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THE INFLUENCE OF HABITUAL PROTEIN INTAKE ON BODY COMPOSITION AND MUSCULAR STRENGTH IN CAREER FIREFIGHTERS

Katie R. Hirsch, MA^{1,2}, Andrew J. Tweedell, MA³, Craig R. Kleinberg, MA³, Gena R. Gerstner, MS, MPH^{2,3}, T.J. Barnette, MA³, Jacob A. Mota, MS^{2,3}, Abbie E. Smith-Ryan, PhD^{1,2}, and Eric D. Ryan, PhD^{2,3}

¹Applied Physiology Laboratory, Department of Exercise and Sport Science, University of North Carolina, Chapel Hill, NC, USA.

²Human Movement Science Curriculum, Department of Allied Health Science, University of North Carolina Chapel Hill, NC, USA.

³Neuromuscular Research Laboratory, Department of Exercise and Sport Science, University of North Carolina, Chapel Hill, NC, USA.

Abstract

OBJECTIVES: To determine the relationship between protein (PRO) intake, body composition, and muscle strength in overweight and obese firefighters. A secondary objective was to evaluate differences in body composition and muscle strength between overweight and obese firefighters with low ($L < 0.8 \text{ g} \cdot \text{kg}^{-1}$), moderate ($M = 0.8\text{--}1.0 \text{ g} \cdot \text{kg}^{-1}$), and high ($H > 1.0 \text{ g} \cdot \text{kg}^{-1}$) PRO intake.

METHODS: Relative PRO intake [r_{PRO}] was evaluated from 3-day dietary logs, self-reported by 43 overweight and obese male, career firefighters (mean $\pm$ SD; age = 37.3 ± 7.2 yrs; body mass index = $33.2 \pm 5.0 \text{ kg} \cdot \text{m}^{-2}$; percent body fat [%BF] = $28.9 \pm 4.0\%$). Body composition (fat mass [FM], %BF, lean mass [LM], percent LM [%LM]) and muscle strength (Peak [PT], relative peak torque [r_{PT}] of the leg extensors) was measured using dual energy x-ray absorptiometry and isokinetic dynamometry, respectively.

RESULTS: Greater r_{PRO} was associated with less FM, %BF, LM ($r = -0.498$ – -0.363), and greater %LM ($r = 0.363$), but not muscle strength ($P > 0.05$). Fat mass ($r = -0.373$) and %BF ($r = -0.369$) were associated with lower r_{PT} ; %LM was associated with greater r_{PT} ($r = 0.373$). Individuals with L r_{PRO} had greater FM (Mean diff. $\pm$ SE: $L\text{--}H = 10.08 \pm 3.18 \text{ kg}$), %BF ($L\text{--}H = 3.8 \pm 1.4\%$), and lower %LM ($L\text{--}H = -3.7 \pm 1.3\%$) than those with H r_{PRO} ($P < 0.05$), but no significant differences in muscle strength ($P > 0.05$).

CONCLUSIONS: Protein intake $> 0.8 \text{ g} \cdot \text{kg}^{-1}$ was associated with more favorable body composition in male career firefighters.

Corresponding Author: Eric D. Ryan, PhD, Stallings Fellow Associate Professor, Department of Exercise and Sport Science, Adjunct Associate Professor Allied Health Sciences, University of North Carolina at Chapel Hill, 209 Fetzer Hall, CB #8700, Chapel Hill, NC 27599-8700, edryan@email.unc.edu, Office: 919-962-0297, Fax: 919-962-0489.

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Keywords

Dietary intake; obesity; first responder; shift worker

Introduction:

Firefighting is a physically demanding career that requires performing at near maximal intensities (a minimum of 12 METs or $42 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$) at a moment's notice, under extreme physical and environmental conditions [1, 2]. Despite the extreme physical demands and danger associated with the job, the percentage of firefighters considered overweight and obese exceeds that of the general US population [3]. In firefighters, excessive body fat has previously been associated with poor performance of firefighting tasks [4], a higher incidence of on-duty cardiovascular events [5], an increased risk of musculoskeletal injury [6], and higher absenteeism-related costs to employers [7].

In order to combat the high obesity rate among firefighters, it is imperative to evaluate dietary strategies that maximize fat loss, without compromising lean mass (LM) and muscle strength, which is critical to job performance. Greater habitual protein intake has been shown to be associated with lower BMI, lower waist circumference, and improved cholesterol, especially in overweight and obese individuals [8]. More importantly, higher protein intake has been shown to be more favorable for improving body composition, promoting fat loss through increases in energy expenditure [9–11]. In blue collar workers, greater habitual protein intake is also associated with greater maximal and explosive strength [12], which is important for firefighter performance [13] and avoiding common injuries (i.e. slips, trips, or falls) in the fire service [14]. It is currently recommended that individuals consume 0.8 g of protein per kg of body mass, but more recent research suggests that consuming $>1.0 \text{ g} \cdot \text{kg}^{-1}$ of protein may have significant health benefits, including improved cardiovascular health [8].

Previous evaluations of dietary intake in firefighters have primarily focused on qualitative descriptions of dietary intake, reporting that firefighters often rely on fast-foods and “firehouse meals” that can be prepared quickly and commonly involve foods that are high in trans fats and refined carbohydrates and sugars [15–18]. However, to date, there has been a lack of quantitative evaluation of the macronutrient intake of firefighters, specifically of protein intake, which limits the ability to critically evaluate the potential benefits of greater protein intake in this population. Therefore, the purpose of this study was to determine the relationship between habitual dietary protein intake, body composition, and muscle strength in overweight and obese career firefighters, as well as to evaluate potential differences in body composition and muscle strength between firefighters who consume low ($<0.8 \text{ g} \cdot \text{kg}^{-1}$), moderate ($0.8\text{--}1.0 \text{ g} \cdot \text{kg}^{-1}$), and high ($>1.0 \text{ g} \cdot \text{kg}^{-1}$) amounts of protein.

Materials and Methods:

Subjects

Forty-eight career firefighters from the central North Carolina region, were originally recruited and enrolled. After screening the data, five were excluded from analysis: three did not return dietary information and two were female, who were excluded due to known differences in body composition between men and women. Therefore, forty-three, overweight and obese male career (full-time) firefighters were analyzed for this study. Subject characteristics are presented in Table 1. Subjects considered overweight or obese [body mass index (BMI) $> 25 \text{ kg}\cdot\text{m}^{-2}$], but weight stable, not having gained or lost 7 kg within the last month were included for participation [19, 20]. To reduce the chances of misclassification of overweight or obese due to high muscle mass, individuals who were involved with heavy resistance training (3+ days per week) were excluded from participation. Individuals consuming protein shakes, high-protein meal replacement products, or sport nutrition products in the three month prior to enrollment were also excluded. No individuals reported having any metabolic diseases, neuromuscular diseases, or current or previous (within the last 3 months) musculoskeletal injuries to the lower back or extremities.

Experimental design

In a cross-sectional design, all subjects completed an assessment of body composition and isokinetic strength testing of the leg extensors during two sessions, each separated by 10 days. At visit one, all subjects provided written-informed consent approved by the University of North Carolina at Chapel Hill institutional review board, completed a health history and exercise status questionnaire, and were familiarized with the isokinetic strength testing. Subjects were also provided with a three-day dietary log, instructed to record all food and drink consumed over the course of three non-consecutive days, and asked to return the completed log at visit 2. At visit 2, each subject completed a body composition assessment, followed by isokinetic strength testing. All testing was completed in the morning, following a minimum of an eight hour fast; individuals were also asked to abstain from physical activity for 24 hours prior to testing.

Dietary assessment

Dietary intake was evaluated from a three-day dietary log, in which individuals were instructed to record all food and drink they consumed on two, non-consecutive weekdays and one weekend day. Individuals were given detailed verbal and printed directions on how to complete the diet logs and estimate portion sizes. Instructions included recording the amount of food, drink, gum, candy, condiments, supplements, etc. as consumed at each meal and snack throughout the day. Individuals were asked to be as specific and detailed as possible, making sure to include brand names and preparation techniques when appropriate. To assist with estimating portion sizes, individuals were provided with a visual guide that compared portion sizes of different foods to common household items. All three-day diet logs were analyzed by a dietitian at the Nutrition Obesity Research Center using Nutrition Data System for Research 2015 diet analysis software (Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN). From these reports, dietary intake was

averaged over the three analyzed days and evaluated for average calories (CAL; kcal), carbohydrate (CHO; g), fat (FAT; g), and protein (PRO; g). Relative protein intake was further evaluated by dividing protein intake by body mass ($r_PRO = PRO [g] / BM [kg]$).

Body Composition

Total body fat mass (FM), percent body fat (%BF), lean mass (LM), and percent lean mass (%LM) were evaluated via dual energy x-ray absorptiometry (DEXA; Hologic Inc., Bedford, MA, USA; Apex Software Version 3.3). Subjects were positioned in the center of the scanning table, with all extremities fitting inside of the scanning parameter. If an individual was wider than the scanning parameter ($n=7$), they were asked to place their hands under their thighs in order to include as much of the arms in the scan as possible. If one entire arm was included in the scanning parameter, but the other was not, the composition of the full limb was used to manually estimate the value for the partially scanned limb [21]. All subjects wore lightweight clothing and were asked to remove all metal to avoid interference with the DEXA scan. Age, stature, body mass, sex, and ethnicity were all entered into the DEXA system prior to measurement. Regions-of-interest were manually adjusted according to manufacturer recommendations to encapsulate the arms, torso, and legs. Test-retest reliability from our laboratory are as follows: intraclass correlation coefficient (ICC)=0.98 and standard error of measure (SEM)=0.85 kg for FM, ICC=0.99 and SEM=1.07 kg for LM, and ICC=0.96 and SEM=1.28% for %BF.

Isokinetic strength testing

Peak torque (PT) of the leg extensors was evaluated on a calibrated isokinetic dynamometer (HUMAC Norm Dynamometer; Computer Sports Medicine Inc., Stoughton, MA, USA). Subjects were restrained with straps placed over the chest, pelvis, and thigh, while the lever arm of the dynamometer was strapped to the lower leg proximal to the lateral malleolus. Each subject completed a warm-up which included three submaximal isokinetic muscle actions at 60°/s on their right leg. Following two minutes of rest, they then performed three maximal voluntary isokinetic muscle actions at 60°/s separated by 30-seconds of rest. For each trial, subjects were instructed to extend the leg as hard and fast as possible from 90° of leg flexion to full extension. Strong verbal encouragement was provided.

Signal processing

Torque, velocity, and position signals were sampled at 2.0 kHz with a Biopac data acquisition system (MP150WSW; Biopac Systems, Inc., Santa Barbara, CA, USA) and stored on a personal computer (Think Pad T420, Lenovo, Morrisville, NC, USA). All signals were processed using custom written software (LabVIEW 8.5, National Instruments, Austin, TX, USA) in which torque signals were gravity corrected and filtered using a fourth order, zero phase shift, low pass Butterworth filter with a 50 Hz cutoff frequency. Peak torque was determined as the highest 25 ms epoch during the isokinetic load range. The average of each muscle action was used to determine PT and subsequently normalized to body mass (r_PT) for all analyses.

Statistical analysis

Initial relationships between protein intake, body composition, and PT were evaluated using Pearson's bivariate correlations. To further evaluate potential effects of protein intake, subjects were divided into three groups based on r_PRO : low (L: $<0.8 \text{ g}\cdot\text{kg}^{-1}$), moderate (M: $0.8 - 1.0 \text{ g}\cdot\text{kg}^{-1}$), and high (H: $>1.0 \text{ g}\cdot\text{kg}^{-1}$). Differences in body composition and PT between groups were evaluated using a one-way ANOVA with Tukey post-hoc analysis. Data within groups were evaluated for normality using the Shapiro-Wilk test. Variables with a significant Shapiro-Wilk test were further evaluated for skewness and kurtosis. A skewness greater than ± 2 or a kurtosis ± 5 was considered non-normally distributed; all variables were considered normally distributed. All statistical analyses were performed using SPSS (Version 21, IBM, Armonk, NY, USA) with an alpha level of 0.05 considered statistically significant.

Results:

When evaluating associations with protein intake, greater r_PRO intake was associated with less FM ($r = -0.498$, $P=0.001$), %BF ($r = -0.440$, $P=0.003$), LM ($r = -0.363$, $P=0.017$), and greater %LM ($r = 0.461$, $P=0.002$), but not PT ($P=0.075$) or r_PT ($P=0.642$). Average PRO intake (g) was not significantly associated with any measures of body composition ($P=0.191 - 0.926$), PT ($P=0.892$), or r_PT ($P=0.433$). When evaluating associations with body composition, greater FM was associated with an increase in PT ($r = 0.385$, $P=0.011$), but a reduction in r_PT ($r = -0.373$, $P=0.014$). Greater %BF was not associated with PT ($P=0.435$), but was associated with a decrease in r_PT ($r = -0.369$; $P=0.015$). Greater LM was associated with a greater PT ($r = 0.530$; $P<0.001$), but not r_PT ($P=0.091$). Conversely, greater %LM was associated with greater r_PT ($r = 0.373$; $P=0.014$), but not absolute PT ($P=0.308$).

Thirteen individuals were considered to have low r_PRO , 15 were considered to have moderate r_PRO , and 15 were considered to have high r_PRO . Differences between r_PRO groups are presented in Table 1. Total and r_PRO intake were significantly different between all three groups ($L<M<H$; $P<0.05$). Individuals consuming L r_PRO intake had significantly greater FM than those consuming M or H (Mean difference [MD] $\pm$ standard error [SE]: $L - M = 8.56 \pm 3.18 \text{ kg}$; $P=0.027$, $L - H = 10.08 \pm 3.18 \text{ kg}$; $P=0.008$), greater %BF than H ($L - H = 3.8 \pm 1.4\%$; $P=0.028$), greater LM than M ($L - M = 11.1 \pm 4.04 \text{ kg}$; $P=0.024$), and lower %LM than H ($L - H = -3.7 \pm 1.3\%$; $P=0.020$) (Figure 1). There were no differences in body composition between M and H groups ($P=0.368-0.874$). There were no significant differences in PT ($P=0.264$) or r_PT between groups ($P=0.753$).

When considering other dietary components, this cohort consumed, on average, a diet consisting of 44% CHO, 39% FAT, and 17% PRO; with protein intake ranging from $0.3 - 1.6 \text{ g}\cdot\text{kg}^{-1}$ and was primarily from animal sources ($\sim 70\%$). Individuals consuming L r_PRO intake had a significantly lower average caloric intake than M or H (mean diff $\pm$ SE: $L - M = -681.3 \pm 238.8 \text{ kcal}$; $P=0.018$; $L - H = -1078.2 \pm 238.8 \text{ kcal}$; $P<0.001$), lower CHO intake than H ($L - H = -104.9 \pm 37.5 \text{ g}$; $P=0.021$), and lower FAT intake than M and H ($L - M = -32.8 \pm 9.9 \text{ g}$; $P=0.005$; $L - H = -50.3 \pm 9.9 \text{ g}$; $P<0.001$). Full macronutrient intakes are presented in Table 2.

Discussion:

Despite the extreme physical demands of firefighting, upwards of 80% of firefighters are considered overweight and obese [3], many of whom also express risk factors for cardiovascular disease [22, 23], and do not meet minimum fitness standards [22, 23]. High protein intake has previously been shown to be beneficial for improving body composition and strength [12, 24], yet to date, there has been a lack of quantitative evaluation of protein intake in firefighters. The primary results of the current study demonstrated that firefighters who habitually consumed greater amounts of protein relative to their body weight, tended to have less body fat and a greater %LM. Specifically, firefighters who habitually consumed $< 0.8 \text{ g}\cdot\text{kg}^{-1}$ PRO, had greater body fat than those consuming $0.8 \text{ g}\cdot\text{kg}^{-1}$ PRO and a lower %LM than those consuming $> 1.0 \text{ g}\cdot\text{kg}^{-1}$ PRO. Current results also showed that a less favorable body composition (greater FM and %fat, and less %LM) was associated with reduced leg extension isokinetic strength. These results suggest that increasing relative protein intake above the current recommended $0.8 \text{ g}\cdot\text{kg}^{-1}$ may have favorable effects on body composition.

Previous reports show that firefighters generally have poor dietary habits, consuming diets that are traditionally high in trans fats, refined carbohydrates and sugars, low in fiber, and are calorically dense [15–18]. Despite what might be described by some as a “meat and potatoes” dietary culture, almost one third of firefighters in the current study consumed less than the recommended intake for protein ($<0.8 \text{ g}\cdot\text{kg}^{-1}$), while almost two thirds consumed less than what would be recommended for individuals participating in strength and power based activities ($<1.0 \text{ g}\cdot\text{kg}^{-1}$). Greater habitual protein intake and increased protein consumption are associated with lower BMI, lower waist circumference, and have been shown to be advantageous for improving body composition [8–10]. Obese individuals commonly have greater LM than normal weight individuals, as a result of carrying a greater body mass [25]. However, greater protein consumption, may help reduce body fat [10]. High protein diets have been previously shown to favorably impact energy expenditure [11], and stimulate muscle protein synthesis [9, 26, 27]. Taken together, increased protein intake may augment resting metabolic rate and promote a more favorable body composition [27]. Although all firefighters in the current study were considered overweight or obese, those who consumed $<0.8 \text{ g}\cdot\text{kg}^{-1}$ had significantly more body fat, a higher %BF, and a lower %LM.

Protein intake has been shown to be associated with greater muscle strength, especially when consumed above dietary recommendations [12, 24, 28–33]. In a study by Thompson et al. (2015), greater habitual protein intake ($\text{g}\cdot\text{kg}^{-1}$) was significantly associated with maximal and explosive strength of the leg flexors in blue collar workers [12]. Contrary to these findings, the current study found no significant association between protein intake (average or relative) and isokinetic strength of the leg extensors. Despite multiple similarities with the Thompson et al. (2015) study, the lack of relationship in the current study may be associated with an overall lower protein intake. The range of relative protein intakes reported in the current study was $0.3 - 1.6 \text{ g}\cdot\text{kg}^{-1}$. In comparison, Thompson et al. (2015) reported nearly double the range of protein intake ($0.4 - 3.0 \text{ g}\cdot\text{kg}^{-1}$), while studies in elderly individuals report intakes of above $2 \text{ g}\cdot\text{kg}^{-1}$ and up to $3 \text{ g}\cdot\text{kg}^{-1}$ [24, 30]. It is possible that protein intake

within the present cohort was not high enough to elicit significant strength differences, especially when considering their large body mass. Age may also be a factor, as a majority of the research examining relationships between habitual protein intake and strength has also primarily been conducted in older adults (>50 years) where protein can help reduce the rate of age-related muscle breakdown and decreases in strength [28–30]. The average age of the firefighters in the current study was 37 years, which is near the time when maximal strength has been reported to peak, but is still below the age (~ 50 years) in which age-related declines in muscle strength begin [34].

Even though lower extremity strength was not significantly associated with protein intake, it was associated with body composition. Specifically, greater FM and %BF was associated with greater PT, but a lower r_{PT} . Conversely, LM was associated with a greater PT, while %LM was associated with a greater r_{PT} . So although firefighters who consumed $<0.8 \text{ g}\cdot\text{kg}^{-1}$ had greater absolute LM, this did not necessarily translate into greater strength, relative to their size. It has been suggested that evaluating PT relative to body mass more accurately represents functional performance relative to an individual's body mass [35, 36]. Obesity related reductions in r_{PT} may be due to the influence of excessive intramuscular fat on tissue structure [37, 38], fiber contractile properties [39], and altered muscle activation [38]. Although participants in the current study produced PT values comparable to what has previously been reported in recreationally active young and middle-aged men [40], reductions in relative strength with increasing %BF may have significant implications for occupational performance and safety.

The current study is the first to evaluate macronutrient intake in career firefighters using criterion three-day dietary food logs. Previous studies evaluating dietary intake in firefighters is sparse and limited to qualitative questionnaires, which do not evaluate caloric and macronutrient composition of dietary intake [5, 15, 23]. Firefighters in the current study consumed about 44% of their caloric intake from CHO, 39% from fat, and 17% from PRO. When comparing energy intake between protein groups, the group consuming $<0.8 \text{ g}\cdot\text{kg}^{-1}$ had significantly lower energy intake than the groups consuming $\geq 0.8 \text{ g}\cdot\text{kg}^{-1}$, which seems paradoxical, as the low protein intake group had greater body mass and body fat than the moderate and high protein groups. Reporting and tracking dietary intake is associated with an inherent amount of error, especially in overweight or obese individuals, who have been known to underreport dietary intake [41]. Based on Harris-Benedict predictions using sedentary and low activity factors, caloric needs for the average firefighter in the present cohort would be between 2600–3000 $\text{kcal}\cdot\text{d}^{-1}$. Therefore, it is possible that those in the low protein group did not accurately report their dietary intake or only reported dietary intake for days when caloric intake was lower. However, all individuals in the current study were overweight or obese, which would theoretically make underreporting consistent across the group. Furthermore, men are less likely to underreport than women, and individuals are more likely to misreport CHO and FAT intake, while PRO intake is more accurately reported [41–43]. Thus, since all individuals in the current study were considered overweight or obese, dietary intake was evaluated using gold-standard three-day diet logs, and groups were established by protein intake, underreporting was not considered to be a significant issue in the current study. It was speculated that the lower energy intake observed in the low protein group may be a reflection of caloric restriction, whether that be intentional or inadvertent.

Although all individuals in the current study were considered weight stable (less than a 7 kg change in body mass in the last month), energy restriction can result in significant losses in LM and metabolic adaptations that can lead to lower strength, higher body fat, and potentially lead to significant weight gain [44].

Conclusion:

In conclusion, firefighters who are overweight and obese, who consumed less than the recommended $0.8 \text{ g}\cdot\text{kg}^{-1}$ of protein per day, had significantly greater FM and %BF, and less %LM, compared to firefighters who consumed greater than $0.8 \text{ g}\cdot\text{kg}^{-1}$ of protein per day. A majority of firefighters in the current study reported consuming less protein than would typically be encouraged for individuals engaging in strength and power activities, or those looking to improve body composition ($>1.0 \text{ g}\cdot\text{kg}^{-1}$). Encouraging firefighters to increase protein intake may be an effective initial strategy to improve the macronutrient composition of their diet, body composition, and reduce health and occupational safety risks associated with obesity. Protein supplementation, in the form of ready-made protein shakes or high protein meal replacement shakes, may prove to be an effective approach to increasing protein intake and addressing the obesity rates among firefighters due to the minimal lifestyle/behavioral changes required and the ability to consume on-the-go [45]. Future interventions evaluating dietary intake in firefighters should continue to utilize more detailed methods of analyzing dietary intake, such as three-day diet logs, in order to evaluate macronutrient intake.

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Abbreviations

CAL	Average calories (kcal)
CHO	Average carbohydrate (g)
FAT	Average fat (g)
PRO	Average protein (g)
r_PRO	Relative protein intake ($\text{PRO [g]} / \text{BM [kg]}$)
L	Low relative protein intake group ($<0.8 \text{ g}\cdot\text{kg}^{-1}$)
M	Moderate relative protein intake group ($0.8\text{--}1.0 \text{ g}\cdot\text{kg}^{-1}$)
H	High relative protein group ($>1.0 \text{ g}\cdot\text{kg}^{-1}$)
BMI	Body mass index ($\text{kg}\cdot\text{m}^{-2}$)
FM	Fat mass (kg)

%BF	Percent body fat
LM	Lean Mass (kg)
%LM	Percent lean mass
PT	Peak torque (Nm)
r_PT	Relative peak torque (PT [Nm] / BM [kg])
DEXA	dual energy x-ray absorptiometry
ICC	Intraclass correlation coefficient
SEM	Standard error of measure

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Figure 1:

Group average and individual measures of body composition between low, moderate and high relative protein intake groups. *significantly different from high ($P < 0.05$); #significantly different from moderate ($P < 0.05$).

Table 1:Protein Intake Group Characteristics (Mean $\pm$ SD)

	Full Group (n=43)	Low (<0.8 g·kg ⁻¹) (n=13)	Moderate (0.8–1.0 g·kg ⁻¹) (n=15)	High (>1.0 g·kg ⁻¹) (n=15)
Age (yrs)	37.28 $\pm$ 7.18	36.38 $\pm$ 6.93	39.07 $\pm$ 5.96	36.27 $\pm$ 8.53
Height (cm)	180.25 $\pm$ 6.31	182.33 $\pm$ 5.15	178.21 $\pm$ 6.16	180.47 $\pm$ 7.09
Weight (kg)	108.27 $\pm$ 20.44	122.37 $\pm$ 22.76 ^{##}	101.57 $\pm$ 13.06	102.75 $\pm$ 19.30
BMI (kg·m ⁻²)	33.17 $\pm$ 4.96	36.59 $\pm$ 5.32 ^{##}	31.91 $\pm$ 3.07	31.48 $\pm$ 4.96
FM (kg)	31.32 $\pm$ 9.29	37.82 $\pm$ 11.11 ^{##}	29.26 $\pm$ 6.23	27.74 $\pm$ 7.53
LM (kg)	72.52 $\pm$ 11.43	79.42 $\pm$ 12.59 [#]	68.34 $\pm$ 7.43	70.72 $\pm$ 11.59
%BF	28.87 $\pm$ 3.95	30.86 $\pm$ 4.63 [*]	28.93 $\pm$ 3.41	27.08 $\pm$ 3.10
%LM	67.42 $\pm$ 3.74	65.38 $\pm$ 4.37 [*]	67.50 $\pm$ 3.03	69.10 $\pm$ 3.07
PT (Nm)	223.52 $\pm$ 52.92	243.35 $\pm$ 49.92	217.82 $\pm$ 50.25	212.02 $\pm$ 56.55
r_PT (Nm·kg ⁻¹)	2.09 $\pm$ 0.45	2.03 $\pm$ 0.42	2.16 $\pm$ 0.49	2.08 $\pm$ 0.45

BMI – body mass index; FM – fat mass; LM – lean mass; %BF – percent body fat; %LM – percent lean mass; PRO – protein; r_PRO – relative protein intake.

^{*} significantly different from high (p<0.05)[#] significantly different from moderate (p<0.05).

Table 2:Macronutrient intake (Mean $\pm$ SD)

	Full Group (n=43)	Low (<0.8 g·kg ⁻¹) (n=13)	Moderate (0.8–1.0 g·kg ⁻¹) (n=15)	High (>1.0 g·kg ⁻¹) (n=15)
Avg CAL Intake (kcal)	2319.59 $\pm$ 757.30	1705.8 $\pm$ 380.7 ^{*#}	2387.1 $\pm$ 579.9	2784.0 $\pm$ 821.1
Avg CHO Intake (g)	254.40 $\pm$ 106.44	189.19 $\pm$ 62.80 [*]	271.20 $\pm$ 109.23	294.11 $\pm$ 112.84
Avg FAT Intake (g)	100.21 $\pm$ 32.76	71.24 $\pm$ 19.10 ^{*#}	104.00 $\pm$ 21.43	121.53 $\pm$ 34.17
Avg PRO Intake (g)	97.59 $\pm$ 26.70	73.68 $\pm$ 18.12 ^{*#}	91.72 $\pm$ 9.93 [*]	124.19 $\pm$ 20.81
r_PRO (g·kg ⁻¹)	0.92 $\pm$ 0.27	0.61 $\pm$ 0.12 ^{*#}	0.91 $\pm$ 0.48 [*]	1.22 $\pm$ 0.16

CAL – calories; CHO – carbohydrate; FAT – fat; PRO – protein; r_PRO – relative protein intake.

^{*} significantly different from high (p<0.05)[#] significantly different from moderate (p<0.05).