concepción, Concepción 4070386, Chile
 - ⁷ Department of Nursing, Pharmacology, and Physiotherapy, University of Córdoba, 14014 Córdoba, Spain; gmrsurf75@gmail.com
 - ⁸ Lifestyles, Innovation, and Health (GA-16), Maimonides Institute for Biomedical Research of Córdoba (IMIBIC), 14004 Córdoba, Spain
- * Correspondence: zapatalamanar@gmail.com; Tel.: +56-41-2661629



Citation: Cárcamo-Regla, R.; Zapata-Lamana, R.; Ochoa-Rosales, C.; Martorell, M.; Carrasco-Marín, F.; Molina-Recio, G. Effectiveness of Resistance Training Program on Body Composition in Adults Following Vegan Diet versus Omnivorous Diet; Developed in Mobile Health Modality. *Nutrients* **2024**, *16*, 2539. <https://doi.org/10.3390/nu16152539>

Academic Editor: Giorgos K. Sakkas

Received: 22 June 2024

Revised: 17 July 2024

Accepted: 18 July 2024

Published: 2 August 2024



Copyright: © 2024 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

Abstract: Background: The vegan diet (VEG_D) has gained popularity in recent years for ecological and ethical reasons, as well as for its health benefits. In addition to the type of diet, the resistance training program (RT_P) plays a fundamental role as one of the main natural anabolic stimuli to increase musculoskeletal mass and reduce fat mass. Methods: The study was a 16-week non-randomized controlled clinical trial consisting of three RT_P sessions per week. The sample included 70 Chilean individuals, aged between 18 and 59 years, who had been following a VEG_D or omnivorous diet (OMN_D) for the past 6 months. Four groups were established: Vegan Diet Resistance Training Program (VEG_D-RT_P), Vegan Diet Control (VEG_D-C), Omnivorous Diet Resistance Training Program (OMN_D-RT_P), and Omnivorous Diet Control (OMN_D-C). Results: The sample consisted of 47 women and 23 men, with a mean age of 30.1 (±8.6) years. A reduction of 1.20% in the percentage of fat mass (%FM) was observed in the VEG_D-RT_P group ($r = 0.554$, $p = 0.016$), as well as a reduction of 0.70 kg in kilograms of fat mass (KFM) ($r = 0.480$, $p = 0.036$). The OMN_D-RT_P group decreased %FM by 0.90% ($r = 0.210$, $p = 0.432$) and KFM by 0.50 kg ($r = 0.109$, $p = 0.683$). Conclusions: RT_P combined with VEG_D or OMN_D significantly reduced the percentage of fat mass, although its effect was more significant in the VEG_D-RT_P participants.

Keywords: vegan diet; non-randomized controlled trial; body composition; resistance training; mobile health; fat mass reduction

1. Introduction

The vegan diet (VEG_D) is characterized by the complete exclusion of animal products. It is primarily composed of plant-based foods such as cereals, legumes, fruits, and vegetables [1,2]. This dietary pattern has gained popularity in recent years due to ecological and ethical motivations and the health benefits it has demonstrated [3–5]. The VEG_D is rich in dietary fiber, has low energy density, and is low in fats, which can increase the thermic effect of food, a physiological phenomenon that represents approximately 10% of total energy expenditure [6]. Plant-based foods are also rich sources of phytochemicals, vitamins,

minerals, antioxidants, and unsaturated fatty acids [7–10], which contribute to effective glycogen storage and reduced oxidative stress, promoting a reduction in body fat [11].

However, a poorly planned VEG_D can lead to micronutrient deficiencies such as vitamin B12, vitamin D, iron, zinc, calcium, and iodine, as well as macronutrient deficits, especially proteins [12–14]. Nutritional deficiency has been shown to cause muscle mass loss and bone demineralization in the medium and long term [15]. It is crucial to consider that the musculoskeletal tissue plays a fundamental role in maintaining muscle mass and strength throughout life, providing the contractile force necessary for postures and locomotor activities such as walking and gripping [15]. Additionally, muscle tissue is vital in endocrine regulation, affecting insulin sensitivity and the metabolism of various energy substrates and promoting the maintenance of a healthy body composition [14,16].

Nevertheless, maintaining muscle mass does not rely exclusively on diet [3]. The anabolic effects of regular resistance training (RT_P) have been demonstrated to be capable of generating a positive protein balance post-exercise through increased muscle protein synthesis, thus acting as a significant natural anabolic stimulus, leading to increased musculoskeletal mass [17]. However, some authors question the anabolic properties of plant-based proteins, mainly due to differences in the composition of specific essential amino acids, such as lysine and methionine, arguing that their availability is lower compared to animal proteins. Despite this, there is insufficient information about a diminished anabolic response in individuals with VEG_D compared to those with OMN_D, as initial studies have not found a clear difference between an omnivorous and a vegan diet in terms of muscle strength or mass [3].

On the other hand, despite the evident benefits of physical exercise, its regular practice has been a challenge for many people who spend prolonged periods in sedentary behavior. Many fail to meet the physical activity recommendations established by the WHO, which suggests 150 to 300 min of moderate to vigorous physical activity per week, or 75 min of vigorous physical activity, including muscle-strengthening activities at least 3 days a week while focusing on major muscle groups [18]. However, the adoption of this sedentary behavior has shown a significant increase in recent years, as observed in the Chilean population where sedentary levels reach 86.7%, resulting in 74.2% of adults being overweight [19].

Given this emerging trend motivating more individuals to adopt a vegan diet (VEG_D) and the importance that muscle training has demonstrated, it seems pertinent to investigate how RTP can affect body composition when combined with a VEG_D. Therefore, the aim of this study was to evaluate the effectiveness of RT_P implemented through a Mobile Health Modality in individuals who follow a VEG_D compared to those who follow an omnivorous diet (OMN_D), analyzing its effect on body composition (body fat percentage, fat mass, and lean mass). The null hypothesis (H₀) states that there are no significant differences in body composition between individuals following a vegan diet and those following an omnivorous diet when both groups perform RT_P, while the alternative hypothesis (H₁) suggests that there are significant differences in body composition between these groups under the same conditions.

2. Materials and Methods

2.1. Study Design

A non-randomized controlled clinical trial was conducted with measurements taken at the beginning and end of a 16-week intervention, following the recommendations of TREND (Transparent Reporting of Evaluations with Non-Randomized Designs). Four groups were established: VEG_D-RT_P (22 individuals following a VEG_D pattern and participating in RT_P), VEG_D-RT_P Control (27 participants, VEG_D without RT_P), OMN_D-RT_P (16 subjects, OMN_D with RT_P), and OMN_D-RT_P Control (18 individuals, OMN_D without RT_P). Group assignment was not randomized, with each participant, classified by diet type, choosing to participate in RT_P or not based on their convenience. Participant recruitment was carried out in accordance with the principles of the Declaration of Helsinki and was

approved by the Ethics, Bioethics, and Biosafety Committee of the University of Concepción (CEBB 1068-2021). Additionally, the study was registered in clinical trials with the identification number NCT06423209. To comply with safety in the use of masks and data management, volunteers were assigned an identification number (ID) upon registration in the form, so neither the evaluator, the nutritionist verifying the diet type, nor the researcher analyzing the data knew to which group each participant belonged.

2.2. Participants

The sample consisted of 83 subjects aged 18 to 59 residing in the Biobío and Araucanía regions of Chile who had maintained a VEG_D or OMN_D for at least the past 6 months. Participant selection was carried out using a non-probabilistic snowball method based on an open invitation disseminated on social media and among VEG_D communities from December 2021 to April 2022. Posters with a QR code were used, which redirected people to an online form for the researcher to contact them.

The sample size was calculated based on a t-test for a multiple fixed-effects linear regression. A conservative effect size was chosen for differences in fat mass percentage ($f^2 = 0.15$) with 3 study predictors. A statistical power of 80% ($\beta = 0.2$) and $\alpha = 0.05$ were considered. Consequently, the sample size resulted in 55 participants. Additionally, a potential follow-up loss of 45% was considered, thus recruiting 80 subjects, with 20 individuals per study group. This high prediction of follow-up loss was made due to the intervention being in mHealth mode, with limited adherence evidence, potentially leading to higher dropout rates. Power calculations were performed using G*Power version 3.1.9.7.

All baseline assessments were conducted during April and May 2022. Additionally, to verify the participants' diet type prior to the intervention, a registered dietitian conducted an interview using a validated survey on quantified food consumption trends, involving 14 food groups [20]. Participants were instructed not to make any changes to their diet during the intervention period. All assessments were repeated in October 2022, following the 16-week intervention, under the same protocol conditions, using calibrated instruments and the same evaluator. Furthermore, a brief semi-structured interview was conducted to verify that participants had not made any dietary modifications during this period.

Exclusion criteria included individuals diagnosed with diabetes, uncontrolled hypertension (with Systolic Blood Pressure > 150 and/or Diastolic Blood Pressure > 90 mmHg), those undergoing cancer treatment, chronic kidney disease, or those reporting health issues in a pre-exercise aptitude questionnaire (PAR-Q) [21]. These measurements were performed by a trained and experienced physical education teacher. Additionally, individuals reporting participation in an exercise program or more than 3 h of vigorous exercise weekly were excluded, verified through a self-reported physical activity and sedentary time questionnaire for the last 7 days, using the abbreviated version of the International Physical Activity Questionnaire (IPAQ) [22].

2.3. Intervention

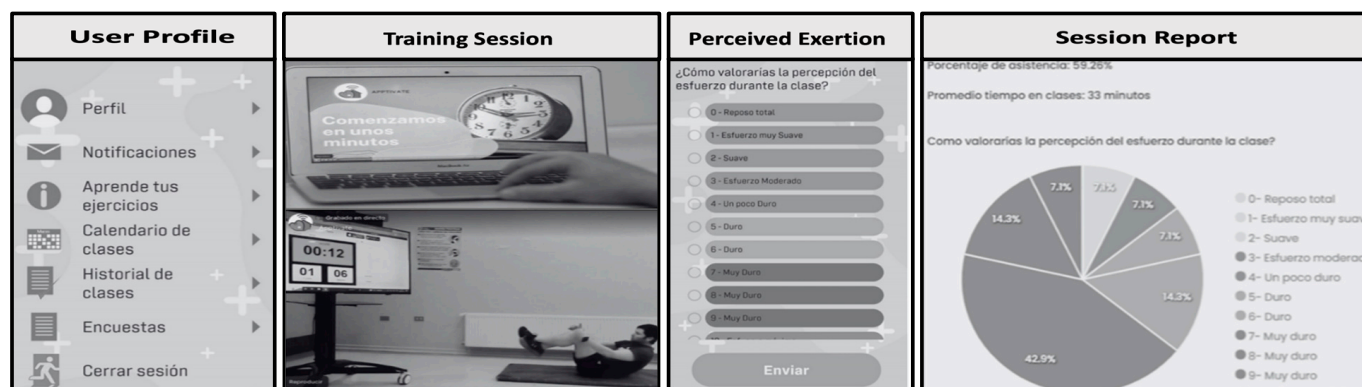
Assignment to the RT_P or Control groups was carried out at the time of completing the intake evaluation, where each participant, according to their type of diet, indicated whether they wished to participate in the RT_P. Once assigned to a group, the participant could not modify their choice under the intention-to-treat principle. The RT_P was implemented remotely between June and September 2022, using the mobile health (mHealth) modality, defined as "the use of mobile and computing technologies in the provision of health and public health services," through the University of Concepción's mHealth digital platform (Apptivate, DDI 2023-A-739, Concepción, Chile) [23]. The VEG_D-RT_P ($n = 22$) and OMN_D-RT_P ($n = 16$) groups participated in an RT_P for a period of 16 weeks, completing a total of 50 training sessions distributed over three weekly sessions, each lasting between 40 and 50 min.

All participants were asked not to make any modifications to their diet, suggesting that they notify the researcher if they attended a consultation with a nutrition professional

during this period or made any changes to their eating habits. During the final evaluation, a brief semi-structured interview was conducted to confirm the maintenance of the diet type during the 16 weeks. Additionally, all participants were required to maintain the physical activity levels reported in the IPAQ questionnaire before the study, suggesting that they should not modify their physical activity levels during the intervention period, considering only the incorporation of RT_P sessions for the VEG_D-RT_P and OMN_D-RT_P groups. Participants were required to notify the researcher if they joined a systematic physical exercise program, which was verified by repeating the IPAQ questionnaire and conducting a brief semi-structured interview at the end of the intervention.

The design and supervision of the RT_P were carried out by a trainer (physical education teacher) and focused on resistance training with bodyweight exercises targeting major muscle groups, such as the upper body, lower body, and abdominal area. The trainer had an administrator profile on the platform that allowed them to upload the training session, review the attendance list, and monitor the time spent in each session. Additionally, the trainer communicated with the participants via phone calls, text messages, or email to provide feedback or resolve questions about the RT_P.

Participants received a notification on their mobile phones with the schedule of their next training session and a reminder 30 min before the session started. The platform automatically recorded participants' attendance and the time spent in each RT_P session. To perform this, the participants in the VEG_D-RT_P and OMN_D-RT_P groups had to log into their profiles and access the exercise session from their mobile phones, tablets, or computers. The RTP session remained available on the platform for 24 h, allowing participants to perform their training synchronously or asynchronously, reducing the risk of dropout due to time constraints. At the end of each session, participants had the opportunity to evaluate and share their perceived effort during the training, using the Modified Borg Scale from 0 to 10 [24] (Figure 1).



User Profile = Contains the users' personal information, notifications, and platform usage tutorial, among other tools; Training Session = Images of a training session; Perceived Exertion = At the end of the training session, participants could evaluate the perceived exertion intensity using the modified Borg Rating of Perceived Exertion Scale; Session Report = The coach had access to review participant reports, individual and group attendance, as well as participants perceived exertion reports.

Figure 1. Images extracted from the APPTIVATE platform.

2.4. Anthropometric and Body Composition Measures

Body composition variables (% Fat Mass, kg Fat Mass, and Lean Mass) were monitored and recorded throughout the study using multifrequency electrical impedance (Inbody 120, Lookin'Body 3.0 Data Management Software, Seoul, Republic of Korea). Measurements were taken under fasting conditions of at least 4 h. In addition, participants did not practice any physical exercise during the last 12 h, avoided stimulant beverages such as caffeine, and women were not in their menstrual period [25]. Other anthropometric measurements were taken following standardized anthropometry manual recommendations [26]. Height was measured with participants barefoot using a digital stadiometer Inlab (Inbody, Seoul, Republic of Korea). Nutritional status was obtained by calculating the Body Mass Index

(BMI kg/m²) [24], while a non-elastic tape measure (Seca 201, Hamburg, Germany) was used for waist circumference. These measurements were performed by a trained and experienced physical education teacher.

2.5. Statistical Analysis

For the baseline analysis, quantitative variables were presented with means and standard deviations, and qualitative variables with frequencies and percentages. The normality of the variables was verified using the Kolmogorov–Smirnov test with Lilliefors correction. For the bivariate hypothesis contrast, a one-way ANOVA test was conducted for three or more means, and the Games–Howell post hoc test was used for comparisons between groups. In addition, the baseline variables that presented a statistically significant difference in the comparison across all groups were analyzed with an ANCOVA test (See Supplement Material). To measure the effectiveness of the treatment, the Wilcoxon test was used, where the medians of the baseline tests were subtracted from the post-intervention medians of each group. The Kruskal–Wallis test adjusted by the Bonferroni correction was used to compare the medians of the 4 groups. The cut-off points established to assess the strength of the association were the following: very weak, from 0 to 0.19; weak, from 0.2 to 0.39; moderate, from 0.4 to 0.59; strong, from 0.6 to 0.79; and very strong, from 0.8 to 1.0 [27]. Multiple adjusted linear regressions were performed to develop predictive formulas that fit the dependent variables studied. These regressions were developed following the backward stepwise regression method, starting with an equation that includes all the independent variables and removing, one by one, the variables with the highest “*p*-value” until reaching a final model with all significant independent variables (*p* < 0.05). The dependent variable considered was the difference in %FM obtained by subtracting the baseline %FM from the final %FM, and the independent variables were those that showed the greatest statistical significance (*p* < 0.05). The age and the group of participants were organized into dummy variables, taking the OMN_D-C group as a reference. For all tests, a significance level of less than 5% (*p* < 0.05) was established. The analysis was performed with IBM SPSS Statistics version 22.0.

3. Results

For data analysis, the Intention-to-Treat approach will be used, where participants will complete the study according to their original assignment regardless of their adherence to the activities. A total of 83 individuals were initially selected to participate in the study, of whom 49 followed a VEG_D and 34 an OMN_D. At the end of the study, thirteen participants did not complete the activities; five of them were participating in RT_P and eight participants were in the control group. The main reasons cited by RT_P participants for not continuing with the study were a lack of time to attend RT_P sessions (three participants) and physical injury (two participants). Both individuals with physical injuries stated that their injuries were unrelated to the intervention activities. Control group participants did not attend the second evaluation, all citing a lack of time as the primary reason. The total sample of participants who completed the study activities consisted of 70 participants, of whom 40 followed a VEG_D and 30 followed an OMN_D. For the management of missing data, participants who did not comply with a minimum of two RTP sessions per week during the intervention or did not attend the final evaluation were not included. Of the evaluated participants, no missing data were present (Figure 2).

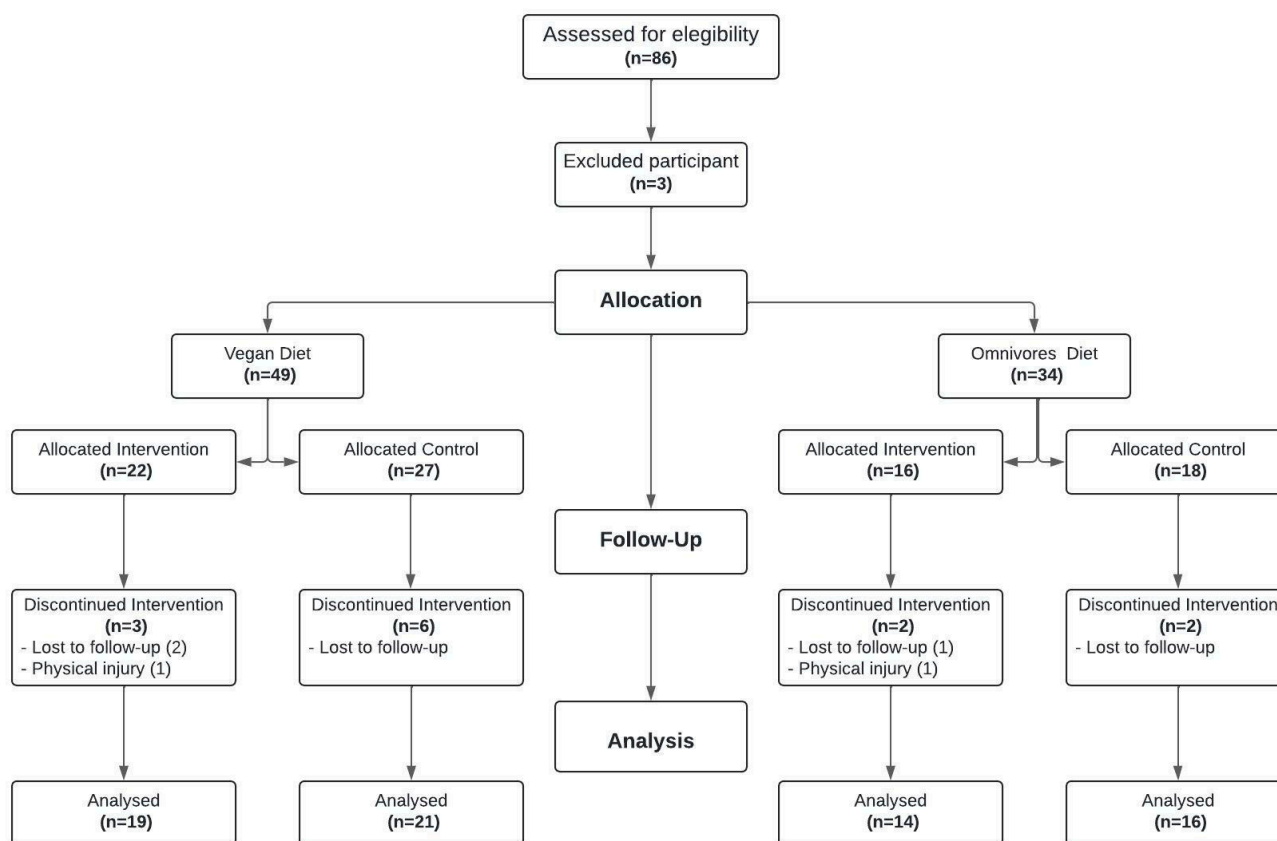


Figure 2. This figure shows the flow diagrams of the participants, separated according to their type of diet, and assigned to either the intervention group with RT_P or the control group.

3.1. Baseline Data

The final sample included 70 participants, with 67.1% being females and 32.9% males. The participants' average age was 30.1 (± 8.6) years. Regarding anthropometric variables, a significant difference in BMI was observed among all groups ($p < 0.030$), with the OMN_D-C group having an average BMI of 4.46 kg/m² higher than the VEG_D-RT_P group ($p = 0.023$, IC -8.40 — 0.53). Concerning body composition variables, a significant difference in KFM was found among all groups ($p = 0.010$), with the greatest difference seen in the OMN_D-C group, showing an average of 9.30 kg more than the VEG_D-RT_P group ($p = 0.013$, IC -16.91 — 1.68). Detailed information on baseline values for study variables is available in Table 1.

Table 1. Baseline characteristics of participants ($n = 70$).

	Total ($n = 70$)	VEG _D -RT _P ($n = 19$)	VEG _D -C ($n = 21$)	OMN _D -RT _P ($n = 14$)	OMN _D -C ($n = 16$)	<i>p</i>
Sociodemographics						
Women (<i>n</i> , %)	47 (67.1%)	10 (52.6%)	4 (19%)	10 (71.4%)	11 (68.8%)	0.154 ^a
Males (<i>n</i> , %)	23 (32.9%)	9 (47.4%)	17 (81%)	4 (28.6%)	5 (31.2%)	
Age (<i>Mean</i> , <i>SD</i>)	30.13 (± 8.6)	27.53 (± 4.1) $\neq$	26.81 (± 5.0) =	33.10 (± 11.0) =	35.00 (± 11.1) $\neq$	0.030 ^w
CD (<i>n</i> , %) Yes	12 (17.1%)	1 (5.3%)	4 (19%)	4 (28.6%)	3 (18.8%)	0.251 ^w
CD (<i>n</i> , %) No	58 (82%)	18 (94.7%)	17 (81%)	10 (71.4%)	13 (81.3%)	
PNC (<i>n</i> , %) Yes	48 (68.6%)	16 (84.2%)	17 (81%)	7 (50%)	8 (50%)	0.173 ^w
PNC (<i>n</i> , %) No	22 (31.4%)	3 (15.8%)	4 (19%)	7 (50%)	8 (50%)	
Anthropometry						
Weight (<i>Mean</i> , <i>SD</i>)	69.11 (± 15.2)	62.00 (± 8.8) $\neq$	72.51 (± 18.6) =	68.34 (± 11.9) =	73.80 (± 16.7) $\neq$	0.080 ^a
Height (<i>Mean</i> , <i>SD</i>)	164.72 (± 8.1)	164.83 (± 8.6)	165.41 (± 9.2)	164.00 (± 3.6)	164.40 (± 7.6)	0.960 ^a

Table 1. Cont.

	Total (n = 70)	VEG _D -RT _P (n = 19)	VEG _D -C (n = 21)	OMN _D -RT _P (n = 14)	OMN _D -C (n = 16)	p
BMI (Mean, SD)	25.44 (±5.1)	22.73 (±2.0) [≠]	26.61 (±6.7) ⁼	25.40 (±3.6) ⁼	27.20 (±5.3) [≠]	0.030 ^w
WC (Mean, SD)	80.90 (±12.7)	76.45 (±7.6)	80.31 (±12.0)	81.20 (±12.8)	86.60 (±16.7)	0.141 ^w
%FM (Mean, SD)	31.10 (±9.6)	26.30 (±9.2)	32.19 (±11.6)	32.20 (±6.4)	34.40 (±7.5)	0.060 ^w
KFM (Mean, SD)	22.05 (±10.4)	16.33 (±6.1) [≠]	24.51 (±14.0) ⁼	22.03 (±6.5) ⁼	25.62 (±9.5) [≠]	0.010 ^w
KLM (Mean, SD)	26.10 (±5.8)	25.19 (±5.3)	26.58 (±5.8)	25.80 (±5.3)	26.71 (±7.0)	0.850 ^a

VEG_D-RT_P = Vegan Diet Resistance Training Program; VEG_D-C = Vegan Diet Control; OMN_D-RT_P = Omnivore Diet Resistance Training Program; OMN_D-C = Omnivore Control; CD = Chronic diseases; PNC = Previous nutritional control; BMI = Body Mass Index; WC = Waist circumference; %FM = % Fat Mass; KFM = Kilograms Fat Mass; KLM = Kilograms Lean Mass; SD = Estándar Deviation; ^a = ANOVA; ^w = Wells; [≠] = Significant differences identified between the groups according to the post hoc test; (Games–Howell). ⁼ = Significant differences identified between the groups according to the post hoc test.

3.2. Post-Intervention Results

3.2.1. Effect of the Intervention on Variables by Group

When comparing the differences (initial value–final value) for each group after completing the 16-week intervention program, the VEG_D-RT_P group showed a statistically significant reduction in the %FM variable by 1.20%, with a moderate size of response to treatment ($r = 0.554$, $p = 0.016$), while the OMN_D-RT_P experienced a decrease of 0.90%, with a weak size of response to treatment ($r = 0.210$, $p = 0.432$). Regarding the KFM variable, the VEG_D-RT_P group experienced a reduction of 0.70 kg, with a moderate size of response to treatment ($r = 0.480$, $p = 0.036$), while in the OMN_D-RT_P group, this variable decreased by 0.50 kg, with a weak size of response to treatment ($r = 0.109$, $p = 0.683$).

In the groups that were not part of the RT_P, a statistically significant increase in Body Weight was observed in the VEG_D-C by 1.30 kg, with a moderate response size to the absence of treatment ($r = 0.414$, $p = 0.058$), while in the OMN_D-C, this increase was higher 2.35 kg, with a moderate response size to the absence of treatment ($r = 0.590$, $p = 0.018$). Consequently, a significant increase in BMI was also observed in both groups. Additionally, in the Waist Circumference variable, an increase of 1 cm was observed in the VEG_D-C group, with a moderate response size to the absence of treatment ($r = 0.474$, $p = 0.030$) and 1 cm in the OMN_D-C group, with a moderate response size to the absence of treatment ($r = 0.563$, $p = 0.024$). In body composition variables, the %FM increased by 1.50% in the OMN_D-C group, with a strong response size to the absence of treatment ($r = 0.731$, $p = 0.003$), in addition to an increase of 1.65 kg, with a strong response size to the absence of treatment ($r = 0.705$, $p = 0.005$) in the KFM variable (Table 2).

Table 2. Effect of the Intervention on Variables by Group.

	Basal	Post-I	Effect Size (r)	p
VEG _D -RT _P -I (n = 19)				
Weight	61.40 [53.10; 70.20]	59.90 [55.60; 67.10]	0.092	0.687
BMI	23.00 [21.40; 24.00]	22.70 [20.90; 23.40]	0.179	0.434
WC	78.00 [71.50; 80.50]	74.00 [72.00; 80.00]	0.336	0.143
%FM	26.60 [19.00; 33.50]	26.50 [14.40; 33.80]	0.554	0.016 *
KFM	16.30 [10.30; 21.60]	15.40 [7.90; 20.20]	0.480	0.036 *
KLM	25.10 [21.10; 29.60]	24.70 [21.00; 29.70]	0.365	0.111
VEG _D -C (n = 21)				
Weight	68.80 [60.20; 80.60]	70.00 [59.40; 82.55]	0.414	0.058 *
BMI	25.10 [21.30; 31.35]	24.60 [21.85; 31.65]	0.418	0.056 *
WC	77.00 [69.50; 89.50]	77.50 [70.25; 91.00]	0.474	0.030 *
%FM	29.60 [21.95; 43.15]	29.00 [24.10; 43.25]	0.023	0.917
KFM	21.30 [14.40; 32.60]	19.90 [15.15; 33.40]	0.330	0.130
KLM	24.20 [22.50; 31.25]	25.40 [22.90; 31.15]	0.376	0.085

Table 2. Cont.

	Basal	Post-I	Effect Size (r)	p
OMN _D -RT _P (n = 14)				
Weight	67.40 [59.78; 73.30]	68.60 [59.60; 74.98]	0.178	0.506
BMI	24.50 [22.50; 27.10]	25.10 [22.80; 27.78]	0.310	0.247
WC	78.50 [73.38; 84.25]	79.00 [75.00; 84.00]	0.118	0.658
%FM	33.55 [27.88; 36.95]	33.70 [27.80; 35.88]	0.210	0.432
KFM	20.05 [17.75; 24.03]	20.50 [15.95; 27.30]	0.109	0.683
KLM	24.75 [21.00; 30.93]	24.75 [21.18; 30.85]	0.357	0.182
OMN _D -C (n = 16)				
Weight	67.70 [61.23; 88.3]	71.20 [62.53; 91.75]	0.590	0.018 *
BMI	26.1 [23.78; 30.60]	27.05 [25.03; 31.28]	0.554	0.027 *
WC	81.75 [72.63; 104.63]	82.75 [75.50; 100.50]	0.563	0.024 *
%FM	33.05 [27.98; 39.95]	34.80 [28.68; 43.60]	0.731	0.003 *
KFM	24.4 [19.2; 27.6]	26.65 [21.36; 30.25]	0.705	0.005 *
KLM	24.3 [21.2; 31.7]	24.50 [20.63; 34.50]	0.117	0.640

VEG_D-RT_P = Vegan Diet Resistance Training Program; VEG_D-C = Vegan Diet Control; OMN_D-I = Omnivore Diet Resistance Training Program; OMN_D-C = Omnivore Control; BMI = Body Mass Index; WC = Waist circumference; %FM = % Fat Mass; KFM = Kilograms Fat Mass; KLM = Kilograms Lean Mass; Basal = Median and Interquartile Range Pre-Intervention Assessment; Post-I = Median and Interquartile Range Post-Intervention Result; * = Statistical Significance < 0.05.

3.2.2. Comparison of Pre–Post Intervention Differentials Across All Groups

When comparing the differences (initial value–final value) across all groups, statistically significant differences were observed in body composition variables %FM (<0.001), and KFM ($p < 0.001$). There were no significant differences in the other variables, Weight, BMI, Waist Circumference, or KLM (Table 3).

Table 3. Comparison of pre–post intervention differentials across all groups.

VEG _D -RT _P (n = 19)			VEG _D -C (n = 21)		OMN _D -RT _P (n = 14)		OMN _D -C (n = 16)		p
Diferential	r		Diferential	r	Diferential	r	Diferential	r	
Weight	−0.20 [−1.80; 1.90]	0.092	1.30 [−0.40; 2.35]	0.414	0.40 [−0.93; 1.80]	0.178	2.35 [0.27; 3.43]	0.590	0.087
BMI	−0.20 [−0.80; 0.70]	0.179	0.50 [−0.20; 0.95]	0.418	0.15 [−0.23; 0.80]	0.310	0.85 [−0.15; 1.30]	0.554	0.054
WC	−1.00 [3.00; 1.50]	0.336	1.00 [0.50; 2.50]	0.474	1.00 [−1.25; 1.62]	0.118	1.00 [0.50; 2.38]	0.563	0.064
%FM	−1.20 [−4.00; 0.40] [≠]	0.554	−0.20 [−1.55; 1.10] ⁼	0.023	−0.90 [−2.82; 1.45] ⁼	0.210	1.50 [0.35; 3.13] [≠]	0.731	<0.001 *
KFM	−0.70 [−2.80; 0.40] [≠]	0.480	0.60 [−0.55; 2.00] ⁼	0.330	−0.50 [−2.05; 1.40] ⁼	0.109	1.65 [0.95; 3.22] [≠]	0.705	<0.001 *
KLM	0.40 [−0.40; 0.90]	0.365	0.20 [−0.20; 0.90]	0.376	0.25 [−0.22; 0.58]	0.357	−0.30 [−0.90; 0.85]	0.117	0.510

VEG_D-RT_P = Vegan Diet Resistance Training Program; VEG_D-C = Vegan Diet Control; OMN_D-RT_P = Omnivore Diet Resistance Training Program; OMN_D-C = Omnivore Control; BMI = Body Mass Index; WC = Waist Circumference; %FM = % Fat Mas; KFM = Kilograms Fat Mass; KLM = Kilograms Lean Mass; Diferential; Median and Confidence Interval Post-Intervention Result—Basal Result; * = Statistical Significance < 0.05; [≠] = Significant differences between the groups are identified according to the Benferroni Test; ⁼ = Significant differences between the groups are not identified according to the Benferroni Test; r = Effect Size.

3.2.3. Linear Regression of the Variable % Fat Mass Difference

A linear regression was performed for the %FM outcome variable, obtained by subtracting the baseline %FM from the post-intervention %FM. Using the correlated independent variables, with a coefficient of determination (R^2) of 0.256 and a significance in the goodness of fit of <0.001, with a 95% confidence interval (CI), it was observed that, keeping all other variables constant, the VEG_D-RT_P group had a %FM that was 3.61% lower ($p = 0.001$, CI −5.22–−2.00), the VEG_D-C group had a %FM that was 1.85% lower ($p = 0.024$, CI −3.44–−0.26), and the OMN_D-RT_P group had a %FM that was 2.33% lower ($p = 0.001$, CI −4.00–−0.69) compared to the %FM of the OMN_D-C group (Table 4).

Table 4. Linear Regression of the Variable % Fat Mass Difference.

% Fat Mass Difference	(Unadjusted) Analysis				(Adjusted) Analysis			
	Coef	SE	CI 95%	<i>p</i>	Coef	SE	CI 95%	<i>p</i>
Age	0.035	0.35	−0.035–0.106	0.322	−0.006	0.034	−0.075–0.063	0.861
VEG _D -RT _P	−3.564	0.756	−5–074–−2.054	<0.001 *	−3.610	0.804	−5.220–−2.003	<0.001 *
VEG _D -C	−1.797	0.740	−3.274–−0.327	0.018 *	−1.850	0.800	−3.440–−0.260	0.024 *
OMN _D -RT _P	−2.321	0.816	−3.950–−0.692	0.006 *	−2.33	0.82	−4.00–−0.69	0.001 *

VEG_D-RT_P = Vegan Diet Resistance Training Program; VEG_D-C = Vegan Diet Control; OMN_D-RT_P = Omnivore Diet Resistance Training Program; OMN_D-C = Omnivore Control; % Fat Mass Difference = % Fat Mass pre intervention—% Fat Mass post intervention; Coef = Unstandardized beta coefficient; SE = Estándar Error; IC 95% = Confidence Interval 95%; * = Statistical significance < 0.05. (For the dummy variables, the Omnivorous Diet Control Group was taken as the reference variable).

4. Discussion

4.1. Body Fat Mass

When analyzing the results obtained in the VEG_D-RT_P group, a statistically significant decrease of 1.20% was observed in the %FM variable ($r = 0.554$, $p = 0.016$) and 0.7 kg in the KFM variable ($r = 0.480$, $p = 0.036$). It has been widely reported that a VEG_D generates a positive impact on the reduction in fat mass because plant-based foods have a lower fat content and are high in dietary fiber [1,5,6]. These characteristics reduce the energy density of meals, generating changes in the mitochondrial activity of muscle cells [28]. Furthermore, the high antioxidant effect of plant-based foods has been proven, thanks to higher levels of vitamin C, vitamin E, and beta-carotene, as well as greater production of antioxidant enzymes [11]. In addition to the type of diet, benefits have been reported when combining a VEG_D with physical exercise, especially RT_P, showing effects on reducing fat mass and increasing musculoskeletal mass [17]. It is possible that the aforementioned antioxidant disposition of VEG_D is a determining factor in the decrease in fat mass observed in the VEG_D-RT_P group due to an enhancement with physical exercise. A study conducted by Boutros et al. evaluated women who had maintained a VEG_D or omnivorous diet for the last 2 years and who also reported being physically active, finding a lower BMI and %FM in women with VEG_D [27]. However, unlike our research, this study was not a clinical trial, and the participants reported their physical activity through questionnaires, which makes it difficult to accurately measure the influence of physical exercise on their results.

On the other hand, the participants in the OMN_D-RT_P group experienced a slight decrease of 0.90% in the %FM variable ($r = 0.210$, $p = 0.432$) and 0.50 kg in the KFM variable ($r = 0.109$, $p = 0.683$), although these reductions did not reach statistical significance. It is likely that the reduced effect observed in the OMN_D-RT_P participants is due to the fact that Western diets rich in animal products induce a high acid load, which is not adequately compensated with dietary buffers such as fruits and vegetables, leading to chronic metabolic acidosis [29,30]. Therefore, considering the eating habits of the Chilean population, characterized by high consumption of meat, ultra-processed foods, and low consumption of fruits and vegetables [19], these results suggest that RT_P generates benefits in the body composition of individuals with OMN_D. However, a stimulus of two to three sessions per week may be insufficient to achieve a significant reduction in fat mass, especially since, in our study, participants were advised not to make dietary changes during the intervention period.

When analyzing the results of the participants in the control groups, we observe that the OMN_D-C group had a statistically significant increase of 2.35 kg in body weight ($r = 0.590$, $p = 0.018$), 0.85 kg/m² in BMI ($r = 0.554$, $p = 0.027$), and 1 cm in waist circumference ($r = 0.563$, $p = 0.024$), reflecting an increase of 1.50% in the %FM variable ($r = 0.731$, $p = 0.003$) and 1.65 kg in the KFM variable ($r = 0.705$, $p = 0.005$). The VEG_D-C group also increased their body weight by 1.30 kg ($r = 0.414$, $p = 0.058$), 0.50 kg/m² in BMI ($r = 0.418$, $p = 0.056$), and 1 cm in waist circumference ($r = 0.474$, $p = 0.030$). These results may not be surprising and should be largely related to data provided by official surveys in Chile, which indicate high levels of physical inactivity, reaching 86.7% in the adult population [19].

It is known that maintaining low levels of physical activity is related to lower energy expenditure [31], and its explanation is based on the interaction between body levels of fat mass and lean mass. This interaction originates from the fact that adipose tissue behaves like an endocrine organ capable of releasing metabolic mediators [32]. Therefore, given the existing background in the literature, we can identify the importance of RT_P in body composition, consistent with the results obtained in this study on the effect caused by the regular practice of RT_P conducted in the intervention of the VEG_D-RT_P and OMN_D-RT_P groups, reflected in the reduction in fat mass in both groups. However, the results obtained by the VEG_D-RT_P participants achieved a greater reduction compared to the OMN_D-RT_P participants.

4.2. Musculoskeletal Mass

Therefore, the increase in fat mass levels due to a sedentary lifestyle becomes a factor that also affects a decrease in lean mass, reducing the main anabolic hormones that increase nitrogen retention at the muscular level and favoring the degradation of muscle proteins through an inflammatory state [32]. When evaluating the impact of RT_P on muscle mass, the VEG_D-RT_P group showed an increase of 0.40 kg in the KLM variable ($r = 0.365$, $p = 0.111$), while the OMN_D-RT_P group showed a slight increase of 0.25 kg ($r = 0.357$, $p = 0.182$), increases insufficient to reach statistical significance. It has been demonstrated that the physiological adaptation of skeletal muscle tissue adjusts as a response to contractile activity induced by training, which is reflected in changes in contractile proteins and their mitochondrial function. These adaptations are conditioned, among other things, by factors such as the duration of the stimulus, rest time, and load intensity [33]. It is in this latter point where the low response of the VEG_D-RT_P and OMN_D-RT_P groups on the KLM variable can be explained, as the intensity in the training load was developed using bodyweight exercises, which may be an insufficient contractile stimulus to generate greater muscle hypertrophy. There are studies where RT_P exercises were incorporated in people with VEG_D and OMN_D, showing effects on muscle mass. This is demonstrated in the study by Hevia Larraín et al., which reported changes in lean mass in participants with VEG_D and OMN_D after a 12-week intervention where RT_P was developed with 2 to 3 weekly training sessions incorporating overload exercises. Their results showed an increase in muscle mass in participants with both types of diets, without differences between VEG_D and OMN_D [34].

The muscle response observed in our research and in other studies to a resistance training regimen [34,35] can be explained by the fact that the contractile stimulation of the muscle increases the sensitivity to the anabolic properties of amino acid or protein administration. The postprandial increase in circulating plasma leucine concentration is of lesser importance when protein is consumed after exercise. Therefore, the lower leucine content of most plant-based proteins does not restrict postprandial muscle protein synthesis rates during exercise recovery [14]. A study evaluated healthy and recreationally active individuals, where, through imaging, they examined the effect of a vegan diet and reported that no differences were found in vascular structure and function, nor in the properties of skeletal muscle, between those who follow a habitual vegan diet and omnivores [36]. Moreover, in recent years, some elite athletes have been able to follow a VEG_D, managing to maintain their athletic performance over time [8]. Therefore, it can be deduced that muscle mass depends on a positive muscle protein balance over time, which can be achieved through adequate intake of proteins and essential amino acids, enhanced with the combination of physical exercise [13].

In summary, it is important to note that no differences were observed in the muscle mass levels of the groups when comparing the different types of diets. These results are relevant due to the widespread belief, manifested by some authors, that a poorly constructed vegan diet could lead to a deficiency of essential amino acids such as leucine, methionine, and lysine, due to lower bioavailability in plant-based foods and, therefore, be related to muscle mass loss. However, it has been noted that the vast majority of

these nutrients can be incorporated into the diet complementarily through nutritional supplementation, obtaining a sufficient nutritional load for anabolic stimulation that allows for maintaining muscle mass levels within normal ranges [14].

4.3. Limitations of the Study

Some important design aspects and limitations of this study require further consideration and context. One of these is the non-random distribution of participants into groups, which affects the homogeneity of the sample. Significant differences were observed between groups in variables such as age and BMI, which could introduce bias into the analysis of results. The choice of this distribution type was necessary to address difficulties encountered in achieving the required number of participants in each group. However, ANCOVA analysis indicated that no variation in results was observed due to baseline differences, suggesting that our study results would not be significantly affected by this disparity. Additionally, our adjusted linear regression model showed that independent variables did not affect the observed changes post-intervention, thereby reducing the risk of bias in results analysis. Despite these findings, the baseline difference caused by non-randomized distribution may still pose a limitation, suggesting that future studies should consider random assignment. Furthermore, although age did not exert a statistically significant influence, it was included in the multiple linear regression model, adjusted using dummy variables separating participants by groups. This decision was based on literature indicating changes in body composition with advancing age [37]. This effect may not be observed in our results due to the distribution and size of our sample.

Since participants were not subjected to nutritional intervention, the information on dietary intake may be imprecise due to the study's duration. Dietary records may have been compromised by a lack of information or recall errors. One way to reduce this bias would have been to repeat the food frequency and consumption questionnaire in weeks 8 and 16. However, this practice is impractical due to the high time demands on both professionals and participants. Nevertheless, to mitigate this bias, a semi-structured interview was incorporated in week 16, with general but relevant questions, such as whether participants had attended nutritional consultations during the past 16 weeks, started any dietary regimen, or made modifications to their diet during this period. Therefore, it is recommended that future research includes more concise forms of dietary habit recording or self-reporting, which, although they may not be as precise as a food frequency and consumption questionnaire, allow for more frequent evaluations during the study.

Although the characteristics of the RTP applied in this study align with the recommendations of the American College of Sports Medicine (ACSM) [35], it would be interesting to develop a program with similar characteristics, increasing the workload and incorporating overload exercises to enhance muscle contractile stimulation. It is noteworthy that adherence to the RTP was 87%, suggesting that it is a training protocol that can be sustained over time.

Finally, the segmentation of the age group of VEG_D participants ranged from 20 to 36 years. However, it should be noted that this type of diet is relatively new and emerging, making it difficult to find older participants, raising the question of whether the effects of VEG_D or the benefits of RT_P on body composition could be maintained in the following years of their life cycle [32]. However, the authors are convinced that these findings contribute to a body of evidence that values the importance of active lifestyles, especially the benefits of RT_P, regardless of diet type. Additionally, according to their findings, a well-designed and supplemented plant-based diet would not negatively affect musculoskeletal mass, and on the contrary, its positive effects are enhanced when physical activity is incorporated. This opens the door to future research with a larger number of participants, randomized intervention assignments, and longer follow-up periods to verify effectiveness over time. Another limitation could be the segmentation of the age group of VEG_D participants, ranging from 20 to 36 years. However, it should be noted that this type of diet is relatively new and emerging, making it difficult to find older participants, raising

the question of whether the effects of VEG_D or the benefits of RT_P on body composition could be maintained in the following years of their life cycle.

5. Conclusions

The results of this study indicate that the VEG_D-RT_P participants experienced a reduction in body fat, showing superior results compared to those in the OMN_D-RT_P. On the other hand, both control groups showed an increase in weight, BMI, and fat mass, presumably attributable to adopting a sedentary behavior and dietary modifications during the intervention period. Although the vegan diet has been associated with weight reduction and the maintenance of a healthier body composition, combining it with an active lifestyle and regular physical exercise seems to be a more efficient strategy for reducing fat mass. Additionally, the sample of participants following a VEG_D consisted mainly of younger individuals, suggesting the need for more studies in older populations to better understand the long-term effects on body composition when combined with RT_P.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/nu16152539/s1>, In the following supplementary information, you can find the baseline variables that showed a statistically significant difference in the comparison between all groups analyzed with an ANCOVA test. Supplementary Table S1: ANCOVA BMI Analysis; Supplementary Table S2: ANCOVA KFM Analysis.

Author Contributions: Conceptualization, R.C.-R.; Methodology, G.M.-R.; Formal analysis, R.C.-R. and C.O.-R.; Data curation, R.C.-R., R.Z.-L., C.O.-R., M.M., F.C.-M. and G.M.-R.; Writing—original draft, R.C.-R., R.Z.-L., C.O.-R., M.M., F.C.-M. and G.M.-R.; Writing—review & editing, R.C.-R., R.Z.-L., M.M., F.C.-M. and G.M.-R. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Ethics Committee of Vice-Rector of Research of the University of Concepcion approved the study protocol (December 30, I completed 2021; Code: 1068-2021). The study is registered in clinical trials under identification number NCT06423209.

Informed Consent Statement: Patient consent was waived due to the use of an anonymized database.

Data Availability Statement: The data presented in this study are available on request to the corresponding author.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Yokoyama, Y.; Levin, S.M.; Barnard, N.D. Association between plant-based diets and plasma lipids: A systematic review and meta-analysis. *Nutr. Rev.* **2017**, *75*, 683–698. [CrossRef] [PubMed]
2. Hauner, H. Vegetarian/vegan diet—Reasonable or dangerous? *MMW Fortschr. Med.* **2015**, *157*, 41–43. [CrossRef] [PubMed]
3. Isenmann, E.; Eggers, L.; Havers, T.; Schalla, J.; Lesch, A.; Geisler, S. Change to a Plant-Based Diet Has No Effect on Strength Performance in Trained Persons in the First 8 Weeks—A 16-Week Controlled Pilot Study. *Int. J. Environ. Res.* **2023**, *20*, 1856. [CrossRef] [PubMed]
4. Kahleova, H.; Fleeman, R.; Hlozkova, A.; Holubkov, R.; Barnard, N.D. A plant-based diet in overweight individuals in a 16-week randomized clinical trial: Metabolic benefits of plant protein. *Nutr. Diabetes* **2018**, *8*, 58. [CrossRef]
5. Crosby, L.; Rembert, E.; Levin, S.; Green, A.; Ali, Z.; Jardine, M.; Nguyen, M.; Elliott, P.; Goldstein, D.; Freeman, A.; et al. Changes in Food and Nutrient Intake and Diet Quality on a Low-Fat Vegan Diet Are Associated with Changes in Body Weight, Body Composition, and Insulin Sensitivity in Overweight Adults: A Randomized Clinical Trial. *J. Acad. Nutr. Diet.* **2022**, *122*, 1922–1939. [CrossRef] [PubMed]
6. Kahleova, H.; Petersen, K.F.; Shulman, G.I.; Alwarith, J.; Rembert, E.; Tura, A.; Hill, M.; Holubkov, R.; Barnard, N.D. Effect of a Low-Fat Vegan Diet on Body Weight, Insulin Sensitivity, Postprandial Metabolism, and Intramyocellular and Hepatocellular Lipid Levels in Overweight Adults. *JAMA Network Open.* **2020**, *3*, e2025454. [CrossRef] [PubMed]
7. Hemler, E.C.; Hu, F.B. Plant-Based Diets for Personal, Population, and Planetary Health. *Adv. Nutr.* **2019**, *10*, S275–S283. [CrossRef] [PubMed]
8. Rogerson, D. Vegan diets: Practical advice for athletes and exercisers. *J. Int. Soc. Sports Nutr.* **2017**, *14*, 36. [CrossRef] [PubMed]

9. Eveleigh, E.; Coneyworth, L.; Welham, S. Systematic review and meta-analysis of iodine nutrition in modern vegan and vegetarian diets. *Br. J. Nutr.* **2023**, *130*, 1580–1594. [\[CrossRef\]](#)
10. Dressler, J.; Storz, M.A.; Müller, C.; Kandil, F.I.; Kessler, C.S.; Michalsen, A.; Jeitler, M. Does a Plant-Based Diet Stand Out for Its Favorable Composition for Heart Health? Dietary Intake Data from a Randomized Controlled Trial. *Nutrients* **2022**, *14*, 4597. [\[CrossRef\]](#)
11. Barnard, N.D.; Goldman, D.M.; Loomis, J.F.; Kahleova, H.; Levin, S.M.; Neabore, S.; Batts, T.C. Plant-Based Diets for Cardiovascular Safety and Performance in Endurance Sports. *Nutrients* **2019**, *11*, 130. [\[CrossRef\]](#) [\[PubMed\]](#)
12. Bakaloudi, D.R.; Halloran, A.; Rippin, H.L.; Oikonomidou, A.C.; Dardavesis, T.I.; Williams, J.; Wickramasinghe, K.; Breda, J.; Chourdakis, M. Intake and adequacy of the vegan diet. A systematic review of the evidence. *Clin. Nutr.* **2020**, *40*, 3503–3521. [\[CrossRef\]](#)
13. Pohl, A.; Schünemann, F.; Bersiner, K.; Gehlert, S. The Impact of Vegan and Vegetarian Diets on Physical Performance and Molecular Signaling in Skeletal Muscle. *Nutrients* **2021**, *13*, 3884. [\[CrossRef\]](#)
14. Pinckaers, P.J.M.; Trommelen, J.; Snijders, T.; van Loon, L.J.C. The Anabolic Response to Plant-Based Protein Ingestion. *Sports Med.* **2021**, *51*, 59–74. [\[CrossRef\]](#)
15. McGlory, C.; van Vliet, S.; Stokes, T.; Mittendorfer, B.; Phillips, S.M. The impact of exercise and nutrition on the regulation of skeletal muscle mass. *Physiol. J.* **2019**, *597*, 1251–1258. [\[CrossRef\]](#)
16. Nilsson, M.I.; Mikhail, A.; Lan, L.; Di Carlo, A.; Hamilton, B.; Barnard, K.; Hettinga, B.P.; Hatcher, E.; Tarnopolsky, M.G.; Nederveen, J.P.; et al. A Five-Ingredient Nutritional Supplement and Home-Based Resistance Exercise Improve Lean Mass and Strength in Free-Living Elderly. *Nutrients* **2020**, *12*, 2391. [\[CrossRef\]](#) [\[PubMed\]](#)
17. Distefano, G.; Goodpaster, B.H. Effects of Exercise and Aging on Skeletal Muscle. *Cold Spring Harb.* **2017**, *8*, a029785. [\[CrossRef\]](#)
18. Directrices de la OMS Sobre Actividad Física y Hábitos Sedentarios. Available online: <https://iris.who.int/bitstream/handle/10665/337004/9789240014817-spa.pdf?sequence=1> (accessed on 5 May 2024).
19. Encuesta Nacional de Salud 2016–2017 Primeros Resultados 2017. Available online: https://www.minsal.cl/wp-content/uploads/2017/11/ENS-2016-17_PRIMEROS-RESULTADOS.pdf (accessed on 7 May 2024).
20. Goni Mateos, L.; Aray Miranda, M.; Martínez, H.A.; Cuervo Zapatel, M. Validación de un cuestionario de frecuencia de consumo de grupos de alimentos basado en un sistema de intercambios. *Nutr Hosp.* **2016**, *33*, 1391–1399. [\[CrossRef\]](#)
21. Duncan, M.J.; Rosenkranz, R.R.; Vandelanotte, C.; Caperchione, C.M.; Rebar, A.L.; Maeder, A.J.; Tague, R.; Savage, T.N.; van Itallie, A.; Mummery, W.K.; et al. What is the impact of obtaining medical clearance to participate in a randomised controlled trial examining a physical activity intervention on the socio-demographic and risk factor profiles of included participants? *Trials* **2016**, *17*, 580. [\[CrossRef\]](#)
22. Craig, C.L.; Marshall, A.L.; Sjöström, M.; Bauman, A.E.; Booth, M.L.; Ainsworth, B.E.; Pratt, M.; Ekelund, U.L.; Yngve, A.; Sallis, J.F.; et al. International Physical Activity Questionnaire: 12-Country Reliability and Validity. *Med. Sci. Sports Exerc.* **2003**, *35*, 1381–1395. [\[CrossRef\]](#)
23. Reyes-Molina, D.; Nazar, G.; Cigarroa, I.; Marín, F.C.; Regla, R.C.; Pardo, K.R.; Martorell, M.; Ochoa, C.; Ulloa, N.; Zapata-Lamana, R. Motivación, barreras y beneficios para la práctica de ejercicio físico en una intervención mobile health en adultos del Biobío, Chile. *Retos* **2023**, *43*, 623–631. [\[CrossRef\]](#)
24. Whittaker, R.L.; Sonne, M.W.; Potvin, J.R. Ratings of perceived fatigue predict fatigue induced declines in muscle strength during tasks with different distributions of effort and recovery. *J. Electromyogr. Kinesiol.* **2019**, *47*, 88–95. [\[CrossRef\]](#) [\[PubMed\]](#)
25. Alomia León, R.; Peña, S.E.; Hernandez Mosqueira, C.; Espinoza Cortez, J. Comparación de los métodos de antropometría y bioimpedancia eléctrica a través de la determinación de la composición corporal en estudiantado universitario. *Mhsalud Rev. En Cienc. Mov. Hum. Salud* **2022**, *19*, 1–10. [\[CrossRef\]](#)
26. Callaway, C.W.; Chumlea, W.C.; Bouchard, C.; Himes, J.H.; Lohman, T.G.; Martin, A.D. Circumferences. In *Anthropometric Standardization Reference Manual*; Lohman, T.G., Roche, A.F., Martorell, R., Eds.; Human Kinetics: Champaign, IL, USA, 1991; pp. 44–45. ISBN 9780873221214.
27. BMJ. Correlation and Regression. Available online: <https://www.bmj.com/about-bmj/resources-readers/publications/statistics-square-one/11-correlation-and-regression> (accessed on 9 July 2024).
28. Barnard, N.D.; Scialli, A.R.; Turner-McGrievy, G.; Lanou, A.J.; Glass, J. The effects of a low-fat, plant-based dietary intervention on body weight, metabolism, and insulin sensitivity. *Am. J. Med.* **2005**, *118*, 991–997. [\[CrossRef\]](#)
29. Boutros, G.H.; Landry-Duval, M.-A.; Garzon, M.; Karelis, A.D. Is a vegan diet detrimental to endurance and muscle strength? *Eur. J. Clin. Nutr.* **2020**, *74*, 1550–1555. [\[CrossRef\]](#)
30. Kahleova, H.; McCann, J.; Alwarith, J.; Rembert, E.; Tura, A.; Holubkov, R.; Barnard, N.D. A plant-based diet in overweight adults in a 16-week randomized clinical trial: The role of dietary acid load. *Clin. Nutr. ESPE* **2021**, *44*, 150–158. [\[CrossRef\]](#) [\[PubMed\]](#)
31. Zwierzchowska, A.; Rosolek, B.; Sikora, M.; Celebańska, D. Forced Sedentariness and Sports Activity as Factors Differentiating Anthropometric Characteristics, Indices, and Body Composition in People with Disabilities. *Biology* **2022**, *11*, 906. [\[CrossRef\]](#)
32. Zhang, X.M.; Liu, C.; Sun, X.; Jiao, J.; Wu, X.; Xie, X. Comment on “global prevalence of sarcopenic obesity in older adults: A systematic review and meta-analysis”. *Clin. Nutr.* **2022**, *41*, 1451–1453. [\[CrossRef\]](#) [\[PubMed\]](#)
33. Egan, B.; Zierath Juleen, R. Exercise Metabolism and the Molecular Regulation of Skeletal Muscle Adaptation. *Cell Metab.* **2013**, *17*, 162–184. [\[CrossRef\]](#)

34. Hevia-Larraín, V.; Gualano, B.; Longobardi, I.; Gil, S.; Fernandes, A.L.; Costa, L.A.R.; Pereira, R.M.R.; Artioli, G.G.; Phillips, S.M.; Roschel, H. High-Protein Plant-Based Diet Versus a Protein-Matched Omnivorous Diet to Support Resistance Training Adaptations: A Comparison Between Habitual Vegans and Omnivores. *Sports Med.* **2021**, *51*, 1317–1330. [[CrossRef](#)] [[PubMed](#)]
35. Garber, C.E.; Blissmer, B.; Deschenes, M.R.; Franklin, B.A.; Lamonte, M.J.; Lee, I.-M.; Nieman, D.C.; Swain, D.P. Quantity and Quality of Exercise for Developing and Maintaining Cardiorespiratory, Musculoskeletal, and Neuromotor Fitness in Apparently Healthy Adults. *Med. Sci. Sports Exerc.* **2011**, *43*, 1334–1359. [[CrossRef](#)] [[PubMed](#)]
36. Page, J.; Erskine, R.M.; Hopkins, N.D. Skeletal muscle properties and vascular function do not differ between healthy, young vegan and omnivorous men. *Eur. J. Sport Sci.* **2021**, *22*, 559–568. [[CrossRef](#)] [[PubMed](#)]
37. Witard, O.C.; McGlory, C.; Hamilton, D.L.; Phillips, S.M. Growing older with health and vitality: A nexus of physical activity, exercise and nutrition. *Biogerontology* **2016**, *17*, 529–546. [[CrossRef](#)] [[PubMed](#)]

Disclaimer/Publisher’s Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.