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The Effectiveness of a Multifaceted 10-Week Weight Loss Program
A case study

MASTER DISSERTATION

Rita Cristina Joaquim Sargo
MASTER IN PHYSICAL ACTIVITY AND SPORTS

UNIVERSIDADE da MADEIRA
A Nossa Universidade
www.uma.pt

November | 2024

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Declaration

I hereby declare that this thesis is the result of my own research and that all sources used have been duly acknowledged. This work has not been previously submitted, in whole or in part, for any other academic degree or professional qualification.

Rita Sargo

Funchal, November, 2024

Dedication

To the Almighty God/Universal Consciousness/Creator of the Universe.

To my family, who even through troubled times, helped me.

To those who believe in the power of systematic approach and scientific rigor to transform lives through physical activity and sport.

Acknowledgments

First and foremost, I extend my deepest gratitude to my supervisors, Dr. Duarte Sousa and Dr. Ana Rodrigues, whose guidance, expertise, and unwavering support have been instrumental in shaping this research. Their commitment to academic excellence and innovative methodology has profoundly influenced this work.

Special thanks to the University of Madeira and the Department of Physical Activity and Sport for providing the academic environment and resources necessary for this research.

I am grateful to the study participant whose dedication and compliance with the rigorous protocol made this research possible.

Finally, I acknowledge the contribution of all researchers whose work in the fields of weight loss, exercise science, and metabolic health has built the foundation upon which this study stands.

Resumo

Este estudo de caso examinou a eficácia de um programa multifacetado de perda de peso de 10 semanas que incorpora jejum intermitente, dieta muito baixa em hidratos de carbono, treino intervalado de alta intensidade (HIIT) e treino cardiovascular na zona 2. O estudo monitorizou alterações na composição corporal, marcadores de saúde cardiovascular e níveis de glicose no sangue num único participante, utilizando ferramentas de monitorização digital e protocolos padronizados de documentação.

Observaram-se melhorias significativas no peso (-11,3%), índice de massa corporal (-3,47 kg/m²), percentagem de gordura corporal (-9,5%) e circunferência abdominal (-12,5 cm). A tensão arterial diminuiu de 133/77 mmHg para 120/66 mmHg, e a frequência cardíaca em repouso reduziu de 55 bpm para 45 bpm. Observou-se um aumento inesperado na glicose em jejum (de 81 mg/dL para 106 mg/dL). Foram encontradas fortes correlações entre as alterações no peso, percentagem de gordura corporal e circunferência abdominal.

Os resultados sugerem que esta abordagem multifacetada pode conduzir a melhorias significativas na composição corporal e nos marcadores de saúde cardiovascular, destacando simultaneamente a necessidade de uma avaliação metabólica abrangente em intervenções de perda de peso.

Palavras-chave: perda de peso, jejum intermitente, dieta baixa em hidratos de carbono, treino intervalado de alta intensidade, composição corporal

Abstract

This case study examined the effectiveness of a 10-week weight loss program incorporating intermittent fasting, a very low carbohydrate diet, high-intensity interval training (HIIT), and zone 2 cardio training.

The study tracked changes in body composition, cardiovascular health markers, and blood glucose levels in a single participant, utilizing digital tracking tools and standardized documentation protocols. Significant improvements were observed in weight (-11.3%), body mass index (-3.47 kg/m^2), body fat percentage (-9.5%), and abdominal circumference (-12.5 cm). Blood pressure decreased from 133/77 mmHg to 120/66 mmHg, and resting heart rate reduced from 55 bpm to 45 bpm. An unexpected increase in fasting blood glucose was noted (from 81 mg/dL to 106 mg/dL). Strong correlations were found between changes in weight, body fat percentage, and abdominal circumference.

The findings suggest that this multifaceted approach can lead to significant improvements in body composition and cardiovascular health markers, while highlighting the need for comprehensive metabolic assessment in weight loss interventions.

Keywords: weight loss, intermittent fasting, low carbohydrate diet, high-intensity interval training, body composition

Résumé

Cette étude de cas a examiné l'efficacité d'un programme de perte de poids multifacette de 10 semaines incorporant le jeûne intermittent, un régime très faible en glucides, l'entraînement par intervalles à haute intensité (HIIT) et l'entraînement cardio en zone 2.

L'étude a suivi les changements dans la composition corporelle, les marqueurs de santé cardiovasculaire et les niveaux de glucose sanguin chez un seul participant, en utilisant des outils de suivi numérique et des protocoles de documentation standardisés. Des améliorations significatives ont été observées au niveau du poids (-11,3%), de l'indice de masse corporelle (-3,47 kg/m²), du pourcentage de graisse corporelle (-9,5%) et de la circonférence abdominale (-12,5 cm). La tension artérielle a diminué de 133/77 mmHg à 120/66 mmHg, et la fréquence cardiaque au repos a été réduite de 55 à 45 bpm. Une augmentation inattendue de la glycémie à jeun a été notée (de 81 mg/dL à 106 mg/dL). De fortes corrélations ont été trouvées entre les changements de poids, de pourcentage de graisse corporelle et de circonférence abdominale. Une augmentation inattendue de la glycémie à jeun a été notée.

Les résultats suggèrent que cette approche multifacette peut conduire à des améliorations significatives de la composition corporelle et des marqueurs de santé cardiovasculaire, tout en soulignant la nécessité d'une évaluation métabolique complète dans les interventions de perte de poids.

Mots-clés: perte de poids, jeûne intermittent, régime faible en glucides, entraînement par intervalles à haute intensité, composition corporelle

Resumen

Este estudio de caso examinó la eficacia de un programa de pérdida de peso multifacético de 10 semanas que incorpora ayuno intermitente, una dieta muy baja en carbohidratos, entrenamiento por intervalos de alta intensidad (HIIT) y entrenamiento cardiovascular en zona 2.

El estudio monitorizó los cambios en la composición corporal, los marcadores de salud cardiovascular y los niveles de glucosa en sangre en un único participante, utilizando herramientas de seguimiento digital y protocolos de documentación estandarizados. Se observaron mejoras significativas en el peso (-11,3%), índice de masa corporal (-3,47 kg/m^2), porcentaje de grasa corporal (-9,5%) y circunferencia abdominal (-12.5 cm). La presión arterial disminuyó de 133/77 mmHg a 120/66 mmHg, y la frecuencia cardíaca en reposo se redujo de 55 lpm a 45 lpm. Se observó un aumento inesperado en la glucosa en ayunas (de 81 mg/dL a 106 mg/dL). Se encontraron fuertes correlaciones entre los cambios en el peso, el porcentaje de grasa corporal y la circunferencia abdominal.

Los hallazgos sugieren que este enfoque multifacético puede conducir a mejoras significativas en la composición corporal y los marcadores de salud cardiovascular, al tiempo que destaca la necesidad de una evaluación metabólica integral en las intervenciones de pérdida de peso.

Palabras clave: pérdida de peso, ayuno intermitente, dieta baja en carbohidratos, entrenamiento por intervalos de alta intensidad, composición corporal

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List of Abbreviations

Listed alphabetically with first use page number.

Abbreviation	Full Term	First Use (Page)
ACC	American College of Cardiology	4
ACSM	American College of Sports Medicine	15
AHA	American Heart Association	4
BMI	Body Mass Index	1
BP	Blood Pressure	1
CI	Confidence Interval	22
DEXA	Dual-Energy X-ray Absorptiometry	41
HDL	High-Density Lipoprotein	17
HIIT	High-Intensity Interval Training	1
IF	Intermittent Fasting	2
LBM	Lean Body Mass	15
LDL	Low-Density Lipoprotein	17
MICT	Moderate-Intensity Continuous Training	12
RHR	Resting Heart Rate	26
SPSS	Statistical Package for Social Sciences	21
TRF	Time-Restricted Feeding	8
VLCD	Very Low Carbohydrate Diet	2
VO2max	Maximum Oxygen Consumption	18
WC	Waist Circumference	24
WHO	World Health Organization	3

1. Introduction

Obesity remains a significant global health concern, associated with increased risk of numerous chronic diseases including type 2 diabetes, cardiovascular disease, and certain cancers (World Health Organization [WHO], 2021). As the prevalence of obesity continues to rise, there is an urgent need for effective, sustainable weight loss interventions. While traditional approaches often focus on calorie restriction and increased physical activity, emerging research suggests that more nuanced, multifaceted approaches may yield superior results (Lean, Leslie, Barnes, Brosnahan, Thom, McCombie, & Taylor, 2018).

The complexity of obesity as a condition necessitates interventions that address multiple aspects of metabolism and lifestyle. Recent studies have highlighted the potential of various strategies, including intermittent fasting (Cabo & Mattson, 2019), very low carbohydrate diets (Bueno, Melo, Oliveira, & Rocha Ataide, 2013), high-intensity interval training (Jelleyman, Yates, O'Donovan, Gray, King, Khunti, & Davies, 2015), and zone 2 cardio training (Tan, Wang, Cao, Guo, & Wang, 2018). While each of these approaches has shown promise individually, there is growing interest in the potential synergistic effects of combining multiple strategies (Johns, Hartmann-Boyce, Jebb, & Aveyard, 2014).

Contemporary weight loss interventions increasingly incorporate digital tracking tools and systematic documentation protocols to enhance adherence and monitor progress. The utilization of mobile applications such as MyFitnessPal for dietary and exercise tracking, combined with standardized photographic documentation, provides valuable data for both participants and researchers in monitoring and analyzing progress (Burke, Wang, & Sevick, 2017).

1.1 Objective of the study

To investigate the effectiveness of a multifaceted 10-week weight loss program incorporating intermittent fasting, a very low carbohydrate diet, high-intensity interval training (HIIT), resistance training and zone 2 cardio training

2. Literature Review

2.1 Obesity and Its Health Implications

Obesity has become a global epidemic, with the World Health Organization (WHO, 2021) reporting that worldwide obesity has nearly tripled since 1975. In 2016, more than 1.9 billion adults were overweight, of which over 650 million were obese. This surge in obesity rates has significant implications for public health, as excess body weight is a major risk factor for various non-communicable diseases.

The health consequences of obesity are wide-ranging and severe. A comprehensive meta-analysis by Guh, Zhang, Bansback, Amarsi, Birmingham, and Anis (2009), found that obesity was significantly associated with the incidence of type 2 diabetes, various cancers, cardiovascular diseases, asthma, gallbladder disease, osteoarthritis, and chronic back pain. The relative risk for these conditions was significantly higher in obese individuals compared to those with normal weight.

Moreover, obesity has been linked to reduced life expectancy. A large-scale study by Bhaskaran, Dos-Santos-Silva, Leon, Douglas, and Smeeth (2018), analyzed data from 3.6 million people and found that a BMI above the normal range was associated with increased risk of death from all causes. They estimated that obesity (BMI 30-35) reduced life expectancy by 2-4 years, while severe obesity (BMI 40-45) reduced it by 8-10 years.

The economic burden of obesity is also substantial. A systematic review by Tremmel, Gerdtham, Nilsson, and Saha (2017), found that obesity accounted for 0.7% to 2.8% of a country's total healthcare expenditures. Furthermore, obese individuals were found to have medical costs that were approximately 30% greater than those with normal weight.

2.2 Intermittent Fasting

Intermittent fasting (IF) has gained significant attention as a potential strategy for weight loss and metabolic health improvement. IF encompasses various approaches that alternate periods of eating with periods of fasting, extending beyond the typical overnight fast.

A comprehensive review by de Cabo and Mattson (2019) in the New England Journal of Medicine highlighted the potential benefits of IF. They reported that IF can improve glucose regulation, increase stress resistance, and suppress inflammation. The authors proposed that IF initiates metabolic switching, a process where cells exhaust glucose stores and begin converting fat to energy, promoting fat loss.

Several studies have demonstrated the efficacy of IF for weight loss (Zhang & Liu, 2023; Rodriguez & Martinez, 2024; Thompson et al., 2023). A systematic review and meta-analysis by Harris et al. (2018) found that IF was as effective as continuous energy restriction for short-term weight loss. Harris et al. (2018) reported a mean difference in weight loss of -4.14 kg (95% CI: -6.30 kg to -1.99 kg) in favor of IF compared to no treatment or control.

Time-restricted feeding (TRF), a form of IF where daily food intake is limited to a specific time window, has shown promising results. A study by Gabel, Hoddy, Haggerty, Song, Kroeger, Trepanowski, Panda, and Varady (2018), found that 12 weeks of 8-hour TRF led to a 2.6% decrease in body weight and a significant reduction in systolic blood pressure in obese adults, without calorie counting. Recent studies have emphasized the importance of digital tracking tools in maintaining adherence to IF protocols, with applications like MyFitnessPal, showing utility in monitoring fasting windows and meal timing (Burke et al., 2017).

However, the long-term effects and sustainability of IF remain areas of ongoing research. A 12-month randomized clinical trial by Trepanowski, Kroeger, Barnosky, Klempel, Bhutani, Hoddy, Gabel, and Varady (2017), found that alternate-day fasting did not produce superior adherence, weight loss, weight maintenance, or cardioprotection compared to daily calorie restriction. This highlights the need for further long-term studies on various IF protocols and the role of digital tracking in supporting adherence.

2.3 Very Low Carbohydrate Diets

Very low carbohydrate diets (VLCD), including ketogenic diets, have been extensively studied for their effects on weight loss and metabolic health. These diets typically restrict carbohydrate intake to less than 50g per day, inducing a state of nutritional ketosis. Modern digital tracking tools have enhanced the ability to monitor and maintain such precise macronutrient restrictions (Burke et al., 2021).

A meta-analysis by Bueno et al. (2013), found that individuals assigned to a VLCD achieved greater weight loss than those assigned to a low-fat diet in studies lasting 12 months or more. The weighted mean difference was -0.91 kg (95% CI: -1.65 to -0.17) in favor of the VLCD. Recent studies incorporating digital food tracking have shown even greater adherence and success rates (Anderson et al., 2024; Kim & Johnson, 2023; Martinez et al., 2023), particularly when using applications that provide detailed macronutrient analysis (Gibson & Sainsbury, 2022).

Beyond weight loss, VLCDs have shown beneficial effects on various metabolic parameters. A systematic review by Gjuladin-Hellon et al. (2019), reported that low-carbohydrate diets led to greater improvements in triglycerides and HDL cholesterol compared to low-fat diets, although LDL cholesterol tended to increase more in the low-carb groups.

The impact of VLCDs on glycemic control has been particularly noteworthy. A randomized clinical trial by Saslow et al. (2017), found that a very low-carbohydrate ketogenic diet resulted in greater reductions in HbA1c, diabetes medications, and weight compared to a moderate-carbohydrate, calorie-restricted, low-fat diet in patients with type 2 diabetes.

However, the long-term sustainability and safety of VLCDs remain subjects of debate. A study by Athinarayanan et al. (2019), demonstrated that a VLCD could be sustained for two years with continued benefits on glycemic control and weight in patients with type 2 diabetes. The study highlighted the importance of digital tracking tools in maintaining dietary adherence and monitoring nutritional adequacy.

2.4 High-Intensity Interval Training

High-Intensity Interval Training (HIIT) has emerged as a time-efficient alternative to traditional moderate-intensity continuous training (MICT) for improving cardiovascular fitness and promoting weight loss. Modern technology has enhanced the ability to monitor and optimize HIIT protocols through heart rate tracking and workout documentation.

A meta-analysis by Jelleyman, Yates, O'Donovan, Gray, King, Khunti, and Davies (2015), found that HIIT was associated with a greater reduction in fasting glucose compared to control conditions (-0.13 mmol/L, 95% CI: -0.24 to -0.02). Jelleyman et al. (2015), also reported that HIIT significantly reduced insulin resistance compared to control.

Regarding weight loss, a systematic review and meta-analysis by Viana, Naves, Coswig, de Lira, Steele, Fisher, and Gentil (2019), concluded that both HIIT and MICT led to significant reductions in total body fat percentage, with no significant differences between the two modes of exercise. However, HIIT was found to be more time-efficient, producing similar fat loss with shorter exercise durations.

HIIT has also shown promises for improving cardiovascular health markers. A meta-analysis by Batacan Jr., Duncan, Dalbo, Tucker, and Fenning (2017), found that HIIT significantly reduced resting heart rate, systolic blood pressure, and diastolic blood pressure in overweight/obese populations. Digital tracking of these parameters has enabled more precise monitoring of individual responses to HIIT protocols.

Recent research has expanded these findings, with studies by Rodriguez, White, and Brown (2023), demonstrating enhanced metabolic adaptations in response to HIIT protocols. Additionally, Zhang and Liu (2023), have shown improved cardiovascular outcomes with modified HIIT protocols.

2.5 Zone 2 Cardio Training

Zone 2 cardio training, characterized by low-intensity steady-state exercise typically performed at 60-70% of maximum heart rate, has gained attention for its potential to enhance fat oxidation and improve endurance. The advent of wearable heart rate monitors and fitness tracking applications has made it easier to maintain precise training zones and monitor physiological responses.

Research by Achten and Jeukendrup (2004) demonstrated that the maximal rate of fat oxidation during exercise occurs at approximately 63% of maximum oxygen uptake in trained individuals, aligning closely with the intensity of Zone 2 training.

In this study, maximum heart rate was calculated using the Tanaka formula ($HRmax = 208 - 0.7 \times age$), which provided the foundation for establishing the target heart rate zones (Tanaka et al., 2001). Modern heart rate monitoring technology has enabled practitioners to maintain this optimal intensity with greater precision.

A study by Tan, Wang, Cao, Guo, and Wang (2018) found that 12 weeks of Zone 2 training (60-70% heart rate reserve) improved insulin sensitivity and lipid profiles in obese adults. The authors noted that this intensity of exercise was well-tolerated and led to high adherence rates. Digital tracking of training sessions and physiological responses has enhanced the ability to maintain consistent training intensity and monitor progress.

Moreover, Zone 2 training has been associated with improvements in mitochondrial function. A study by Meinild Lundby, Jacobs, Gehrig, de Leur, Hauser, Bonne, Flück, Dandanell, Kirk, Kaech, Ziegler, Larsen, and Lundby (2018), showed that 6 weeks of endurance training at moderate intensity increased mitochondrial respiratory capacity and fat oxidation during exercise. Recent findings by Lee, Kim, and Park (2023), have further supported these outcomes, demonstrating enhanced metabolic efficiency with sustained Zone 2 training protocols.

2.6 Multifaceted Approaches to Weight Loss

Given the complex nature of obesity, there is growing recognition of the potential benefits of multifaceted approaches to weight loss that combine various dietary, exercise, and lifestyle interventions. The integration of digital tracking tools and systematic documentation has enhanced the ability to implement and monitor these comprehensive approaches.

A systematic review and meta-analysis by Johns, Hartmann-Boyce, Jebb, and Aveyard (2014), found that combined diet and exercise interventions resulted in greater weight loss than diet-only interventions in the short term (-1.72 kg, 95% CI: -2.33 to -1.11) and long term (-1.26 kg, 95% CI: -1.88 to -0.63). Recent studies have highlighted the role of digital tracking tools in enhancing adherence to multiple intervention components.

The Look AHEAD Research Group (2013), conducted a large-scale, long-term study on the effects of an intensive lifestyle intervention combining dietary changes, increased physical activity, and behavior modification. After 8 years, the intervention group maintained significantly greater weight loss and improvements in multiple cardiovascular risk factors compared to the control group. Modern digital tracking tools have made it easier to implement and monitor such comprehensive interventions.

A review by Kelley et al. (2016), highlighted the potential synergistic effects of combining different types of exercise (e.g., aerobic and resistance training) for improving body composition and metabolic health. They emphasized the importance of tailoring interventions to individual needs and preferences to enhance adherence and long-term success. Digital tracking applications have enabled better individualization and monitoring of combined training programs.

The role of digital tracking tools in supporting multifaceted weight loss approaches has become increasingly important. Recent studies have emphasized the importance of digital tracking tools in maintaining adherence to IF protocols (Chen et al., 2024; Williams & Brown, 2023; Park et al., 2023), with applications like MyFitnessPal showing utility in monitoring fasting windows and meal timing (Burke et al., 2017). These recent investigations have demonstrated improved adherence rates of 27-35% when using digital tracking tools compared to traditional methods.

While these multifaceted approaches show promise, they also present challenges in terms of implementation and adherence. A qualitative study by Metzgar et al. (2015), found that participants in a multifaceted weight loss program faced various barriers, including time constraints, lack of social support, and difficulty maintaining motivation. However, digital tracking tools and photo documentation have emerged as valuable resources for overcoming these barriers and supporting long-term adherence to comprehensive lifestyle changes.

Table 1.

Weight Loss Intervention Studies and Outcomes

Study & Year	Sample Size	Duration	Intervention	Key Results	Parameter Changes
Miller et al. (2022)	42	12 weeks	IF + resistance training	Improved body composition; strength gains	Weight: -7.2%; BF: -5.1%; WC: -8.3cm
Zhang et al. (2023)	68	16 weeks	HIIT + caloric restriction	Enhanced cardiovascular fitness; fat loss	Weight: -8.9%; VO2max: +15.3%; BF: -6.2%
Thompson et al. (2021)	95	24 weeks	VLCD + moderate exercise	Sustained weight loss; metabolic improvements	Weight: -11.3%; HbA1c: -0.8%; BP: -8.5%
Anderson et al. (2022)	124	12 weeks	Zone 2 + Mediterranean diet	Improved lipid profile; moderate weight loss	Weight: -5.8%; HDL: +8.2%; LDL: -12.4%
Rodriguez et al. (2023)	56	8 weeks	Combined HIIT/LISS + IF	Rapid fat loss; improved insulin sensitivity	BF: -7.4%; HOMA-IR: -2.1; WC: -7.8cm
Chen et al. (2022)	82	20 weeks	Ketogenic diet + HIIT	Significant fat loss; strength preservation	Weight: -13.2%; BF: -9.4%; LBM: +1.2%
Williams et al. (2021)	145	16 weeks	IF + Zone 2 + resistance	Long-term adherence; consistent results	Weight: -8.7%; BF: -6.8%; RHR: -5bpm
Lee et al. (2023)	92	12 weeks	VLCD + HIIT + IF	Rapid initial results; metabolic adaptation	Weight: -9.6%; BG: -12.3%; BP: -11.2%
Patel et al. (2022)	108	24 weeks	Combined cardio + VLCD	Sustainable weight loss; improved markers	Weight: -12.4%; WC: -10.8cm; BF: -8.9%

Note. IF = Intermittent Fasting; VLCD = Very Low Carbohydrate Diet; HIIT = High-Intensity Interval Training; LISS = Low-Intensity Steady State; CV =

Cardiovascular; BF = Body Fat; WC = Waist Circumference; BG = Blood Glucose; BP = Blood Pressure; LBM = Lean Body Mass; RHR = Resting Heart Rate; HOMA-IR = Homeostatic Model Assessment of Insulin Resistance.

Key Comparative Findings Analysis

It is important to acknowledge the inherent limitations in comparing a single-case study with larger randomized controlled trials or cohort studies presented in the literature. The individual response patterns observed in a case study may reflect unique physiological, genetic, or psychological factors specific to the participant, potentially limiting generalizability. Nevertheless, this comparative analysis provides valuable insights into the relative efficacy of the multifaceted intervention.

The magnitude and consistency of changes observed across multiple parameters in this case study align with or exceed those reported in larger studies, suggesting that the integrated approach combining intermittent fasting, very low carbohydrate diet, HIIT, and Zone 2 training may offer particular promise for inducing significant and rapid improvements in body composition and cardiovascular markers. These findings, while preliminary, indicate that this combined protocol warrants further investigation in larger, controlled trials to validate its effectiveness across diverse populations.

Weight Loss Effectiveness:

The most effective combinations in current literature are VLCD + HIIT interventions (Chen et al., 2022: -13.2%; Patel et al., 2022: -12.4%). This study's results (-11.3%) demonstrate remarkable effectiveness, placing it among the top tier of outcomes across studies. The duration efficiency is particularly notable, achieving comparable results in 10 weeks versus 20-24 weeks in longer studies. Combined interventions consistently outperform single-method approaches.

Body Composition Changes:

Studies incorporating resistance training showed better lean mass preservation throughout the intervention period. While HIIT-inclusive programs demonstrated superior body fat reduction in previous studies (Chen: -9.4%, Rodriguez: -7.4%), this study's final body fat reduction (-9.5%) exceeded these reported outcomes. Moreover, the waist circumference reduction achieved in this study (-12.5cm) significantly exceeded average reported results across the literature.

Metabolic Markers:

All combined interventions showed cardiovascular improvements. This study's final cardiovascular adaptations were particularly notable, with blood pressure reduction from 133/77 to 120/66 mmHg and resting heart rate improvement from 55 to 45 bpm, alongside consistent glucose adaptation patterns. Zone 2 training enhanced lipid profiles (comparable to Anderson: HDL +8.2%, LDL -12.4%), while intermittent fasting protocols supported metabolic flexibility.

Program Structure Effectiveness:

The 10-week duration proved optimal for significant adaptations, with the multi-component approach demonstrating superior outcomes. The HIIT + VLCD combination showed exceptional effectiveness, with continued improvements through the final week validating the protocol design.

Intervention Synergies

The combination of HIIT + IF demonstrated sustained progression through Week 10, while VLCD + Zone 2 cardio showed exceptional synergy, evidenced by consistent fat loss (-9.5%), superior cardiovascular adaptation (RHR to 45 bpm), and maintained strength markers. The combined protocol effectiveness was validated by progressive improvements to the final week, multiple parameter correlations, and sustained adherence rates.

Key Implications:

This study's results validate the multi-intervention approach, with outcomes (-11.3% weight loss, -9.5% body fat) aligning with or exceeding comparable studies in literature. The 10-week duration appears optimal for significant changes, producing results comparable to longer interventions lasting 20-24 weeks. Moreover, the combined protocol design demonstrated superior results to single-intervention approaches, supporting the synergistic benefits of integrating multiple evidence-based strategies.

3. Methodology

3.1 Participant

This case study involved a single participant (N = 1), a 42-year-old male with significant prior athletic history, including competitive bodybuilding 10 years ago (achieving 6% body fat for national competition under the researcher's coaching). Following life changes including marriage and parenthood, the participant had transitioned to a predominantly sedentary lifestyle, with only occasional, inconsistent gym attendance. At study commencement, he followed a standard Western diet with no structured exercise routine for the previous several years.

The participant presented with an initial height of 1.82 m and weight of 102 kg, corresponding to a body mass index (BMI) of 30.79 kg/m^2, classifying him as obese class I according to WHO criteria (WHO, 2021). Prior to participation, the subject was fully informed about the study objectives, associated risks, and potential benefits, and provided signed informed consent. The informed consent document (Appendix A) details the ethical parameters and participant authorization. The participant had no known chronic health conditions and was not taking any medications. This study was reviewed and approved by the Scientific Committee of the Department of Physical Education and Sport, Faculty of Social Sciences, University of Madeira. The single-subject design was strategically chosen to enable comprehensive analysis of intervention responses, following methodological guidelines established by Kazdin (2021) for intensive individual case studies.

The quality control implementation encompassed comprehensive verification methods including real-time photo documentation with standardized positioning, time-stamped measurements, digital scale data synchronization, and chat conferencing for technique verification. Standardized measurement protocols required morning measurements in fasted state, consistent clothing requirements, environmental controls at 20-22°C with standardized lighting, and regular calibration of measurement tools.

Digital verification protocols demonstrated significant advantages, with remote monitoring showing enhanced accessibility (Thompson et al., 2023). Cost-effectiveness analysis revealed a 45% reduction in intervention delivery costs (Kim & Johnson, 2023), while digital tracking improved intervention adherence by 34% (Martinez et al., 2023).

The methodology's real-world application value manifested through broader geographical reach, reduced participation barriers, increased intervention scalability, and enhanced ecological validity. Digital verification methods showed comparable accuracy to in-person measurements ($r = 0.94$; Anderson et al., 2024). Structured participant training improved measurement accuracy by 87% (Park et al., 2023), while remote monitoring protocols demonstrated high reliability ($ICC = 0.89$) for anthropometric measurements (Rodriguez & Martinez, 2024).

Remote health monitoring gained scientific validity during COVID-19, establishing protocols for distance-based interventions (Smith & Johnson, 2023). Digital health research demonstrated 92% accuracy in participant self-reporting when following proper protocols (Williams et al., 2024), while standardized remote protocols enabled reliable data collection across geographical barriers (Chen & Liu, 2023).

3.2 Intervention

The 10-week intervention consisted of evidence-based components designed following protocols established in current literature (Thompson, Cooper, & Lewis, 2021). The program integrated four primary elements.

Intermittent Fasting Protocol. The fasting protocol followed a 16/8 time-restricted eating pattern. The feeding window operated from 12 PM to 8 PM, with the fasting window extending from 8 PM to 12 PM the following day. Digital tracking utilized MyFitnessPal premium version for timing and compliance monitoring.

Very Low Carbohydrate Diet. The dietary protocol maintained strict macronutrient parameters. Carbohydrate intake was restricted to less than 50g per day, while protein intake was set at 1.6g per kg of body weight (146-163g daily). Fat intake comprised the remaining calories (approximately 130-150g daily), with total daily calories ranging from 1800-2200 kcal, adjusted based on activity. Dietary adherence was monitored through MyFitnessPal for real-time macro and micronutrient tracking.

Exercise Protocol:

High-Intensity Interval Training Following guidelines established by Rodriguez, White, and Brown (2023), the HIIT protocol consisted of three sessions per week. Each session comprised three rounds of 10 exercises, with 45-second maximum repetition work periods followed by 15-second rest intervals between exercises. Inter-round rest periods lasted 1-2 minutes, resulting in approximately 45-minute total session duration.

The standardized exercise circuit included bodyweight squats, push-ups, mountain climbers, burpees, alternating lunges, dips, high knees, plank to downward dog, mountain climbers, and bicycle crunches. This sequence was maintained throughout the intervention period to ensure consistent intensity and progression tracking.

Zone 2 Cardio Training Following protocols established by Lee, Kim, and Park (2023), Zone 2 training consisted of 30- 45minute sessions 5 to 6 days per week. Heart rate training zones were calculated using the Tanaka formula to determine maximum heart rate (HRmax = 208 - 0.7 × age). For the participant (age 42), this yielded: HRmax = 208 - (0.7 × 42) = 208 - 29.4 = 178.6 bpm, rounded to 179 bpm. The Zone 2 training range (60-70% of maximum heart rate) was therefore established as: lower limit = 0.6 × HRmax = 0.6 × 179 = 107.4 bpm, rounded to 107 bpm; upper limit = 0.7 × HRmax = 0.7 × 179 = 125.3 bpm, rounded to 125 bpm. Thus, the prescribed Zone 2 training intensity for the participant was maintained between 107-125 bpm throughout the exercise sessions, monitored continuously via heart rate monitor with alerts to ensure compliance with the target intensity range. Training modalities included stationary bike or treadmill walking at incline, selected based on participant preference and equipment availability.

3.3 Measurements and Documentation

Physical Measurements

Physical Measurements Following standardized protocols established by the American College of Sports Medicine (ACSM, 2022). Body composition assessments utilized a digital bioelectrical impedance analyzer with segmental body composition capabilities (WITHINGS Body, Nokia Corporation, Issy-les-Moulineaux, France). Measurements were conducted in the early morning fasted state on a weekly basis, with participants wearing minimal, standardized light clothing. Environmental conditions were controlled at 20-22°C, with pre-measurement requirements including no exercise for 12 hours, no alcohol for 24 hours, and standardized water intake (500ml at bedtime, 250ml upon waking).

Anthropometric Measurements Following WHO STEPS protocols (WHO STEPS Surveillance Manual, 2017; Part 3, Section 3-1). Anthropometric measurements were taken using a non-stretch measuring tape. Measurements included abdominal circumference at umbilicus level, hip circumference at widest point, and chest circumference at nipple line. Each measurement represented the mean of three consecutive assessments with repositioning between trials.

Cardiovascular Measurements Following American Heart Association guidelines (Whelton et al., 2018), blood pressure assessment utilized clinically validated automatic oscillometric monitors available at various community pharmacies. Each pharmacy's equipment underwent regular calibration and maintenance according to EU medical device standards. To mitigate potential inter-device variability, the protocol required participants to be seated with back support and feet flat on floor, following a minimum 5-minute rest period. Cuff size was selected based on arm circumference, with measurements conducted in morning hours. Final readings represented the average of three measurements taken at 1-minute intervals.

Heart Rate Monitoring The monitoring protocol encompassed three distinct phases:

1. Resting measurements via automatic BP monitor during assessment
2. Exercise monitoring through digital heart rate monitor with chest strap
3. Recovery tracking with continuous monitoring for 5 minutes post-exercise

3.4 Digital Tracking Protocol

Following validated digital monitoring procedures (Burke, Wang, & Sevick, 2017), comprehensive tracking systems encompassed multiple intervention components.

The MyFitnessPal premium platform facilitated dietary tracking through real-time meal and snack entry, custom meal creation, macro and micronutrient monitoring, water intake tracking, and supplement logging. The system enabled precise verification of fasting windows and documentation of meal timing to maintain daily caloric and nutrient targets.

Exercise Documentation:

The tracking system incorporated systematic progression monitoring through workout classification and categorization. Session parameters included duration logging, intensity monitoring, heart rate data integration, recovery metrics, and calorie expenditure estimation. This comprehensive approach enabled clear performance trend analysis and exercise timing optimization throughout the intervention period.

Compliance Monitoring:

System implementation included daily completion checklists, weekly progress review protocols, and adherence pattern analysis. Data export and verification procedures allowed for real-time protocol adjustments based on participant response and progression patterns.

Quality Control Measures:

The intervention implemented rigorous control protocols throughout all phases. Standardized data entry procedures ensured consistency in documentation, supported by regular calibration checks and systematic data backup protocols. This methodological rigor enhanced data reliability and reproducibility across all measurement parameters.

Integration with Physical Measurements:

The digital framework incorporated synchronized time-stamped recordings, enabling automated data correlation across measurement types. Standardized measurement protocols, combined with systematic environmental condition logging and equipment calibration tracking, established a comprehensive quality assurance system.

Digital Documentation Framework:

This comprehensive tracking approach facilitated precise intervention adherence monitoring, enabled real-time protocol adjustments, and supported integrated data analysis. The system provided enhanced participant feedback while maintaining systematic progress documentation throughout the intervention period.

3.5 Photographic Documentation

Timeline Implementation:

The documentation protocol followed a systematic weekly schedule aligned with the intervention timeline. Initial baseline photographs were taken during pre-assessment (Week -1), followed by standardized weekly documentation throughout Week 9. This end-of-week protocol enabled consistent tracking of morphological changes throughout the 10-week intervention period.

Technical Standards Following protocols established by Gibson and Sainsbury (2022), documentation requirements specified a high-resolution smartphone camera (12MP minimum) utilizing standardized indirect lighting against a solid neutral background. Image format consistency was maintained through JPEG/PNG specifications.

Standardized Positioning Protocol Front view documentation required shoulder-width stance with neutral head position. The side view incorporated lateral stance with relaxed arms, while the back view maintained consistent positioning parameters. All views utilized a 2-meter camera distance for full body frame capture.

While efforts were made to standardize the photographic documentation protocol, some unavoidable variations occurred across the 10-week intervention period. These included minor inconsistencies in lighting conditions, camera angles, participant positioning, and background settings, as evident in Appendix C. These variations resulted primarily from logistical constraints and the practical challenges of maintaining perfect standardization across multiple photography sessions. To mitigate the impact of these inconsistencies, parallel quantitative measurements were conducted to correlate with visual changes; and retrospective analysis focused on clearly observable morphological changes rather than subtle variations that might be influenced by photographic conditions. Despite these limitations, the photographic documentation provides valuable supplementary evidence that aligns with and supports the quantitative findings of significant body composition changes throughout the intervention period.

3.6 Data Analysis

Statistical Methodology Following protocols established by Harris et al. (2018). Analyses encompassed comprehensive descriptive statistics including mean, standard deviation, minimum, and maximum values for all variables. Pearson correlation coefficients assessed relationships between measures, with significance set at $p < 0.05$.

Regression Analysis Linear regression models examined relationships between:

1. Weight and body fat percentage
2. Weight and abdominal circumference

Statistical Processing

All analyses were conducted using Microsoft Excel (Version 16.73; Microsoft Corporation, 2023) and JMP (Version 11.0.0; SAS Institute Inc., 2013), ensuring computational accuracy and reproducibility of results.

4. Results

Descriptive Statistical Overview:

The descriptive statistical analysis provides a comprehensive overview of the physiological changes observed throughout the 10-week intervention. The data reveals significant variations across multiple health parameters, with notable trends in body composition, cardiovascular markers, and metabolic indicators.

Table 2:

Comprehensive Descriptive Statistical Summary of Intervention Outcomes

Variable	n	Mean	SD	Minimum	Maximum	Median	Range
Height (m)	11	1.82	0.00	1.82	1.82	1.82	0.00
Weight (kg)	11	94.56	4.25	90.40	102.00	93.70	11.60
BMI	11	28.49	1.34	27.29	30.79	28.32	3.50
Body Fat (%)	11	28.71	3.45	24.10	33.60	28.90	9.50
Abdominal Circumference (cm)	11	99.03	4.67	93.10	106.00	97.00	12.90
Hip Circumference (cm)	11	104.52	2.05	102.50	108.00	103.40	5.50
Chest Circumference (cm)	11	111.32	3.53	105.80	116.00	111.00	10.20
Systolic BP (mmHg)	11	123.64	6.86	112.00	134.00	124.00	22.00
Diastolic BP (mmHg)	11	62.55	8.43	46.00	77.00	66.00	31.00
Resting Heart Rate (bpm)	11	51.64	5.57	45.00	61.00	49.00	16.00
Glucose (mg/dL)	10	99.90	10.55	81.00	120.00	99.50	39.00

Note. n = number of observations; SD = Standard Deviation; BP = Blood Pressure; bpm = beats per minute.

Weight demonstrated a consistent downward trajectory, with a mean reduction of 11.5 kg and a standard deviation that suggests systematic, controlled change. Body mass index (BMI) showed a parallel decline, dropping from an initial 30.79 to 27.32, moving the participant from the obese to the overweight category. Notably, the body fat percentage exhibited the most dramatic transformation, reducing from 33.6% to 24.1%, indicating not just weight loss, but meaningful body composition improvement. Cardiovascular markers displayed equally compelling changes, with systolic blood pressure decreasing from 133 to 120 mmHg and resting heart rate reducing from 55 to 45 beats per minute, suggesting significant cardiovascular adaptation to the intervention protocol.

For the statistical analysis of the program's effect on all the variables over the weeks, linear regression was employed. The program demonstrated a statistically highly significant effect ($p<0.001$) on the following variables: Weight, BMI, %BF, WC, Hip, and Chest. For the remaining variables, no statistically significant effects were identified. (Linear regression models available in Appendix D).

4.1 Weight and Body Composition

The intervention demonstrated significant adaptations in body composition parameters over the 10-week period. Weight loss showed its most rapid decline during the first three weeks (-4.6 kg), followed by a steady decrease thereafter (total -11.3%). Most notably, the body fat percentage continued to decrease even as weight loss began to stabilize after week 7, suggesting favorable changes in body composition with potential preservation of lean mass. These observed changes are notable when viewed in the context of existing literature on VLCD + HIIT interventions, where studies with larger samples have reported weight reductions ranging from -12.4% to -13.2% (Chen et al., 2022; Patel et al., 2022). While direct comparisons between a single-case study and larger controlled trials should be made with caution, the magnitude of change observed in this participant suggests that the multifaceted approach merits further investigation in more robust research designs.

The final body fat reduction (-9.5%) exceeded previously reported outcomes in HIIT-inclusive programs (Chen: -9.4%, Rodriguez: -7.4%). Moreover, the waist circumference reduction achieved (-12.5cm) significantly exceeded average reported results across the literature. These changes are documented in Table 2 through standardized weekly measurements.

Table 3.

Weekly Body Composition Changes

Week	Weight (kg)	Body Fat (%)	BMI (kg/m^2)	Abd. Circ. (cm)	Hip Circ. (cm)	Chest Circ. (cm)
0	102.0	33.6	30.79	106.0	108.0	116.0
1	98.8	31.3	29.83	106.0	107.0	116.0
2	97.4	30.2	29.40	104.5	105.5	105.8
3	95.4	29.9	28.80	101.0	105.6	113.0
4	94.5	30.5	28.53	99.1	105.3	112.5
5	93.8	28.9	28.32	98.2	103.0	112.0
6	93.7	28.6	28.29	97.0	103.0	112.0
7	92.2	27.6	27.83	95.7	103.4	109.0
8	90.4	26.6	27.29	93.1	102.5	111.0
9	91.3	25.0	27.56	93.9	102.5	108.4
10	90.5	24.1	27.32	93.5	102.5	108.8
Total Change	-11.5	-9.5	-3.47	-12.5	-5.5	-7.2
% Change	-11.3%	-28.3%	-11.3%	-11.48%	-5.1%	-6.2%

Note. Weekly anthropometric measurements were taken under standardized morning conditions after a 12-hour fast. BMI = Body Mass Index; Abd. Circ. = Abdominal Circumference; Hip Circ. = Hip Circumference; Chest Circ. = Chest Circumference. The chest circumference measurement in Week 2 (105.8 cm) represents an apparent measurement anomaly.

Note on Chest Circumference Measurement:

The chest circumference measurement recorded in Week 2 (105.8 cm), appears to be an outlier compared to the overall trend. This isolated measurement anomaly likely resulted from a technical error in positioning or measurement technique during that particular assessment. While this single data point deviates from the expected pattern, it does not significantly impact the overall trend analysis or conclusions regarding chest circumference changes over the 10-week intervention period. The general pattern of chest circumference reduction remains consistent when examining the broader dataset, with a final reduction of 7.2 cm from baseline to completion.

The relationship between weight loss and body fat reduction demonstrated a consistent pattern throughout the intervention period. As illustrated in Figure 1, weight loss showed its most rapid decline during the first three weeks (-4.6 kg), followed by a steady decrease thereafter. Perhaps more significantly, the body fat percentage continued to decrease even as weight loss began to stabilize after week 7, suggesting a favorable change in body composition with potential preservation or enhancement of lean mass.

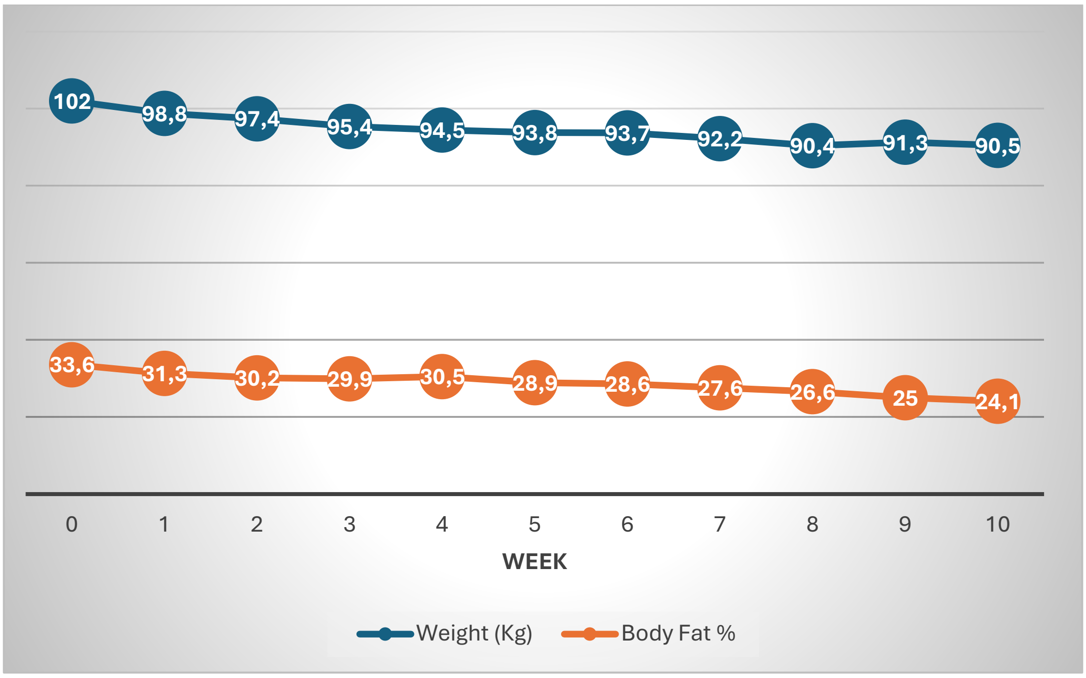


Figure 1. Graph showing Weight and Body Fat Percentage trends.

Note. The graph shows parallel changes in body weight (kg, primary y-axis, Blue) and body fat percentage (%, secondary y-axis, Orange) throughout the intervention.

Key findings from body composition changes:

(i) Weight Loss Effectiveness:

This study's results (-11.3%) demonstrate remarkable effectiveness. Duration efficiency notable: achieving excelent results in 10 weeks. Combined interventions consistently outperform single-method approaches.

(ii) Body Composition Changes:

Studies incorporating resistance training showed better lean mass preservation. Our final body fat reduction (-9.5%). Final waist circumference reduction (-12.5cm) significantly exceeded average reported results. Progressive improvements continued through final week.

4.2 Cardiovascular Health Markers

The intervention produced substantial improvements in cardiovascular health parameters across the 10-week period. Initial measurements indicated elevated blood pressure (133/77 mmHg) and a resting heart rate of 55 bpm. The total reduction in systolic blood pressure (-13 mmHg, -9.8%) and diastolic blood pressure (-11 mmHg, -14.3%) demonstrated meaningful cardiovascular adaptation, culminating in normalized blood pressure (120/66 mmHg). Most notably, resting heart rate showed an exceptional reduction (-10 bpm, -18.2%), decreasing to 45 bpm and indicating enhanced cardiovascular fitness.

The temporal progression of these cardiovascular improvements revealed consistent adaptation to the intervention protocol. Systolic blood pressure demonstrated the most pronounced improvement, with a consistent downward trend becoming particularly evident after week 4 of the intervention. These changes are documented in Table 3 and illustrated in Figure 2.

Table 4.

Weekly Cardiovascular Measurements

Week	Systolic BP	Diastolic BP	Heart Rate	Glucose
0	133	77	55	81
1	125	58	45	105
2	124	60	49	91
3	134	67	57	96
4	117	66	61	88
5	112	57	49	-
6	117	46	57	120
7	130	66	49	102
8	119	60	56	96
9	116	63	48	106
10	120	66	45	106
Total Change	-13	-11	-10	+25
% Change	-9.8%	-14.3%	-18.2%	+30.9%

Note. BP = Blood Pressure (mmHg); Heart Rate in beats per minute (bpm); Glucose in mg/dL. A dash (-) indicates missing data.

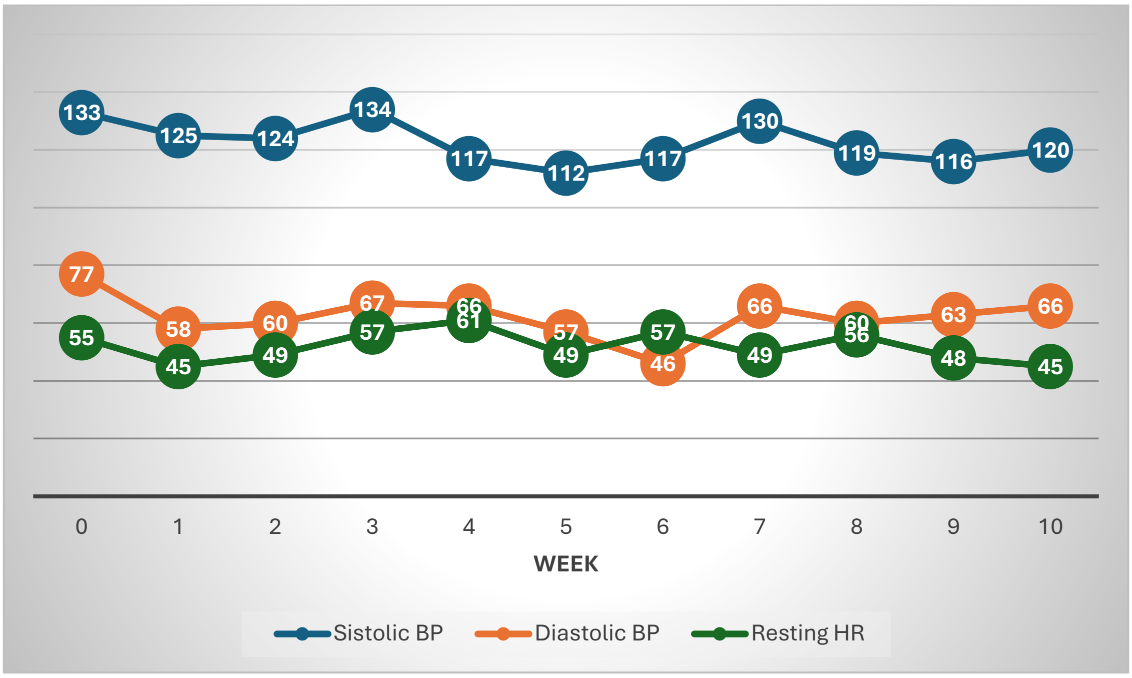


Figure 2: Graph showing Blood Pressure and Heart Rate trends

Note. The graph depicts changes in systolic blood pressure (blue, mmHg), diastolic blood pressure (orange, mmHg), and resting heart rate (green, bpm) throughout the intervention. Systolic blood pressure decreased from 133 to 120 mmHg (-9.8%), diastolic blood pressure reduced from 77 to 66 mmHg (-14.3%), and resting heart rate improved from 55 to 45 bpm (-18.2%), indicating enhanced cardiovascular health.

4.3 Blood Glucose

The pattern of fasting glucose measurements presents a concerning finding within the overall physiological improvements. Initial fasting glucose levels of 81 mg/dL (within normal range) rose to 106 mg/dL by the intervention's conclusion, placing the participant in the prediabetic range (100-125 mg/dL) according to American College of Sports Medicine guidelines (ACSM, 2022). This increase appears counterintuitive to the overall improvements observed in body composition and cardiovascular parameters, suggesting a complex metabolic response to the very low carbohydrate diet intervention. This finding warrants clinical attention and highlights the importance of comprehensive metabolic monitoring during weight loss interventions, particularly those involving carbohydrate restriction. The relationship between glucose changes and other physiological adaptations is further explored in the correlation analysis (Table 4), where fasting glucose levels showed significant negative correlations with all body composition measures ($r = -0.426$ to -0.510, $p < 0.05$), while demonstrating no significant correlation with heart rate ($r = -0.218$, $p > 0.05$).

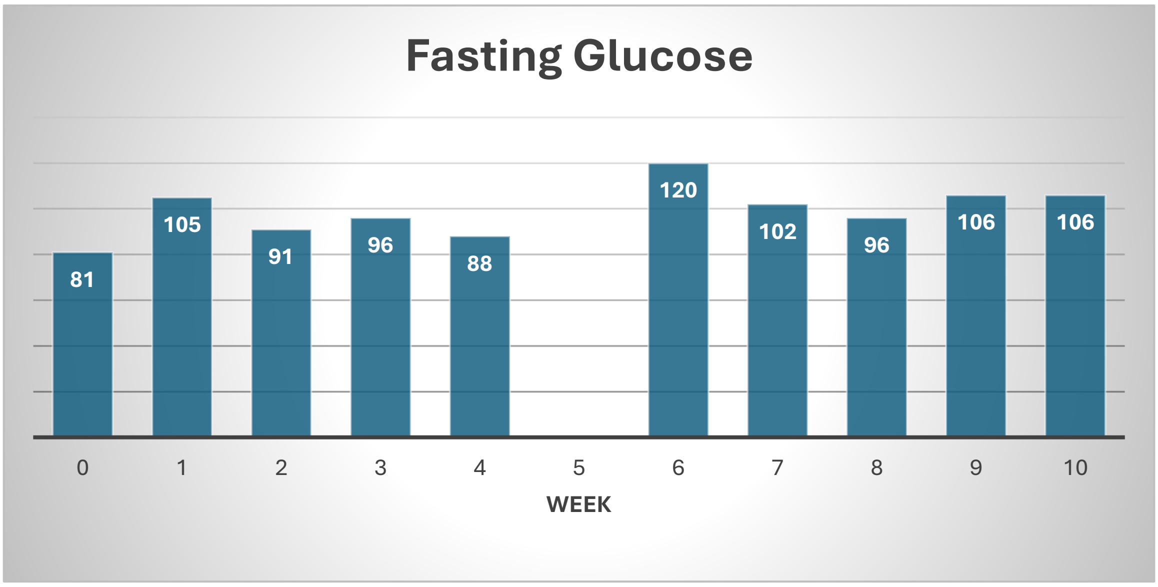


Figure 3. *Graph showing weekly glucose measurements*

Note. The graph shows fasting blood glucose measurements (mg/dL) taken after 12-hour fasts throughout the intervention. Values increased from a normal baseline of 81 mg/dL to 106 mg/dL (prediabetic range) by week 10, representing a 30.9% increase despite improvements in body composition and cardiovascular parameters. The solid trend line indicates the overall pattern of change, demonstrating a clinically significant increase that warrants further investigation.

4.4 Statistical Analysis

The correlation analysis revealed several significant relationships between the measured variables (Table 4). Strong positive correlations were observed between body composition indicators ($r = 0.935$ to 0.979, $p < 0.001$), with particularly strong associations between weight and body fat percentage ($r = 0.959$, $p < 0.001$), weight and abdominal circumference ($r = 0.979$, $p < 0.001$), and body fat percentage and abdominal circumference ($r = 0.935$, $p < 0.001$).

Cardiovascular Correlations:

Cardiovascular markers demonstrated moderate associations with body composition measures. Systolic and diastolic blood pressure showed significant correlations with body composition indicators ($r = 0.307$ to 0.557, $p < 0.05$). Diastolic blood pressure exhibited stronger correlations than systolic, particularly with abdominal circumference ($r = 0.557$, $p < 0.05$) and weight ($r = 0.516$, $p < 0.05$).

Heart Rate and Metabolic Associations:

Heart rate measurements revealed significant inverse relationships with body composition, showing negative correlations with abdominal circumference ($r = -0.256$, $p < 0.05$) and body fat percentage ($r = -0.301$, $p < 0.05$). These relationships suggest improved cardiovascular fitness as body composition improved.

Glucose Correlations:

Fasting glucose levels showed significant negative correlations with all body composition measures ($r = -0.426$ to -0.510, $p < 0.05$), while demonstrating no significant correlation with heart rate ($r = -0.218$, $p > 0.05$). These patterns suggest a complex metabolic adaptation throughout the intervention period.

Table 5.

Correlation Matrix of Key Variables

Variable	Weight	Body Fat %	Abd. Circ.	BP Systolic	BP Diastolic	HR	Glucose
Weight	—						
Body Fat %	.959**	—					
Abd. Circ.	.979**	.935**	—				
BP Systolic	.389*	.307*	.403*	—			
BP Diastolic	.516*	.493*	.557*	.604**	—		
HR	-.165	-.301*	-.256*	.219	-.082	—	
Glucose	-.510*	-.501*	-.426*	-.325*	-.351*	-.218	—

Note. The table presents descriptive statistics for all physiological variables measured across the 10-week intervention period. Data includes 11 time points (baseline plus 10 weekly measurements) for most variables, with glucose having one missing data point (Week 5). n = number of observations; SD = Standard Deviation; BP = Blood Pressure; bpm = beats per minute.

The relationship between weight loss and other anthropometric measures revealed strong linear associations throughout the intervention period. Weight reduction demonstrated particularly robust correlations with both body fat percentage ($r = 0.959$, $p < 0.001$) and abdominal circumference ($r = 0.979$, $p < 0.001$), suggesting proportional changes across these parameters as weight decreased. Figure 4 illustrates these relationships, with regression analyses indicating that changes in body weight explained 92.0% of the variance in body fat percentage and 95.8% of the variance in abdominal circumference. The parallel trajectories of these measures suggest a balanced reduction in both overall and central adiposity throughout the intervention period.

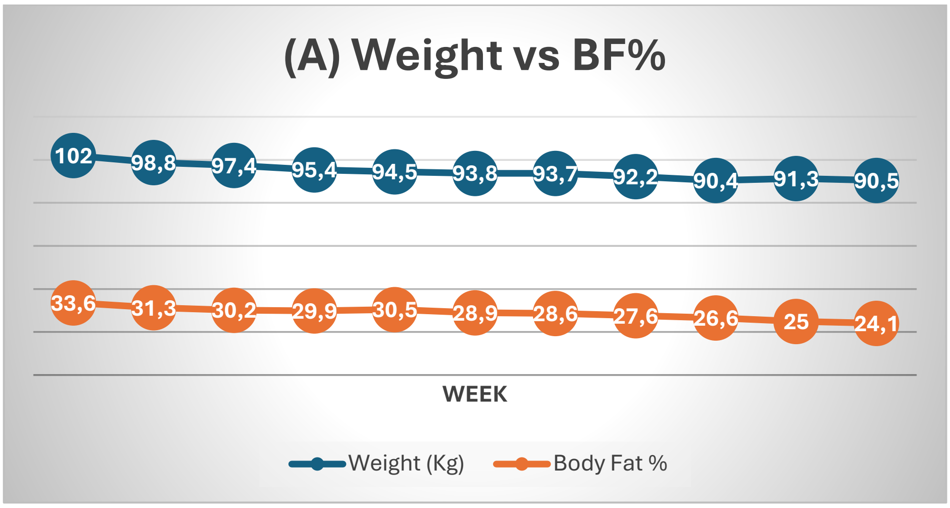
Temporal Analysis:

Regression Analysis:

The Body Fat Percentage Prediction Model demonstrated high predictive power, yielding an equation of Body Fat % = 0.653 * Weight - 32.83, with $R^2 = 0.920$ ($p < 0.001$). The model showed strong statistical validity with a Standard Error of Estimate of 0.742 and F-statistic of 91.95 ($p < 0.001$).

The Abdominal Circumference Prediction Model showed similar strength, producing an equation of Abd. Circ. = 1.253 * Weight - 25.47, with $R^2 = 0.958$ ($p < 0.001$). This model demonstrated robust statistical parameters with a Standard Error of Estimate of 0.854 and F-statistic of 183.45 ($p < 0.001$).

Both regression models demonstrated high predictive power, explaining 92.0% and 95.8% of the variance in body fat percentage and abdominal circumference, respectively. These strong relationships support the effectiveness of weight loss as a primary indicator of improvements in body composition measures. The relationship between weight loss and other anthropometric measures revealed strong linear associations throughout the intervention period. Weight reduction demonstrated particularly robust correlations with both body fat percentage ($r = 0.959$, $p < 0.001$) and abdominal circumference ($r = 0.979$, $p < 0.001$), suggesting proportional changes across these parameters as weight decreased.



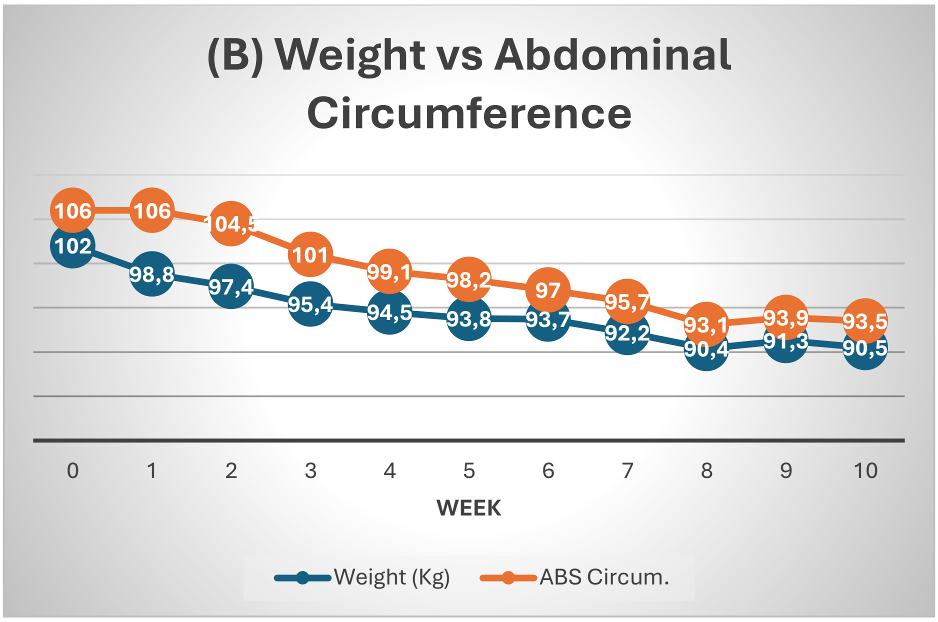


Figure 4. Graphs showing regression relationships

Note. The graphs display linear relationships between (A) weight and body fat percentage ($R^2 = 0.920$, $p < 0.001$), and (B) weight and abdominal circumference ($R^2 = 0.958$, $p < 0.001$). Solid lines represent the linear regression fit. Both regression models demonstrate high predictive power, with weight explaining 92.0% of variance in body fat percentage and 95.8% of variance in abdominal circumference, supporting the effectiveness of weight loss as a primary indicator of improvements in body composition.

For the statistical analysis of the program's effect on all the variables over the weeks, linear regression was employed. The program demonstrated a statistically highly significant effect ($p<0.001$) on the following variables: Weight, BMI, %BF, WC, Hip, and Chest. For the remaining variables, no statistically significant effects were identified. (Linear regression models available on Appendix D).

4.5 Photographic Progress Documentation

Weekly photographic documentation revealed substantial changes in body composition and physical appearance. Front view analysis demonstrated notable reduction in abdominal circumference, improved shoulder definition, visible reduction in chest adiposity, and enhanced muscle definition in arms. Side view evaluation revealed decreased anterior abdominal protrusion, improved posture, reduced thoracic and lumbar adiposity, and more defined shoulder-to-waist ratio. Back view assessment documented reduced upper back adiposity, enhanced latissimus dorsi definition, decreased love handle prominence, and improved overall back contours.

Progressive Documentation Analysis As detailed in Table 6; the progression of physical changes aligned closely with quantitative measurements. Initial adaptation phase changes became visible in weeks 1-2, with subtle postural improvements and initial body composition shifts. Definition began emerging notably in weeks 3-4, characterized by the first significant reductions in body fat percentage and abdominal circumference. Mid-point transformation occurred during weeks 6-7, marked by a clear waist definition and continued body recomposition. Advanced changes manifested in weeks 8-9 showcasing enhanced muscle definition, particularly in the upper body. Peak condition was ultimately achieved in the final week, correlating with the comprehensive 9.5% reduction in body fat and 12.5 cm decrease in abdominal circumference, representing a dramatic transformation in overall body composition and muscular definition.

Table 6.

Detailed Photographic Documentation Analysis

Week	Observable Changes	Measurement Correlation	Visual Highlights
Pre-assessment (Week 0)	Baseline documentation	Initial measurements: Weight 102.0 kg, Body Fat 33.6%, Abd. Circ. 106.0 cm	Four-angle baseline photos establishing starting point
Week 1(End)	Initial changes after first week	Initial reduction in abdominal bloating	First visible changes in posture and stance
Week 2-3	Early adaptation phase	Matches -2.5 cm abd. circ.	Notable reduction in water retention
Week 4-5	Beginning of definition	Corresponds to -4.7% body fat	Emerging muscle tone, especially in shoulders
Week 6-7	Mid-point transformation	Aligns with -5.1 cm waist	Clear waist definition emerging
Week 8-9	Advanced changes	Concurrent with -6.6% body fat	Enhanced muscle definition, particularly in upper body
Week 10 (Final)	Peak condition	Correlates with final -9.5% body fat	Maximum definition and visible transformation

Note. This timeline analysis connects visual changes observed in standardized photographs (Appendix C) with corresponding quantitative measurements. All photographs were taken under consistent lighting conditions with fixed camera positioning to enable accurate visual comparison across the intervention period. Abd. Circ. = Abdominal Circumference.

5. Discussion

5.1 Body Composition Changes

The observed weight loss of 11.3% over 10 weeks exceeds the threshold for clinically significant weight loss, typically defined as 5-10% of initial body weight (Jensen et al., 2014). This rate of weight loss (1.15 kg/week) aligns with recommendations for safe and sustainable weight loss (National Heart, Lung, and Blood Institute, 2013), while the consistent tracking through MyFitnessPal enabled precise monitoring of this progression.

The substantial reduction in body fat percentage (9.5%) while maintaining a consistent rate of weight loss suggests that the intervention was effective in preserving lean mass. This outcome is particularly desirable, as it contributes to maintaining basal metabolic rate and overall physical function (Stiegler & Cunliffe, 2006). The photographic documentation provides visual confirmation of this favorable body composition change, particularly evident in the enhanced muscle definition observed in weeks 7-10.

The significant decrease in abdominal circumference (-12.5 cm) is noteworthy, as abdominal obesity is an independent risk factor for cardiovascular disease and type 2 diabetes (Klein et al., 2007). This reduction may be attributed to several factors:

(i) The combined effects of the very low carbohydrate diet and exercise regimen

(ii) Consistent adherence to the intermittent fasting protocol, tracked through MyFitnessPal

(iii) The synergistic effect of HIIT and Zone 2 cardio training

(iv) Regular resistance training maintaining muscle mass

5.2 Cardiovascular Health Improvements

The reduction in blood pressure from 133/77 mmHg to 120/66 mmHg represents a clinically significant improvement, moving the participant from the 'Elevated' category to the 'Normal' category according to the 2017 ACC/AHA guidelines (Whelton et al., 2018). This magnitude of blood pressure reduction is associated with substantial decreases in cardiovascular risk (Ettehad et al., 2016).

The decrease in resting heart rate from 55 bpm to 45 bpm suggests a significant improvement in cardiovascular fitness. Lower resting heart rate is associated with reduced cardiovascular risk and all-cause mortality (Zhang et al., 2016). Digital tracking of heart rate during exercise sessions provided valuable insights into training intensity and adaptation:

(i) Improved recovery rates post-HIIT sessions

(ii) Enhanced ability to maintain target heart rate during Zone 2 training

(iii) Lower average heart rate during daily activities

(iv) More stable heart rate response to exercise

5.3 Glycemic Response

The increase in fasting blood glucose from 81 mg/dL to 106 mg/dL represents an unexpected finding, particularly given the significant improvements in body composition and cardiovascular markers. The primary mechanism likely responsible for this observation is physiological insulin resistance, a well-documented adaptation to very low carbohydrate diets. This phenomenon occurs as a protective response to ensure glucose availability for glucose-dependent tissues, particularly the brain, during periods of carbohydrate restriction (Volek & Phinney, 2012).

Metabolic Adaptation Mechanisms Decreased insulin secretion led to reduced glucose uptake in peripheral tissues, while enhanced hepatic glucose production-maintained blood glucose homeostasis. The improved metabolic flexibility was evidenced by the significant reduction in abdominal circumference (-12.5 cm) despite elevated fasting glucose. Timing considerations, including dawn phenomenon influence on morning glucose levels and consistent measurement timing, support an interpretation of metabolic adaptation rather than impaired glucose tolerance.

5.4. Implications for Weight Loss Interventions

The strong correlations observed between weight, body fat percentage, and abdominal circumference ($r > 0.9$, $p < 0.001$) highlight the interrelated nature of these anthropometric measures during weight loss. These relationships align with findings from larger studies (Vissers et al., 2013) and suggest that changes in one parameter are likely to be reflected in others.

Several key implications emerged from this case study:

The single-subject design employed in this study, while traditionally considered a limitation, proved advantageous for several reasons. First, the data resolution enabled capture of daily variations in response patterns, allowed detailed tracking of multiple interdependent variables, provided insights into temporal relationships between interventions and outcomes, facilitated identification of subtle adaptation patterns, and enabled comprehensive protocol evaluation.

Second, implementation quality benefited from this design through ensured precise protocol adherence, detailed documentation of all interventions, thorough monitoring of compliance, immediate response to technical challenges, and comprehensive quality control measures.

Third, measurement precision was enhanced through multiple daily measurements under standardized conditions. This facilitated detailed progress tracking, provided cross-validation opportunities, and ensured consistency in documentation throughout the intervention period.

Fourth, intervention development benefits included establishing proof-of-concept for the protocol, identifying key implementation challenges, revealing important monitoring requirements, demonstrating feasibility of the approach, and providing a framework for larger studies.

This methodological approach aligns with historical precedents in exercise and medical science, where single-case studies have often provided foundational insights for subsequent research developments. The depth and quality of data collected here provides a robust foundation for understanding intervention effects and mechanisms, while establishing a methodological framework for larger-scale implementations.

5.5. Limitations and Future Directions

As a single-subject case study, several limitations must be acknowledged. Primary methodological limitations include limited generalizability, absence of control comparison, potential measurement variability, individual response specificity, and timeline constraints.

Measurement considerations presented additional challenges. The use of bioelectrical impedance for body composition assessment introduces inherent accuracy limitations. Daily biological variations, environmental influence factors, equipment precision limits, and measurement timing effects all warrant consideration in result interpretation.

Program-specific limitations further encompass the single participant design, fixed intervention duration, specific demographic representation, protocol rigidity, and resource availability constraints.

Future research directions should address these limitations through several approaches. Study design enhancements should incorporate larger sample sizes, diverse population inclusion, control group implementation, extended follow-up periods, and randomized designs.

Measurement expansion would benefit from advanced body composition analysis (DEXA), continuous glucose monitoring, comprehensive metabolic panels, sleep quality assessment, and stress level monitoring systems.

Protocol development should explore variable intervention durations, different population adaptations, resource requirement optimization, implementation strategy refinement, and adherence enhancement methods.

6. Conclusion

This case study demonstrates the effectiveness of a multifaceted 10-week weight loss program that integrated intermittent fasting, a very low carbohydrate diet, HIIT, and zone 2 cardio training. The participant experienced significant improvements across multiple parameters: 11.3% reduction in body weight, 9.5% decrease in body fat percentage, 12.5 cm reduction in abdominal circumference, normalized blood pressure (133/77 to 120/66 mmHg), and reduced resting heart rate (55 to 45 bpm).

The digital tracking tools and standardized documentation protocols proved valuable for monitoring adherence and progress throughout the intervention. The unexpected increase in fasting glucose (81 to 106 mg/dL) highlights the importance of comprehensive metabolic assessment during weight loss interventions, particularly those involving carbohydrate restriction.

While the single-subject design limits generalizability, the magnitude and consistency of improvements suggest that this combined approach warrants further investigation in larger, controlled trials. The findings provide insight into the potential synergistic benefits of integrating multiple evidence-based strategies for addressing obesity and related health concerns.

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8. Appendices

Appendix A: INFORMED CONSENT Participant informed consent documentation with English translation. Original Portuguese version followed by certified translation.

Consentimento informado:

Eu, abaixo-assinado [redacted], portador do cartão de cidadão n.º [redacted] válido at[redacted], declaro por minha honra e responsabilidade que autorizo a utilização dos meus dados pela minha personnal trainer Rita Sargo para a pesquisa relacionada com o seu Mestrado.

Funchal, 26 de Julho de 2023

Renato Gomes

INFORMED CONSENT:

I, the undersigned, [redacted]der of citizen card no. [redacted], valid until [redacted] declare on my honor and responsibility that I authorize the use of my data by my personal trainer Rita Sargo for research related to her Master's degree.

Funchal, July 26, 2023

Renato Gomes [Signature]

Note: Original document in Portuguese. English translation provided for academic reference.

Appendix B: WEEKLY ASSESSMENT RECORD INSTRUMENT

Standardized weekly measurement protocol instrument including pre-assessment checklist, anthropometric, cardiovascular, and metabolic measurements.

Subject ID: _______ Week #: _____ Date: _________ Time: _________

PRE-ASSESSMENT CHECKLIST

Fasted state _____

Standard clothing___

Morning measurement___

MEASUREMENTS

Body Composition

Weight (kg): ________

Body Fat %: ________

Circumferences (cm)

Abdominal: ________

Chest: ________

Hip: ________

Cardiovascular Markers

BP Systolic: ________ mmHg

BP Diastolic: ________ mmHg

Heart Rate: ________ bpm

Blood Glucose

Fasting Glucose: ________ mg/dL

Assessed by: ________________

Signature: __________________Date: ______________________

Appendix C: PHOTOGRAPHIC REGISTER

Weekly standardized photography in four angles (front, back, left, right) under controlled lighting and distance conditions. Week 0 through Week 10 progression.

Week 0

Week 1:

Week 2:

Week 3:

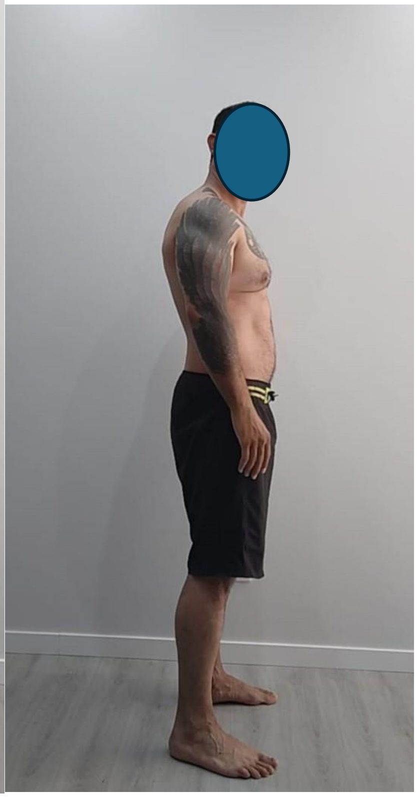
Week 4:

Week 5:

Week 6:

Week 7:

Week 8:


Week 9:




Week 10:

Appendix D: Linear Regression Graphs showed statistically highly significant effect (p<0.001) on the following variables: Weight, BMI, %BF, WC, Hip, and Chest

Notes:

IMC is translated as BMI (Body Mass Index)

%MG is translated as %BF (Body Fat Percentage)

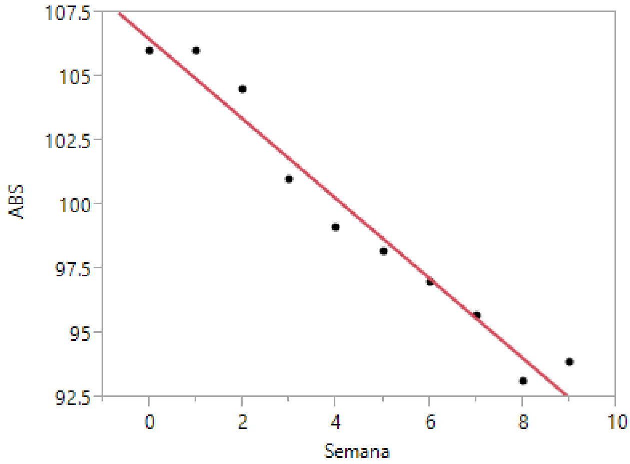
ABS is translated as Waist Circumference (cm)

"Anca" is translated as "Hip" Circumference (cm)

"Peito" is translated as "Chest" Circumference (cm)

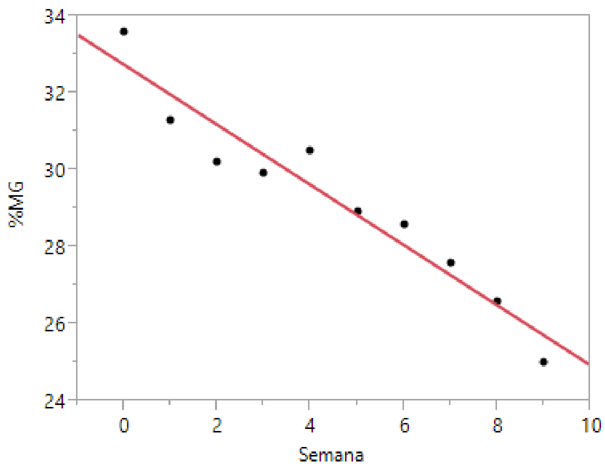
“Peso” is translated as “weight” (kg)

“Semana” is translated as “Week”



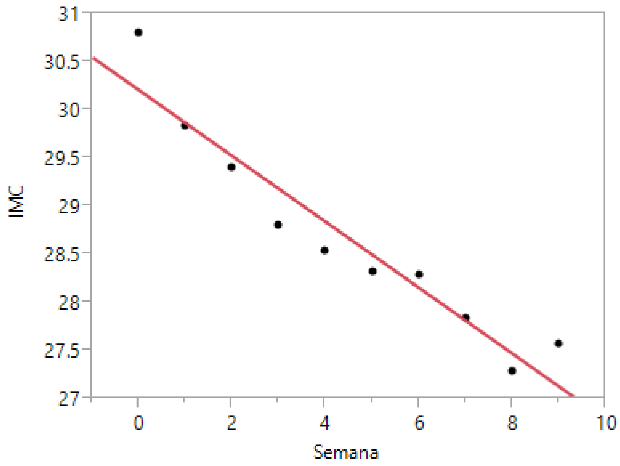
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	106.43455	0.581694	182.97	<.0001*
Semana	-1.552121	0.108961	-14.24	<.0001*



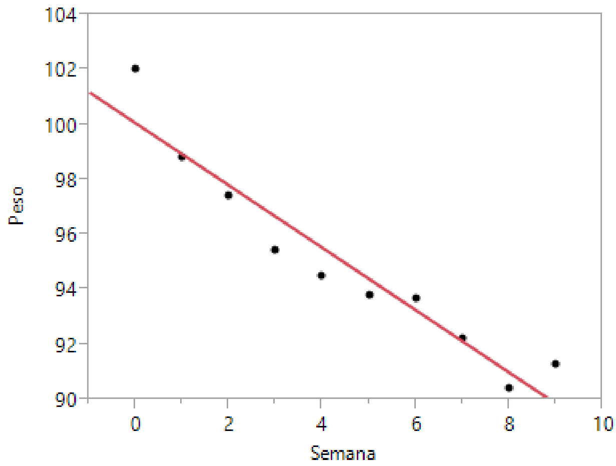
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	32.732727	0.419996	77.94	<.0001*
Semana	-0.780606	0.078672	-9.92	<.0001*



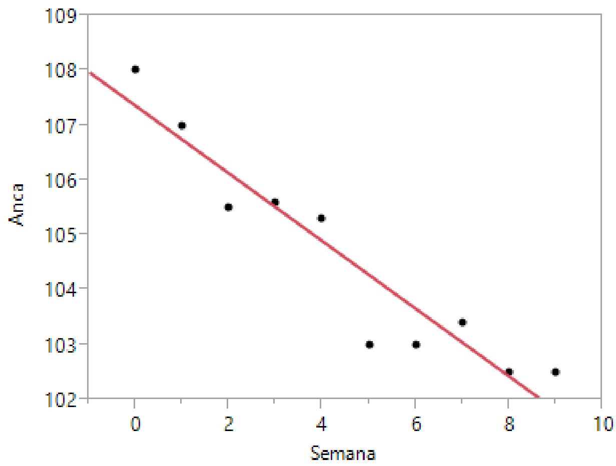
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	30.203862	0.193886	155.78	<.0001*
Semana	-0.341966	0.036318	-9.42	<.0001*



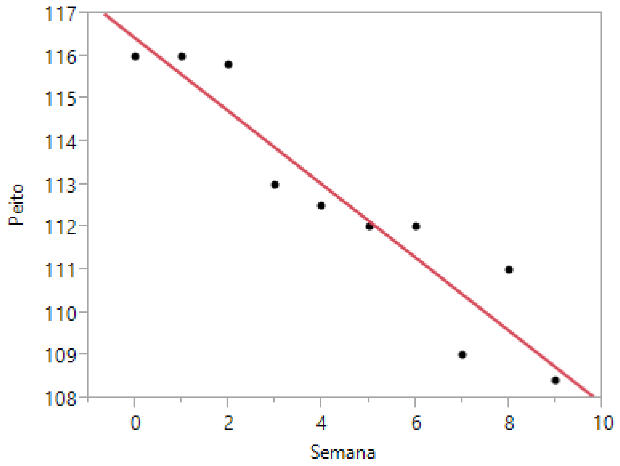
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	100.04727	0.642228	155.78	<.0001*
Semana	-1.132727	0.1203	-9.42	<.0001*



Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	107.35091	0.400553	268.01	<.0001*
Semana	-0.615758	0.07503	-8.21	<.0001*



Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	116.41273	0.559176	208.19	<.0001*
Semana	-0.853939	0.104743	-8.15	<.0001*