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Optimizing Body Composition in Soccer Players Through Caloric Restriction: A Randomized Controlled Trial

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Abstract

Introduction: Achieving optimal body composition can be advantageous for athletes in terms of competitive performance. To date, there is scarce research examining the effects of caloric restriction (CR) on body composition in male professional soccer players. This study aims to investigate the impact of 6 weeks of CR with protein supplementation on body composition and the maintenance of changes after stopping CR for the next 6 weeks. **Methods:** The study was a controlled, randomized, parallel-group, experiment involving 28 participants. Recommended energy intake (REI) was individually calculated. The experimental group received a CR diet (-25%; average REI 2650 kcal/d) and the control group received a normal caloric (NC) diet (average REI 3500 kcal/d). All participants received protein supplementation. The intervention lasted for 6 weeks, followed by 6 weeks without intervention and provision of *ad libitum* diet in both groups. Body composition was assessed using anthropometric measurements. **Results:** The study participants were aged 27.6 ± 4.4 year on average. After 12 weeks, the CR group showed a significant reduction in body weight compared with the NC group (−0.33 kg for CR vs. −0.08 kg for NC; *p* 0.028). Both groups experienced a reduction in adipose mass after 6 and 12 weeks. Intragroup analyses demonstrate that only CR group continued a significant reduction after 12 weeks (*6w -1.06kg; 12w -1.4kg. p 0.045*). Throughout the study, there was an increase in muscle mass, and no significant difference was observed between groups. **Conclusions:** CR with protein supplementation in male professional soccer players reduces weight and promotes sustained fat loss over time without losing muscle mass.

Keywords: Adiposity, Body Weight, Diet, Muscle Mass, Soccer

Resumen

Introducción: Lograr una composición corporal óptima es ventajoso para los atletas en términos de rendimiento competitivo. Hasta la fecha, existe poca investigación que examine los efectos de la restricción calórica (RC) en la composición corporal de futbolistas profesionales masculinos. Este estudio tiene como objetivos investigar el impacto de 6 semanas de RC con suplementación proteica en la composición corporal y el mantenimiento de los cambios tras suspender la RC durante las siguientes 6 semanas. **Métodos:** se realizó un experimento controlado, aleatorizado, de grupos paralelos, con 28 participantes. La ingesta energética recomendada (IRE) se calculó individualmente. El grupo experimental recibió una dieta RC (-25%; IRE promedio 2650 kcal/día) y el grupo control recibió una dieta normocalórica (NC) (IRE promedio 3500 kcal/día). Todos los participantes recibieron suplementación proteica. La intervención duró 6 semanas, seguida de 6 semanas sin intervención con dieta *ad libitum* en ambos grupos. La composición corporal se evaluó mediante mediciones antropométricas. **Resultados:** Los participantes del estudio tenían una edad promedio de 27,6 ± 4,4 años. Tras 12 semanas, el grupo RC mostró una reducción significativa del peso corporal en comparación con el grupo NC (RC −0,33 kg vs. NC −0,08 kg; p=0,028). Ambos grupos experimentaron una reducción de la masa adiposa tras 6 y 12 semanas. Los análisis intragrupo demuestran que solo el grupo RC mantuvo una reducción significativa tras 12 semanas (6 semanas -

1,06 kg; 12 semanas -1,4 kg; p = 0,045). A lo largo del estudio, se observó un aumento de la masa muscular, sin observarse diferencias significativas entre los grupos. **Conclusiones**: La restricción calórica con suplementación proteica en futbolistas profesionales masculinos reduce el peso corporal, promueve una pérdida de grasa sostenida a lo largo del tiempo y preserva la masa muscular.

Palabras Clave: Adiposidad, Peso corporal, Dieta, Masa muscular, Fútbol

Introduction

Soccer is characterized by intermittent changes in movements, speeds, directions, and technical tasks. These demands require physiological adaptations from soccer players (Slimani and Nikolaidis 2018). The body composition confers soccer players competitive benefits and contributes to high performance (Sebastiá-Rico et al. 2023). A satisfactory body composition in soccer players can prevent injuries, improve fatigue resistance during games and training, reduce post-match recovery time, and maintain player performance (e.g., strength, endurance, and jump-sprint ability) (Silva 2022). The specific body composition requirements for the performance of elite soccer players vary by playing level and position, for instance, adipose mass varies between 10% and 12%, goalkeepers tend to have greater body fat than outfielders, and midfielders have less body mass than players in other positions (Slimani and Nikolaidis 2018; Spehnjak et al. 2021).

Manipulating body composition is important for preseason, in-season, and off-season training (Collins et al. 2021). To achieve optimal body composition, specific training programs coupled with nutritional interventions are employed (Slimani and Nikolaidis 2018; Spehnjak et al. 2021). One of the dietary strategies employed to reach optimal body composition is caloric restriction (CR) (Aragon et al. 2017; Pons et al. 2018). CR is the restriction of dietary energy intake while maintaining sufficient nutrient supply to guarantee optimal nutrition status and avoid malnutrition. By starting a CR of ~12% with an optimal macronutrient distribution for athlete, the supply of glucose decrease and fatty acid oxidation is required to provide the demand for ATP (Rhoads and Anderson 2022; Most and Redman 2020; Lee and Dixit 2020). Correspondingly, CR induces metabolic mitochondrial energy efficiency, reduces oxidative damage, decreases energy expenditure during physical activity, improve perceived exertion, preserve immunity response, stimulate body weight reduction, intensify adipose mass loss, and promote lean body mass gain (Pons et al. 2018; Most and Redman 2020; Golbidi et al. 2017; Green, Lamming, and Fontana 2022; Garcia-Morales et al. 2025).

The impact of CR on the body composition of elite male soccer players has been scarcely studied. A study conducted with 15 male professional soccer players who underwent CR found a significant decline in weight, adipose mass reduction, and preservation of lean mass (Hammouda et al. 2013). However, there is insufficient data on the effects of CR on the body composition of male professional soccer players. Therefore, this study aims to evaluate the effect of CR with protein supplementation on body composition in a group of male professional soccer players. Additionally, we aimed to determine if intervention outcomes persisted for 6 weeks after treatment cessation.

Material and Methods

Study Design

The study was a controlled, randomized, parallel-group experiment with a 1:1 allocation. The experimental group was provided with a CR diet in preseason matches. The control group was given a normal caloric (NC) diet across the study. All players were provided with whey protein supplement. The participants underwent baseline measurements, followed by a measurement at 6 weeks and another in the subsequent 6 weeks, with *ad libitum* diet in-season matches. This report follows the recommendations of the Proper Reporting of Evidence in Sport and Exercise Nutrition Trials -PRESENT- statement (Betts et al. 2020).

Ethical disclosure

All participants read and signed the informed consent document. The study was approved by the research ethics committee of the Autonomous University of Madrid (CEI 100-1873) (21-06-2019) and met the standards for the use of human participants in research, as outlined in national and international normativity.

Sample size estimation and participants

The sample size was estimated for the difference of independent means at the end of the intervention, considering a Confidence Interval of 95%, Power of 80%, Sample Size Ratio 1 and difference of 2 kg. The calculated total sample size was 20 subjects. Through block randomization by position, they were assigned to receive either the CR diet or NC diet. The distribution of players in a game position was equal between both groups, which included goalkeeper, central defense, wing defense, midfielder, forward, and outside midfielder. During the study, four players withdrew: two due to injury and two due to team changes Figure 1.

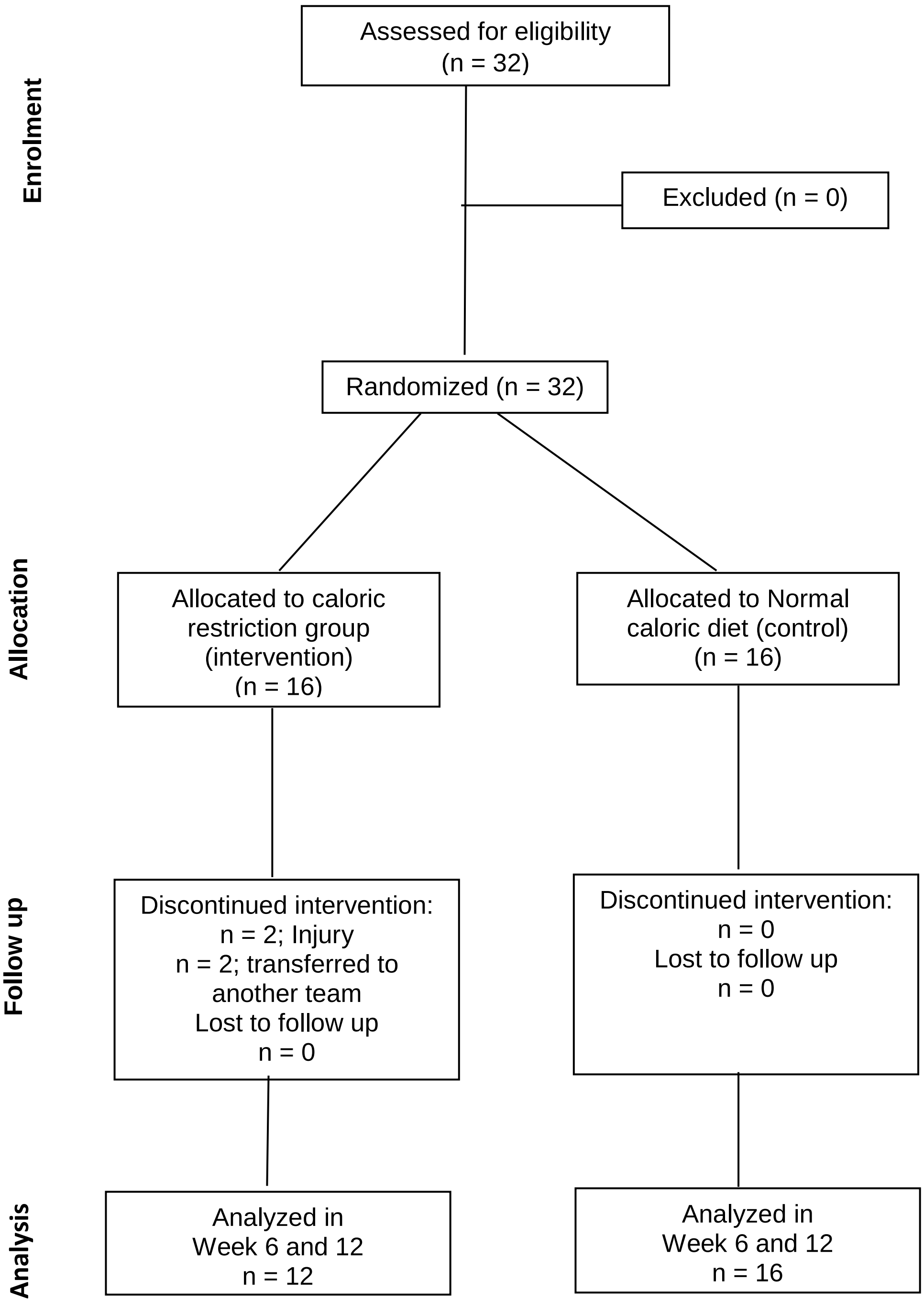

Figure 1. Flow of participants through each stage of the trial

The study involved 32 male professional soccer players who participated in the initial phase of the soccer season at the highest category of a professional soccer league. Players with a sum of six skinfolds (triceps, subscapular, supraspinal, abdominal, mid-thigh, and calf) >60 mm; metabolic diseases (e.g., cardiovascular, respiratory, gastrointestinal, thyroid-related, etc.); weight change ±2 kg in the last month following special diets (e.g., vegan diet, restrictive diet, etc.); consumption of nutritional supplements in the last month; and use of medications to control blood lipid or glucose were excluded. Additional exclusion criteria were failure to comply with all the measurements (physical, physiological, nutritional, and laboratory evaluations) and missing >5% of the scheduled training sessions. During the study, the players were encouraged to maintain their normal and constant training programs (8 h training/week).

Dietary intervention

Recommended energy intake (REI) was individually calculated based on physical activity, training, competition, rest days and resting metabolic rate. Cunningham's equation was used for resting metabolic rate, incorporating lean body mass from anthropometric measures and daily physical activity. For daily physical activity (e.g., stay at home and study), a factor of 1.25 was employed. The addition of energy expenditure per sports was 5 METS (Metabolic Equivalent of Task) by training and 9 METS by competition (Tinsley, Graybeal, and Moore 2019). The REI of CR group was reduced by 25% (Jagim et al. 2018; Thomas, Erdman, and Burke 2016). In order to safeguard the athlete's body composition and performance, this restriction has been implemented (Aragon et al. 2017). The average REI of the CR group was 2650 kcal/d, whereas that of the NC group was 3500 kcal/d, similar to that recommended for professional soccer players (Collins et al. 2021).

All soccer players were given a dietary plan with an equal macronutrient percentage distribution of REI: 18%–22% protein (CR: 2.3 g/kg/d; NC: 2.6 g/kg/d), 22% fat (1 g/kg/d), and 56%–60% CHO (5–7 g/kg/d). The plan was low in saturated fat, free of trans fats and sugar, and encouraged intake of unsaturated fats (Collins et al. 2021; Keen 2018; Hector and Phillips 2018). All soccer players followed the dietary plan prescribed at home and during the concentration period in the team facilities.

All participants were given a protein supplement in order to maintain adequate recovery and performance for training and soccer matches (Collins et al. 2021; Master and Macedo 2021; Abreu et al. 2023). All players were provided with 27 g of a whey protein supplement, which lacked carbohydrates or fats, immediately after their morning training. In the evening, 13.5 g of the whey protein supplement was provided to promote muscle recovery and rest (Collins et al. 2021; Keen 2018).

Dietary assessment and adherence

Dietary assessment was conducted at baseline, 6 weeks, and 12 weeks by a trained nutritionist. A standard menu and diet referrals were prescribed, based on the energy and nutrient calculation for each group and menu. To assess dietary adherence, a 24-h habitual consumption recall and food consumption frequency questionnaire were used for the following: day with regular training, day without training, and day with only strength or recovery training. The portions were quantified through food models, vessels, measuring spoons, and direct observation during meals (Bailey 2021; Salvador Castell 2015). The diet was quantitatively analyzed in an Excel sheet, using national nutritional content tables.

Body composition outcomes

Body composition was assessed using anthropometric measurements. Anthropometry was chosen because the use of bioimpedance or dual-energy X-ray absorptiometry requires equations and reference values that are not available for the study population. Furthermore, anthropometry was chosen for its evidence of reliability, speed of measurement, affordability, ease of standardization and suitability for sport (Kasper et al. 2021; Campa et al. 2021).

Body composition was determined by Ross & Kerr's five-components model (Ross, WD and Kerr 1991) and AntropoS2.8. Version software. Lean body mass was obtained by subtracting adipose mass from total body mass. An anthropometrist Instructor level III of The International Society for the Advancement of Kinanthropometry -ISAK- realized 15 anthropometric measures: weight, height, skinfolds (triceps, subscapular, supraspinal, abdominal, thigh, and calf), and perimeters (arm relaxed, arm flexed and contracted, forearm, waist, hips, thigh middle, and calf).

The technical measurement error was 1.17% due to duplicate measurements, guaranteeing the measurements' validity and accuracy. The anthropometric variables were measured earlier in the morning, fasting for at least 8 h, and without previous training.

Biochemical parameters

During the initial stage of the study, a range of nutritional blood biomarkers were measured to evaluate nutritional status. These included hemoglobin, hematocrit, leukocytes, lymphocytes, ferritin, total protein, albumin, and globulin. All blood samples were collected in the morning after an 8-h fast with no prior exercise. The samples were processed on the day of collection at a reliable clinical laboratory.

Data Analyses

Results were described as mean, standard deviation, frequency, or percentage. Normal distribution of quantitative variables was tested by the Shapiro–Wilk test. An independent samples *t*-test and χ^2 test were used to test baseline differences between CR and NC groups. The Mann–Whitney *U* test was used for cases that lacked normal distribution. Student's *t*-test or Wilcoxon signed-rank test of dependent samples was used for intragroup comparison. All differences were considered significant at p <0.05 and with Bonferroni's adjustments for multiple comparisons (p < 0.002). Statistical analyses were performed in Stata 12 software (StataCorp. Stata Statistical Software: Release 12. College Station, TX: StataCorp LLC).

Results

Characteristics and dietary adherence

The study involved 28 male professional soccer players with an average age of 27.6 ± 4.4 years. At the beginning of the study, both groups had similar nutritional blood biomarkers status (table 1) and nutritional intake (calories, protein, fat, and carbohydrates) (Table 2). After 6 weeks, the CR group had a lower intake of calories, fat, and carbohydrates, which remained low for the next 6 weeks of *ad libitum* diet. High protein intake was observed in both groups (Table 2). No side effects or health issues were reported during the study.

Table 1. Baseline characteristics of the 28 professional male soccer players included in the study.

	Calorie restricted diet n = 12	**Normal caloric Diet n = 16**	***p* value**
Age. Years. mean (SD)	27.8 (4.4)	27.5 (4.6)	0.86
Position n (%)			
Goalkeeper	1(8.3)	1(6.3)	
Center back	2(16.7	2(12.5)	
Wing back	2(16.7)	2(12.5)	
Center	4(33.3)	5(31.3)	
Winger	3 (25.0)	6 (37.5)	
Nutritional status blood biomarkers. Mean (SD)			
Hemoglobin (g/dL)	15.0 (0.8)	14.9 (0.9)	0.949
Hematocrit (%)	45.3 (2.6)	46.1 (2.7)	0.443
Ferritin (ng/mL)	163.5 (69.4)	158.1 (58	0.837
Total proteins (g/dL)	7.0 (0.4)	7.1 (0.6)	0.454
Albumin (g/dL)	4.2 (0.3)	4.3 (0.4)	0.413
Globulins (g/dL)	2.7 (0.5)	2.8 (0.4)	0.879

SD: standard deviation

Significance difference (p < 0.05) and Bonferroni's adjustment (p < 0.002).

Body composition

At baseline, both groups demonstrated similar body weights; however, the CR group presented higher fat mass and lower muscle tissue compared to the NC group. At both 6 and 12 weeks, the CR group continued to exhibit superior fat mass relative to the NC group, while muscle mass was comparable between the groups (Table 3).

Table 2. Nutritional intake and adherence to intervention at baseline, 6, and 12 weeks of follow-up.

	Calorie restricted diet n = 12	**Normal caloric Diet n = 16**	***p* value**
Calorie intake (kcal/kg/d). mean (SD)	41.0 (4.0)	41.5 (4.0)	0.6258
Baseline	30.3 (3.7)	46.9 (4.0)	**0.0001***
6 weeks	33.4 (4.4)	45.6 (4.3)	**0.0001***
12 weeks			
Protein intake (g/kg/d). mean (SD)	2.1 (0.3)	2.1 (0.3)	0.9254
Baseline	2.1 (0.3)	2.5 (0.2)	**0.0012***
6 weeks	2.3 (0.3)	2.6 (0.2)	**0.0001***
12 weeks			
Fat intake (g/kg/d). mean (SD)	1.0 (0.1)	1.0 (0.1)	0.8850
Baseline	0.8 (0.2)	1.1 (0.1)	**0.0003***
6 weeks	1.0 (0.2)	1.1 (0.1)	0.0621
12 weeks			
Carbohydrate intake (g/kg/d). mean (SD)	6.1 (0.7)	6.0 (0.7)	0.6080
Baseline	3.5 (0.5)	6.7 (0.7)	**0.0001***
6 weeks	4.0 (0.5)	6.4 (0.8)	**0.0001***
12 weeks			

SD: standard deviation

* *p* values are statistically significant at Bonferroni's adjustment p <0.002

When analyzing body composition changes at 6 weeks, the CR diet was associated with significant weight loss. Both groups experienced reductions in adipose mass and increases in muscle mass during this period. After discontinuing the intervention at 12 weeks, the CR group maintained fat loss and sustained muscle growth, whereas the NC group showed only a proportional increase in muscle mass (Table 4).

Discussion

The findings of this study underscore the potential of CR with protein supplementation as an effective strategy for changing body composition in soccer players. Our results demonstrate significant reductions in body weight, adipose mass, and sustained muscle growth in professional soccer players, even after the intervention concluded. These outcomes provide valuable insights into the role of CR in achieving fat loss while enhancing muscle mass—key aspects of physical conditioning in high-performance sports, such as with professional soccer players. CR brings benefits for professional soccer players, contributing to weight reduction and adipose mass loss. CR reduces the availability of energy, which inhibits lipogenesis and forces the body to utilize fatty acid oxidation for energy, resulting in decreased body fat (Lee and Dixit 2020; Thomas, Erdman, and Burke 2016; Wasserfurth et al. 2020). These benefits can be attributed to the negative caloric balance created by CR, which triggers a series of physiological, molecular, and cellular, mechanisms, such as metabolic pathways and formation of stress-activated advanced glycation end-products (Golbidi et al. 2017; Hofer et al. 2022).

CR with protein supplementation stimulates muscle gain by using oxidation of free fatty acids as fuel (Randell et al. 2019), inhibiting gluconeogenesis, and stimulating protein synthesis by preserving mTOR (Hofer et al. 2022; Hector and Phillips 2018). Indeed, adequate protein intake is essential for building and maintaining muscle mass (Bettonviel et al. 2016; Phillips 2016). Consuming protein pre- and post-training prevents muscle protein breakdown during exercise, preserves muscle mass, and promotes fatty acid oxidation (Hector and Phillips 2018; Phillips 2016; Hulton et al. 2022). Therefore, during exercise, mild CR with protein supplementation maintains the beneficial effect of protein consumption on muscle mass (Longland et al. 2016).

Table 3. Body composition of the 28 male professional soccer players included in the study at baseline and after 6 and 12 weeks.

	Calorie restricted diet n = 12 Mean (SD)	**Normal caloric diet n = 16** Mean (SD)	***p* value**
Body weight. Kg			
Baseline	76.9 (6.2)	74.1 (4.8)	0.1435
6 weeks	76.3 (6.1)	74.4 (4.9)	0.3409
12 weeks	76.6 (6.4)	74.1 (5.1)	0.3068
BMI. kg/m^2	24.3 (0.9)	23.5 (1.1)	
Baseline	24.2 (0.9)	23.6 (1.1)	**0.0482**
6 weeks	24.2 (1.0)	23.5 (1.1)	0.0814
12 weeks			0.0567
6-fold sum. Mm			
Baseline	52.0 (6.4)	38.4 (5.3)	**0.0001***
6 weeks	46.3 (7.1)	33.0 (5.3)	**0.0001***
12 weeks	44.3 (7.4)	33.1 (6.3)	**0.0009***
Adipose mass. Kg			
Baseline	16.5 (1.9)	14.0 (1.0)	**0.0007***
6 weeks	15.4 (1.7)	13.2 (1.2)	**0.0013***
12 weeks	15.1 (1.9)	13.0 (1.2)	**0.0029**
Adipose mass. %			
Baseline	21.4 (1.8)	18.9 (1.4)	**0.0010***
6 weeks	20.2 (1.7)	17.8 (1.6)	**0.0022**
12 weeks	19.6 (1.8)	17.6 (1.7)	**0.0062**
Muscle mass. Kg			
Baseline	40.1 (3.9)	39.6 (3.3)	0.6259
6 weeks	40.5 (4.0)	40.2 (3.5)	0.8892
12 weeks	41.0 (3.8)	40.4 (3.7)	0.6424
Muscle mass. %			
Baseline	52.1 (1.9)	53.3 (1.7)	**0.0432**
6 weeks	53.0 (1.6)	54.1 (2.0)	0.0701
12 weeks	53.6 (1.6)	54.5 (2.2)	0.1143

kg: kilogram

mm: millimeter

SD: standard deviation

p values in bold are statistically significant at $p < 0.05$

* *p* values are statistically significant at Bonferroni's adjustment $p < 0.002$

Studies have not delved into the maintenance of bodily changes after discontinuing CR intervention. Our hypothesis is that the loss of adipose mass and gain of muscle mass after CR cessation can be attributed to the lasting metabolic adaptations of CR attached to nutritional education, protein supplementation, and acceptance of dietary plan. This is supported by the fact that the intervention of nutrition education used to implement CR has enhanced dietary intake quality (Sánchez-Díaz et al. 2020), and CR was successful for participants to achieve physical, psychological, and environment needs (Wasserfurth et al. 2020; Collins et al. 2021).

Table 4. Body composition changes of the 28 male professional soccer players included in the study after 6 and 12 weeks.

	6 weeks	12 weeks	*P value*
Body weight. Kg	-0.6 (1.1)	-0.33 (1.7)	
CR	0.25 (0.56)	-0.08 (0.9)	*0.261*
NC	***0.031***	*0.816*	***0.037***
P value			--
BMI. Kg/m2	-0.18 (0.36)	-0.11 (0.53)	
CR	0.06 (0.26)	-0.03 (0.28)	*0.353*
NC	*0.078*	*0.871*	*0.079*
P value			--
6-fold sum. Mm			
CR	-5.8 (3.7)	-7.8 (3.8)	*0.050*
NC	-5.4 (4.6)	-5.3 (5.2)	*0.893*
P value	*0.829*	*0.341*	--
Body fat. Kg	-1.06 (0.67)	-1.4 (0.68)	
CR	-0.81 (0.59)	-0.98 (0.77)	**0.045**
NC	*0.295*	*0.390*	0.195
P value			
Body fat. %			
CR	-1.22 (0.71)	-1.76 (0.69)	**0.018**
NC	-1.15 (0.87)	-1.3 (1.02)	0.327
P value	*0.812*	*0.318*	--
Muscle mass. Kg			
CR	0.44 (0.96)	0.96 (1.17)	**0.021**
NC	0.68 (0.72)	0.81 (0.74)	0.310
P value	*0.469*	*0.642*	--
Muscle mass. %			
CR	0.95 (0.7)	1.51 (0.64)	**0.012**
NC	0.76 (0.65)	1.14 (0.76)	**0.029**
P value	*0.469*	*0.219*	--

CR: Calorie restricted diet

NC: normal caloric diet

kg: kilogram

mm: millimeter

SD: standard deviation

p values in bold are statistically significant at $p < 0.05$

To our knowledge, this is one of the first studies on CR in professional soccer players. The findings are similar those of a pre-post trial including 15 male professional soccer players, with CR −20% for 4 weeks, without protein supplementation (Hammouda et al. 2013). The trial demonstrated a reduction in body mass (−2.4 kg; $p < 0.05$), reduction in adipose mass (−0.6%; $p < 0.05$), and preservation of lean mass. According to Hammouda (Hammouda et al. 2013), these changes can be attributed to decreased daily energy intake and lipid use during restriction. Also, our findings demonstrate that muscle gain during CR could be stimulated through protein supplementation.

Similarly, our findings align with previous studies investigating CR combined with protein supplementation in various sports disciplines. A systematic review conducted on resistance-trained male athletes reported a reduction in body fat percentage across all included studies, with 50% of them also demonstrating an increase or maintenance of fat-free mass (Helms et al. 2014). Additionally, a study involving 17 resistance-trained males showed that CR with protein supplementation effectively reduced fat mass while preserving lean body mass (Dudgeon, Kelley, and Scheett 2016). Another study in trained male participants demonstrated that a 40% caloric restriction coupled with high protein supplementation led to an increase in lean body mass and a reduction in adipose tissue mass (Longland et al. 2016). These findings suggest that CR with protein supplementation can facilitate weight loss and adipose tissue reduction while supporting muscle mass growth in professional soccer players and athletes from other disciplines.

Future directions

Skinfold thickness and anthropometric methods are a popular and reliable surrogate method for measuring adiposity and muscularity. We followed a high quality protocol to ensure that the data were unbiased (Aragon et al. 2017; Thomas, Erdman, and Burke 2016; Collins et al. 2021). Evidence indicates possible differences between anthropometry with bioelectrical impedance analysis and dual-energy X-ray absorptiometry to estimate adipose mass percentage and fat-free mass kilogram (Sebastiá-Rico et al. 2023). For instance, our findings should be corroborated by studies using other body composition assessment techniques, such as dual-energy X-ray absorptiometry or bioelectrical impedance analysis. Furthermore, we demonstrate continuous improvement of body composition after cessation of intervention. Therefore, studies must focus in describing the physiological mechanism involved in maintaining changes.

Limitations

Our main strength was testing mild CR with protein supplementation during competition season and follow-up after cessation of CR. An important limitation includes sample size, which prevented in-depth subgroup analyses. Current research has emphasized the influence of a player's physiology, field position, and playing style on their body composition (Slimani and Nikolaidis 2018; Collins et al. 2021). Therefore, future studies should consider a larger sample size for detailed statistical analysis, according to soccer player characteristics. A second limitation was the baseline imbalance in fat mass distribution between the groups, attributed to the failure of block randomization and the resulting heterogeneity in football positions, which are associated with distinct body composition profiles. To address this limitation, Table 4 focuses on comparing relative changes rather than absolute measures, providing a more robust analysis.

Conclusions

This study highlights the effectiveness of caloric restriction with protein supplementation as a promising approach for optimizing body composition in professional soccer players. The intervention significantly reduced adipose mass and sustained muscle growth, even beyond the active phase of CR. Notably, the sustained benefits observed after discontinuation of CR highlight the role of protein supplementation and nutritional education in achieving long-term metabolic adaptations. These findings underscore the potential of CR combined with adequate protein intake to enhance physical conditioning in high-performance athletes. Future research with larger sample sizes should explore the physiological mechanisms underlying these sustained benefits and validate the outcomes using advanced body composition assessment techniques.

Practical implication

- A successful caloric restriction was achieved with a 25% reduction in Recommended energy intake, distributed as 18%–22% protein (2.3 g/kg/d), 22% fat (1 g/kg/d), and 56%–60% carbohydrates (5–7 g/kg/d).
- Body composition confers competitive benefits and contributes to achieving high performance among soccer players. Therefore, manipulating body composition through mild CR with protein supplements could increase muscle mass and decrease adipose mass in male professional soccer players.
- After 6 weeks, body weight was significantly reduced in the CR group compared with the NC group (−0.33 kg for CR vs. −0.08 kg for NC; $p < 0.05$). Both groups experienced a reduction in adipose mass after 6 weeks.
- Six weeks after cessation of CR, only the CR group showed a continued decrease in adipose mass. Muscle mass increased throughout the study.

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Ethics approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The study followed ethical research practices and received approval from the research ethics committee at the Autonomous University of Madrid (CEI 100-1873) on June 21, 2019.

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Informed Consent Statement

All the athletes included in the study provided written informed consent.

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