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Effect of mixed protein supplementation on golf performance and muscle function: a randomized, double-blind, placebo-controlled study

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ABSTRACT

Background: As a relatively novel approach to enhancing skeletal muscle health, mixed protein supplementation has shown similar responses to whey protein. However, no previous studies have examined its impact on golf swing performance. This study aimed to examine the effect of mixed protein supplementation on the swing performance and muscle strength of casual golfers.

Methods: Sixty participants with a handicap of less than 20 were recruited and randomly assigned to a double-blind, placebo-controlled study design. The participants were divided into two groups: a mixed protein group (MG, $n = 30$), and a placebo control group (CG, $n = 30$). They were instructed to ingest either a supplement containing casein calcium, whey protein, and isolated pea protein, or a placebo, once daily for 8 weeks. Pre- and posttests consisted of anthropometric measurements, muscle strength (isokinetic knee and trunk strength, and handgrip strength), 2-minute push-ups, balance, and golf swing performance using a driver and 7-iron.

Results: After the 8-week supplementation period, ANCOVA, using baseline values as covariates, revealed significant differences for driver distance ($p = .004$) and driver ball speed ($p < .001$). MG significantly increased driver distance by 5.17 ± 12.8 m ($p = .046$), driver ball speed by 1.36 ± 2.87 m/s ($p = .021$). Additionally, significantly improvements were observed in hand grip strength ($+2.12 \pm 3.47$ kg, $p = .004$), two-minute push-ups ($+4.89 \pm 8.14$ reps, $p = .004$), and balance score (-0.37 ± 0.69 min, $p = .009$). No significant differences were observed in body composition parameters ($p > .05$).

Conclusion: The intake of a mixed protein containing both animal and plant proteins had positive effects on golf performance and muscle function. Therefore, mixed proteins may represent a safe and effective approach to enhancing skeletal muscle health in golf players.

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1. Introduction

Golf is a demanding sport requiring both aerobic and anaerobic energy [1]. During a golf competition, walking around the golf course utilizes most of the energy generated through aerobic respiration. The golf swing, on the other hand, is considered to be an anaerobic movement, mostly focusing on the production of power. Nutrition is of great importance in fueling athletes and improving their performance. A recently published review provided an overview of the nutritional strategies and aerobic fitness of golfers, and highlighted that performance nutrition is an important consideration for golfers while walking around the golf course [2,3]. With regard to the strength regimen, previous studies have mainly focused on strength and mechanics training to increase ball distance or assess fitness in golfers [4], but nutritional guidance for golfers to improve strength and power is limited. Ziegenfuss et al. reported that a blend of ingredients, including creatine monohydrate, coffea arabica fruit extract, calcium fructoborate, and vitamin D, improves driving distance in a randomized control trial [5]. This suggests that nutritional supplementation plays a crucial role in enhancing golf performance, encouraging further research into optimizing diets for maximum effectiveness.

Proteins are well-known for facilitating muscle protein synthesis (MPS), increasing muscle mass, and improving muscle strength. However, there is some debate regarding the superiority of different protein sources in their effects on MPS. Animal protein sources remain the most important sources of proteins due to their higher levels of essential amino acids, superior digestibility, and absorption [6]. Nonetheless, traditional animal protein production is associated with severe adverse environmental impacts, and issues such as lactose intolerance [7]. On the other hand, consuming larger doses of plant proteins, such as soy and nuts, or a blend of plant-based proteins can also supply the required amino acid profile to enhance MPS rates [8]. However, plant protein sources are considered to be of lower quality compared to animal proteins, and potentially less effective in reducing exercise-induced muscle damage due to their single-source nature. Mixed proteins (mixtures of different isolated protein sources) have been barely studied, but in all instances where MPS has been measured, these mixed proteins have shown similar responses to whey protein [9].

In this context, mixing animal and plant proteins is a relatively new approach to enhance skeletal muscle health by optimizing amino acid availability and minimizing environmental impacts [10]. A previous animal study revealed that soy-whey blended protein intake was associated with a 1.5-fold increase in swimming time to exhaustion (vs. control), and plasma levels of key amino acids also increased significantly after ingestion of the blended protein [11]. Several studies have reported similar results regarding the physical performances of blended and pure proteins [9,12]. To the best of our knowledge, no study has examined the impact of mixed protein supplementation on golfing performance. The primary purpose of this randomized, double-blind, placebo-controlled trial was to examine the impact of mixed protein supplementation on the swing performance and muscle strength of casual golfers.

2. Materials and methods

2.1. Study design and ethics approval

The study was a randomized, placebo-controlled, double-blind, parallel clinical trial, which was reviewed and approved by the Institutional Review Board of Seoul National University (IRB No. 2201/001-013). The trial was conducted in accordance with the ethical principles of the Declaration of Helsinki. Informed consent was obtained from all the participants.

Participants were required to visit the laboratory three times in total. The study protocol is shown in Figure 1. During the first visit (screening week, week – 2), participants' handicap index was checked through the SmartScore APP (SmartScore Co., Ltd., Seoul, South Korea). Fasting blood samples were also collected and analyzed to assess indicators for inclusion such as glucose, creatinine, aspartate transaminase (AST), alanine aminotransferase (ALT) and others. Participants who met the inclusion criteria were then randomly assigned to either the mixed protein group (MG) or the placebo control group (CG) at visit 2 (pretest week, week 0) after a run-in period of 2 weeks. Each participant was instructed to ingest a powdered dietary supplement mixed with water once daily for 8 weeks. Post-tests were conducted at visit 3 (posttest week, week 8).

During the pre- and posttest weeks, participants were asked to empty their bladders after a 12 h overnight fast, prior to measuring body composition parameters, including body weight, skeletal muscle mass, and fat mass. After that, to determine indications of clinical safety, fasting blood samples were collected, followed by the assessments of blood pressure and resting heart rate. Next, muscle strength, golf swing performance, 2-minute push-ups, and balance were measured. Finally, subjective assessments were conducted using questionnaires, including the Global Physical Activity Questionnaire (GPAQ), Fatigue Severity Scale (FSS), Multidimensional Fatigue Inventory (MFI), and Quality of Life (QoL).

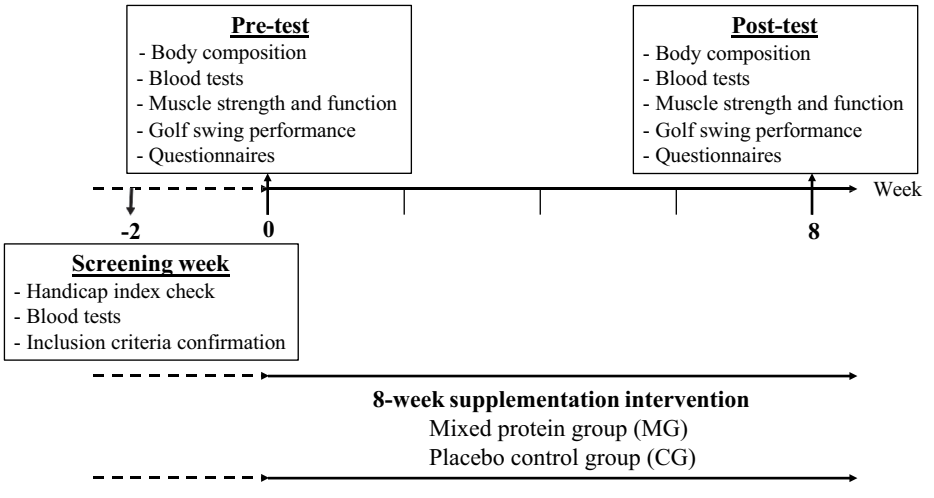


Figure 1. Study protocol.

2.2. Participants

Sixty healthy adults aged 26 to 64 years with a handicap index of 20 or less were recruited as participants. Exclusion criteria for this study included individuals: (1) who had regularly performed high-intensity exercise (confirmed via the GPAQ) within the last 3 months; (2) who were underweight with a body mass index (BMI) ≤ 18.5 kg/m^2, or obese with a BMI >30 kg/m^2, according to the obesity classifications defined by National Institutes of Health [13]; (3) with severe cardiovascular disease or a malignant tumor within the preceding six months; (4) who had experienced a central bone fracture within the preceding year; (5) with uncontrolled hypertension (blood pressure greater than 140/100 mmHg) or diabetic patients with a fasting blood plasma glucose level greater than 126 mg/dL; (6) with uncontrolled hyperthyroidism or hypothyroidism; (7) whose creatinine level exceeded twice the upper limit of normal (0.7 to 1.3 mg/dL for men and 0.6 to 1.1 mg/dL for women); (8) whose AST or ALT level exceeded twice the upper limit of normal (ALT ranges from 7 to 56 units/liter of serum, AST ranges from 5 to 40 units/liter of serum); (9) who complained of severe gastrointestinal symptoms such as heartburn and indigestion; (10) who had participated in another clinical trial or plan to participate in it within the past month; (11) who had mental illness such as severe depression, schizophrenia, and/or drug addiction, confirmed by a medical doctor; (12) who consumed alcohol over 210 g/week for male and 140 g/week for female; (13) with pregnancy confirmed by urine pregnancy test, breastfeeding, or who planned to conceive during the study period; (14) who had allergic reactions to constituent foods; (15) who reported consuming branched-chain amino acids (BCAA), creatine or other protein supplements within the past month; and (16) who were considered inappropriate to participate in this study by the researchers. Study participants were recruited by mass mailing and community-based screenings in Gwanak-gu, Seoul, South Korea.

2.3. Randomization and blinding

Participants were randomly assigned to the two groups (MG and CG) using a permuted block randomization list that was generated with SAS software (version 9.3; SAS Institute Inc., Cary, NC, USA). The assignments were made in a 1:1 ratio using the block randomization method, ensuring that the ratio of male to female between the groups was as balanced as possible [14]. Both participants and researchers were blinded to the study assignments until the study was completed.

2.4. Intervention

All participants were instructed to consume either a mixed protein supplement or a placebo (60 g each) once daily for 8 weeks. Both supplements contained 12 g crystalline fructose, 18 g cocoa powder, 1.8 g chocolate flavor powder, 0.18 g enzyme-treated stevia, and 0.3 g silicon dioxide. Additionally, the mixed protein supplement contained the animal proteins calcium casein (11.112 g) and whey protein (5.748 g), along with the plant protein, isolated pea protein (5.718 g), and dextrin (5.142 g), whereas the placebo

consisted only 27.72 g dextrin. The ratio of animal to plant protein was set at 3:1, based on previous studies and the properties of the proteins [9,15]. Participants were instructed to consume the supplements by mixing it with approximately 200 mL of pure water in the afternoon, after lunch. To ensure complete blinding, both supplements were made in powder form with a similar appearance and flavor. The supplements were produced in a manufacturing facility that adheres to Good Manufacturing Practice (GMP) and Hazard Analysis Critical Control Point (HACCP) standards.

The participants were asked to maintain their usual diet and lifestyle during the 8-week intervention. A 3-day dietary log was used to measure their diet, as shown in Table 2. It was also recommended to eat the same diet the day before each visit and to avoid alcohol and caffeine for 24 h before the visit. The participants were instructed not to engage in intensive exercise for 48 h prior to the visit.

2.5. Measurements

2.5.1. Anthropometric measurements

Body weight, skeletal muscle mass, and fat mass were measured via bioelectrical impedance analysis (BIA) using the InBody720 (InBody, Seoul, South Korea) [16]. Prior to the measurements, participants were instructed to empty their bladders, wear light clothing, and remove any metal and jewelry.

2.5.2. Compliance

Compliance with the supplementation protocol was monitored by having the participants complete a supplementation log and return any remaining supplements. Participants who consumed less than 80% of the supplements were considered dropouts. Additionally, a contact research organization (CRO) was responsible for double-checking the remaining number of supplements to ensure accuracy.

2.5.3. Dietary intake and physical activity

The usual dietary intake during the 8-week intervention was measured using a validated 3-day dietary log [5]. Participants received thorough instructions for completing detailed weighed food records on two weekdays and one weekend day in a random week prior to their visits. The amounts of consumed dietary nutrients (carbohydrates, fat, and protein) and calories were then calculated by CRO using the CAN-Pro 5.0 program (The Korean Nutrition Society, Seoul, Korea). The GPAQ was used to assess physical activity levels [17]. The amount of activity was calculated based on activity time and frequency per week. High-intensity activities were defined as follows: 1) engaging in high-intensity activity at least 3 times a week with a total activity volume of 1500 MET-min/week or more; or 2) performing walking, moderate-intensity, and high-intensity activities more than 7 times a week with a total activity volume of 3000 MET-min/week or more.

2.5.4. Muscle strength

Isokinetic knee strength (hamstring and quadriceps muscles) and isokinetic trunk strength (back and abdominal muscles) were measured using the same dynamometer (HUMAC NORM, CSMI Solutions, Stoughton, MA, USA) [18]. Each subject performed three maximal contractions at 60°/s and 30°/s to measure the isokinetic knee strength and trunk

strength, respectively. The highest value (Nm) of the three maximal contractions was recorded and divided by the body weight (BW).

Handgrip strength was measured twice in both hands using a grip dynamometer (TANAKA NO6103; Takei, Japan), and the mean value was recorded [19]. The participants were instructed to hold the dynamometer in the standing position and were forbidden from moving their body sideways or bending forward to ensure that only grip strength was measured during the test.

2.5.5. Golf swing performance

Golf swing performance was measured using a screen golf system (SG Golf, Seongnam, South Korea), which provides an environment allowing users to enjoy golf indoors through virtual reality technology. The participants completed a series of five successive swings using a 7-iron and a driver. The distance, head speed, and ball speed were recorded. The average value of the best 3 swings was calculated and recorded.

2.5.6. Push-ups and balance

Push-ups were instructed to be performed for 2 minutes continuously with a maximum of 80 times in total [19]. For females, the knees were permitted to touch the floor. The speed was set at 80 bpm, 40 per minute. Balance was assessed using the MFT Challenge Disc 2.0 software, Bluetooth version (MFT Body Teamwork, Vienna, Austria) [20]. The participants were asked to stand still in the middle of the disc for 20 seconds. The software provided instant feedback on their standing position within a circle. The stability level was measured based on the body's center of gravity within the circle. The stability level ranges from 1 (perfect) to 5 (poor).

2.5.7. Safety

Blood tests were performed to ensure safety during the study. Blood samples were obtained under fasting conditions in the morning as soon as the participants arrived at the laboratory, and were subsequently analyzed for clinical chemistry analysis [lactic acid, creatinine, lactate dehydrogenase (LDH), creatine kinase (CK), blood urea nitrogen (BUN), red blood cell (RBC), white blood cell (WBC), hemoglobin (Hb), platelet, hematocrit (Hct), glucose, AST, ALT, and gamma-glutamyl transferase (GGT)]. Each sample contained 12 mL of blood. Serum samples were obtained from blood samples after centrifugation at 3000 rpm and 4°C for 10 min. All biomarkers were analyzed by experienced and board-certified laboratory technicians at the Global Clinical Central Laboratory in Yong-in, South Korea, who were blinded to clinical information. In addition, blood pressure and resting heart rate were also measured before the tests for safety assurance. All measurements were conducted by the same researcher in the morning at the same time points during each visit.

2.6. Sample size calculation

Sample size calculations were based on a previous study that demonstrated significant effects of herb extracts on muscle strength and mass [21]. With an effect size of 0.67, a significance level of 5%, and 85% statistical power, it was estimated that 60 participants

would be required for this study (30 per group), considering a dropout rate of 20%. The sample size determination was conducted using G*Power 3.1 software.

2.7. Statistical analyses

Continuous variables were presented as means and standard deviations. Shapiro – Wilk test was used to test the normality of all continuous variables. Independent *t*-tests were performed to compare the differences between the two groups at baseline. Paired *t*-tests were performed to compare the differences within each group. Blood biomarker data were analyzed using two-way repeated measures analysis of variance (ANOVA) to compare differences between groups. Other data were analyzed using analysis of covariance (ANCOVA), with baseline values as the covariate. If the group × time interaction was statistically significant, the differences between the pre- and posttest values within each group were further examined using paired *t*-tests. The level of statistical significance was set to 5%. Statistical analyses were performed using SPSS software (version 26.0; IBM Corp., Armonk, NY, USA).

3. Results

3.1. Participants

In total, 66 participants were screened and 60 of them were included in the study. These participants were randomly assigned to either the CG ($n = 30$) or the MG ($n = 30$). During the 8-week intervention period, 3 participants from the MG withdrew consent, resulting in 57 participants completing the study (CG: $n = 30$, age: 50.40 ± 10.18 years; MG: $n = 27$, age: 48.44 ± 9.18 years) (Figure 2). There were no significant differences in the baseline characteristics (sex, age, height, weight, BMI, body fat, skeletal muscle mass, blood pressure, and resting heart rate) between the MG and CG (Table 1). In addition, no significant differences were observed in compliance between the two groups (MG: 96.22 ± 7.52%, CG: 95.44 ± 5.68%, $p = .674$). There were no significant differences in dietary intake between groups ($p > .05$) (Table 2). Both groups engaged in similar levels of physical activity before the pretest (MG: 1481 ± 919 METs/week, CG: 1582 ± 1018 METs/week, $p = .698$). In the posttest, the MG reported an average of 1688 ± 907 METs/week, while the CG reported an average of 1580 ± 975 METs/week of physical activity ($p = .668$).

3.2. Reliability and validity of the measurement

The reliabilities for golf swing measurement were assessed using the intraclass correlation coefficient (ICC) and 95% confidence intervals (CI). For the tests using a driver, the reliability was 0.993 for distance (95% CI = .990–.996), 0.992 for ball speed (95% CI = .988–.995), and 0.987 for head speed (95% CI = .980–.992). For the tests using a 7-iron, the inter-rater reliability was 0.989 for distance (95% CI = .983–.993), 0.989 for ball speed (95% CI = .983–.993), and 0.975 for head speed (95% CI = .960–.984).

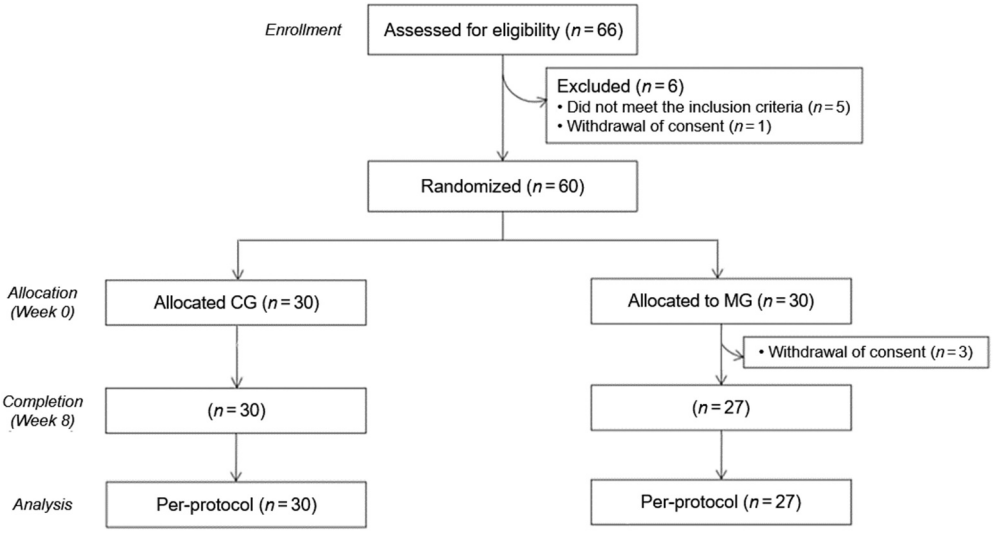


Figure 2. Flowchart of participant enrollment, randomization and exclusion. CG, placebo control group; MG, mixed protein group.

Table 1. Baseline characteristics.

Variables		CG ($n = 30$)	MG ($n = 27$)	p-value
Sex	Male	13 (43.3%)	14 (51.9%)	.520[a]
	Female	17 (56.7%)	13 (48.1%)	
Age (years)		50.40 ± 10.18	48.44 ± 9.18	.451[b]
Height (cm)		166.03 ± 7.81	168.01 ± 7.80	.341[b]
Weight (kg)		64.10 ± 11.09	66.12 ± 13.06	.530[b]
BMI (kg/m^2)		23.23 ± 2.35	23.13 ± 2.99	.888[b]
Body Fat (kg)		16.81 ± 4.80	15.38 ± 5.15	.283[b]
Skeletal Muscle Mass (kg)		26.24 ± 6.13	28.09 ± 6.80	.285[b]
Systolic Blood Pressure (mmHg)		125.47 ± 12.73	123.30 ± 12.35	.517[b]
Diastolic Blood Pressure (mmHg)		77.07 ± 8.10	75.78 ± 10.55	.605[b]
Resting Heart Rate (bpm)		71.37 ± 9.32	73.48 ± 10.19	.417[b]

Data are expressed as mean ± SD. CG, placebo control group; MG, mixed protein group; BMI, body mass index.
[a]Chi-squared test.
[b]Independent t-test.

Table 2. Dietary intake.

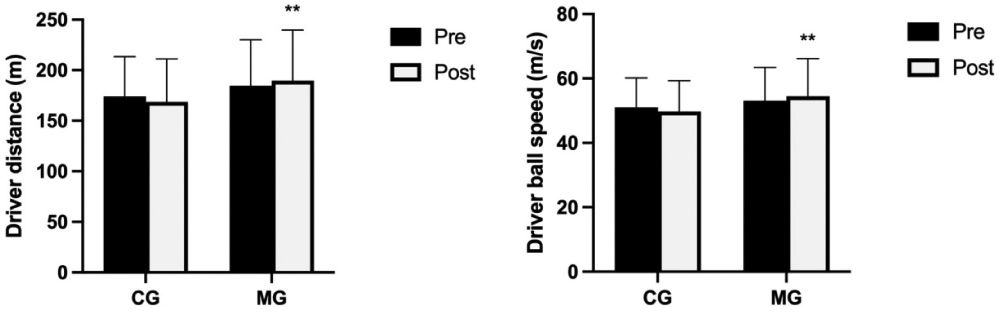
	CG ($n = 30$)			MG ($n = 27$)		
Variables	Pre-test	Post-test	p-value[a]	Pre-test	Post-test	p-value[a]
Caloric intake (kcal/day)	1421 ± 379	1474 ± 421	.456	1378 ± 358	1421 ± 339	.546
Carbohydrates (g)	202.98 ± 58.56	202.86 ± 69.25	.991	197.87 ± 67.47	196.79 ± 58.93	.927
Lipids (g)	38.00 ± 12.38	43.64 ± 18.56	.107	37.10 ± 9.02	42.25 ± 15.94	.135
Proteins (g)	63.23 ± 24.75	64.19 ± 24.02	.869	57.63 ± 16.32	57.87 ± 12.82	.948

Data are expressed as mean ± SD. CG, placebo control group; MG, mixed protein group.
[a]Paired t-test.

Table 3. Comparison of golf performance between the two groups.

	Intervention			Comparison				
	Pre-test	Post-test	Change	Effect size	Difference (95% CI)	*p*-value[a]	*F*[b]	*p*-value[b]
Driver Distance (m)								
CG	173.97 ± 39.40	168.71 ± 42.51	−5.25 ± 11.67	−0.45	−9.61 to − 0.90	.020*	6.123	.004**
MG	184.59 ± 45.55	189.76 ± 50.00	5.17 ± 12.81	0.40	0.11 to 10.24	.046*		
Driver Head Speed (m/s)								
CG	37.46 ± 6.38	36.13 ± 6.85	−1.33 ± 2.77	−0.48	−2.37 to − 0.30	.013*	2.272	.113
MG	39.02 ± 7.47	39.59 ± 8.54	0.57 ± 3.90	−0.15	−0.98 to 2.11	.457		
Driver Ball Speed (m/s)								
CG	51.01 ± 9.14	49.76 ± 9.54	−1.25 ± 2.63	−0.48	−2.23 to − 0.27	.014*	8.585	<.001***
MG	53.13 ± 10.31	54.49 ± 11.69	1.36 ± 2.87	0.47	0.23 to 2.49	.021*		
7-iron Distance (m)								
CG	120.47 ± 26.61	115.62 ± 25.51	−4.85 ± 9.75	−0.50	−8.49 to − 1.21	.011*	3.573	.035*
MG	129.25 ± 29.72	132.24 ± 33.77	2.99 ± 12.92	0.23	−2.12 to 8.10	.240		
7-iron Head Speed (m/s)								
CG	30.14 ± 4.69	29.22 ± 4.42	−0.92 ± 2.19	−0.42	−1.74 to − 0.10	.029*	4.311	.018*
MG	31.36 ± 5.62	32.19 ± 6.51	0.83 ± 2.87	0.29	−0.31 to 1.97	.146		
7-iron Ball Speed (m/s)								
CG	39.73 ± 6.20	38.54 ± 5.87	−1.19 ± 2.22	−0.54	−2.02 to − 0.36	.006*	3.929	.026*
MG	41.94 ± 7.17	42.42 ± 7.87	0.48 ± 2.84	0.17	−0.64 to 1.60	.389		

Data are expressed as mean ± SD. CG, placebo control group; MG, mixed protein group.
*$p < .05$, **$p < .01$, ***$p < .001$.
[a]Paired *t*-test.
[b]ANCOVA with baseline as the covariate due to significant difference between groups at baseline.



a. Driver distance b. Driver ball speed

Figure 3. Changes in driver distance (a) and driver ball speed (b) of the two groups. CG, placebo control group; MG, mixed protein group. *Significant differences within the groups, $p < .05$.

3.3. Golf performance

Table 3 reports the data for golf performance. ANCOVA analysis revealed significant differences in driver distance ($F = 6.123$, $p = .004$), driver ball speed ($F = 8.585$, $p < .001$), 7-iron distance ($F = 3.573$, $p = .035$), 7-iron head speed ($F = 4.311$, $p = .018$), and 7-iron ball speed ($F = 3.929$, $p = .026$). For driver distance, MG significantly increased by 5.17 ± 12.8 m after ingestion of protein ($p = .046$), while CG significantly decreased by 5.25 ± 11.67 m ($p = .020$). For driver ball speed, MG significantly increased by 1.36 ± 2.87 m/s ($p = .021$), while CG significantly decreased by 1.25 ±

Table 4. Comparison of muscle function between the two groups.

	Intervention			Comparison				
	Pre-test	Post-test	Change	Effect size	Difference (95% CI)	*p*-value [a]	*F* [b]	*p*-value [b]
	Isokinetic Knee Flexion Strength (Nm/BW%)							
CG	101.07 ± 34.70	105.63 ± 33.56	4.57 ± 20.97	0.22	-3.26 to 12.40	.243	2.288	.111
MG	110.11 ± 34.27	119.37 ± 37.92	9.26 ± 17.77	0.52	2.23 to 16.29	.012		
	Isokinetic Knee Extension Strength (Nm/BW%)							
CG	200.33 ± 63.02	198.40 ± 46.08	-1.93 ± 38.24	-0.05	-16.21 to 12.35	.784	11.603	< .001***
MG	234.15 ± 58.27	235.30 ± 57.54	1.15 ± 31.88	0.04	-11.46 to 13.76	.853		
	Isokinetic Trunk Flexion Strength (Nm/BW%)							
CG	263.93 ± 61.96	263.13 ± 47.89	-0.80 ± 56.44	-0.01	-21.88 to 20.28	.939	19.826	< .001***
MG	285.41 ± 45.03	264.81 ± 42.56	-20.59 ± 45.22	-0.46	-38.48 to -2.70	.026*		
	Isokinetic Trunk Extension Strength (Nm/BW%)							
CG	258.30 ± 78.22	264.60 ± 78.22	6.30 ± 32.12	0.20	-5.69 to 18.29	.292	4.460	.016*
MG	277.44 ± 83.34	275.63 ± 81.05	-1.81 ± 71.76	-0.03	-30.20 to 26.57	.896		
	Handgrip Strength (kg)							
CG	32.11 ± 8.83	32.45 ± 7.69	0.34 ± 3.69	0.09	-1.04 to 1.72	.614	7.848	.001**
MG	34.67 ± 9.43	36.79 ± 9.03	2.12 ± 3.47	0.61	0.74 to 3.49	.004*		
	Two-minute Push Ups (reps)							
CG	22.30 ± 13.70	25.00 ± 11.67	2.70 ± 9.11	0.30	-0.70 to 6.10	.115	8.259	< .001***
MG	21.93 ± 15.30	26.81 ± 14.49	4.89 ± 8.14	0.60	1.67 to 8.11	.004*		
	Balance Score (min)							
CG	3.90 ± 0.60	3.67 ± 0.75	-0.23 ± 0.69	-0.33	-0.49 to 0.02	.075	5.958	.005**
MG	3.99 ± 0.60	3.62 ± 0.64	-0.37 ± 0.69	-0.54	-0.64 to -0.10	.009*		

Data are expressed as mean ± SD. CG, placebo control group; MG, mixed protein group.
*$p < .05$, **$p < .01$, ***$p < .001$.
[a]Paired *t*-test.
[b]ANCOVA with baseline as the covariate due to significant difference between groups at baseline.

Table 5. Comparison of body composition between the two groups.

	Intervention			Comparison				
	Pre-test	Post-test	Change	Effect size	Difference (95% CI)	*p*-value [a]	*F* [b]	*p*-value [b]
	Body Fat Mass (kg)							
CG	16.81 ± 4.80	13.73 ± 4.74	-0.08 ± 1.42	-0.06	-0.61 to 0.45	.769	.354	.703
MG	15.38 ± 5.15	15.44 ± 5.37	0.06 ± 1.20	0.05	-0.41 to 0.54	.788		
	BMI (kg/m^2)							
CG	23.23 ± 2.35	23.22 ± 2.39	-0.01 ± 0.78	-0.01	-0.30 to 0.28	.963	.249	.781
MG	23.13 ± 2.99	23.22 ± 3.03	0.10 ± 0.44	0.23	-0.08 to 0.27	.268		
	Skeletal Muscle Mass (kg)							
CG	26.24 ± 6.13	23.22 ± 2.39	0.08 ± 0.74	0.11	-0.20 to 0.36	.560	.770	.468
MG	28.09 ± 6.80	23.22 ± 3.03	0.09 ± 0.64	0.14	-0.17 to 0.34	.480		

Data are expressed as mean ± SD. CG, placebo control group; MG, mixed protein group; BMI, Body mass index.
[a]Paired t-test.
[b]ANCOVA with baseline as the covariate due to significant difference between groups at baseline.

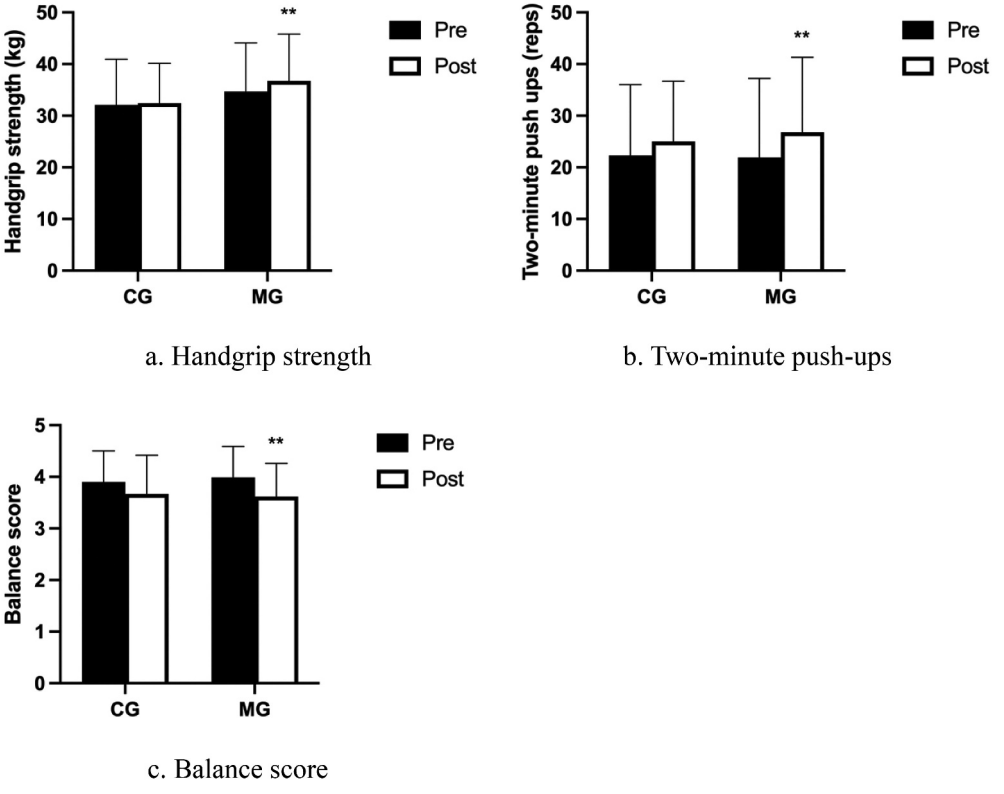


Figure 4. Changes in handgrip strength (a), two-minute push-ups (b), and balance score (c) of the two groups. CG, placebo control group; MG, mixed protein group. **Significant differences within the groups, $p < .01$.

2.63 m/s ($p = .014$) (Figure 3). Significant decreases were observed in 7-iron distance ($p = .011$), 7-iron head speed ($p = .029$), and 7-iron ball speed ($p = .006$). No significant differences were observed in driver head speed ($F = 2.273$, $p = .113$).

3.4. Muscle function and body composition

Changes in muscle function and body composition of the two groups are shown in Tables 4 and 5. As a result of ANCOVA analysis, significant differences were found for isokinetic knee extension strength ($F = 11.603$, $p < .001$), isokinetic trunk flexion strength ($F = 19.826$, $p < .001$), isokinetic trunk extension strength ($F = 4.460$, $p = .016$), handgrip strength ($F = 7.848$, $p = .001$), two-minute push-ups ($F = 8.259$, $p < .001$) and balance ($F = 5.958$, $p = .005$). MG significantly increased hand grip strength by 2.12 ± 3.47 kg ($p = .004$), two-minute push-ups by 4.89 ± 8.14 reps ($p = .004$), and balance score by 0.37 ± 0.69 min ($p = .009$) (Figure 4). No significant differences were observed in body composition, such as body fat mass ($F = .354$, $p = .703$), BMI ($F = .249$, $p = .781$), and skeletal muscle mass ($F = .770$, $p = .468$).

3.5. Safety biomarker

Changes in blood (safety) biomarkers are shown in Table 6. No significant group × time interaction effects were revealed for the blood biomarkers, including lactic acid ($F = .343$, $p = .560$), creatinine ($F = .243$, $p = .624$), LDH ($F = 1.355$, $p = .250$), CK ($F = .000$, $p = .983$), BUN ($F = 2.021$, $p = .161$), RBC ($F = .942$, $p = .336$), WBC ($F = 1.366$, $p = .248$), Hb ($F = .781$, $p = .381$), platelet ($F = .478$, $p = .492$), Hct ($F = 1.256$, $p = .267$), glucose ($F = .794$, $p = .377$), AST ($F = .115$, $p = .735$), ALT ($F = .225$, $p = .637$), and GGT ($F = .395$, $p = .532$).

4. Discussion

With golf being a demanding sport that requires both aerobic and anaerobic energy, there is an important role for ergogenic supplements. In particular, proteins are essential for power production during golf swings [1]. This study examined the effects of a mixed protein supplement containing calcium casein, isolated pea proteins, and whey proteins on golf performance and muscle strength. The major finding of the study was that after 8 weeks of the mixed protein ingestion, there was a significant increase in golf swing performance, including driver distance and driver ball speed, as well as improvements in muscle function, such as hand grip strength, two-minute push-ups, and balance score. Additionally, no safety concerns were reported.

Our data indicate that the mixed protein supplement has a positive effect on driver distance, which is consistent with a previous study showing improvements in the best drive distance after 30 days of ingesting a dietary supplement containing creatine monohydrate, *coffea arabica* fruit extract, calcium fructoborate, and vitamin D [5]. To the best of our knowledge, limited research is available investigating the effects of dietary supplementation on golf performance. It was reported that phosphatidylserine supplementation, an essential component of all biological membranes, increased the quality of ball flight [22]. And a caffeine-containing supplement was reported to improve the total score, greens in regulation, and drive distance in skilled golfers during a competitive golf tournament [23]. However, muscle mass was not measured in these studies.

In the present study, no significant differences in body composition, such as body fat mass and skeletal muscle mass were observed between the two groups after 8 weeks of consumption. Protein supplements are commonly used during resistance training to increase muscle mass and strength, facilitate muscle recovery, and improve exercise performance [24,25]. The

Table 6. Comparison of blood biomarkers of safety between the two groups.

	Intervention			Comparison				
	Pre-test	Post-test	Change	Effect size	Difference (95% CI)	*p*-value [a]	*F* [b]	*p*-value [b]
	Lactic acid (mmol/L)							
CG	8.82 ± 3.93	10.65 ± 5.90	1.83 ± 5.05	0.36	-0.06 to 3.72	.057	.343	.560
MG	8.73 ± 3.74	9.85 ± 3.95	1.12 ± 3.99	0.28	-0.46 to 2.70	.157		
	Creatinine (mg/dL)							
CG	0.80 ± 0.14	0.83 ± 0.15	0.02 ± 0.08	0.25	-0.01 to 0.05	.160	.243	.624
MG	0.89 ± 0.16	0.90 ± 0.15	0.01 ± 0.07	0.14	-0.02 to 0.04	.421		
	Lactate dehydrogenase (LDH) (U/L)							
CG	170.60 ± 46.01	161.93 ± 37.58	-8.67 ± 41.26	-0.21	-24.08 to 6.74	.259	1.355	.250
MG	164.30 ± 27.39	165.89 ± 23.01	1.59 ± 20.89	0.08	-6.67 to 9.86	.695		
	Creatine kinase (CK) (U/L)							
CG	137.83 ± 123.46	131.27 ± 88.77	-6.57 ± 114.52	-0.06	-49.33 to 36.20	.756	.000	.983
MG	117.48 ± 113.39	110.30 ± 38.07	-7.19 ± 101.67	-0.07	-47.40 to 33.03	.716		
	Blood urea nitrogen (BUN) (mg/dL)							
CG	13.68 ± 3.31	13.36 ± 3.11	-0.32 ± 3.13	-0.10	-1.48 to 0.85	.584	2.021	.161
MG	14.60 ± 3.27	15.60 ± 3.15	1.00 ± 3.84	0.26	-0.52 to 2.51	.189		
	Red blood cell (RBC) count ($\times 10^6$/UL)							
CG	4.70 ± 0.51	4.71 ± 0.58	0.00 ± 0.24	0.00	-0.09 to 0.09	.928	.942	.336
MG	4.78 ± 0.46	4.84 ± 0.39	0.06 ± 0.23	0.26	-0.03 to 0.15	.153		
	White blood cell (WBC) count ($\times 10^3$/UL)							
CG	5.68 ± 1.04	6.07 ± 1.54	0.39 ± 1.37	0.28	-0.12 to 0.91	.128	1.366	.248
MG	5.95 ± 1.50	5.94 ± 1.37	0.01 ± 1.24	0.01	-0.05 to 0.48	.955		
	Hemoglobin (Hb) (grams/dL)							
CG	14.25 ± 1.44	14.19 ± 1.68	-0.06 ± 0.69	-0.09	-0.32 to 0.19	.617	.781	.381
MG	14.50 ± 1.48	14.60 ± 1.35	0.09 ± 0.64	0.14	-0.16 to 0.35	.459		
	Platelet ($\times 10^3$/UL)							
CG	244.20 ± 56.20	242.60 ± 53.11	-1.60 ± 30.19	-0.05	-12.87 to 9.67	.774	.478	.492
MG	258.26 ± 83.20	262.85 ± 89.07	4.59 ± 37.36	0.12	-10.19 to 19.37	.529		
	Hematocrit (Hct) (%)							
CG	42.78 ± 4.23	42.56 ± 4.96	-0.22 ± 2.17	-0.10	-1.03 to 0.59	.589	1.256	.267
MG	43.31 ± 4.11	43.71 ± 3.43	-0.40 ± 1.99	-0.20	-0.38 to 1.19	.301		
	Glucose (mg/dL)							
CG	98.73 ± 9.12	98.40 ± 10.14	-0.33 ± 9.22	-0.04	-3.78 to 3.11	.844	.794	.377
MG	96.78 ± 10.04	98.81 ± 15.50	2.04 ± 10.89	0.19	-2.26 to 6.33	.339		
	Aspartate aminotransferase (AST) (U/L)							
CG	21.23 ± 6.81	20.30 ± 4.04	-0.93 ± 5.63	-0.17	-3.04 to 1.17	.372	.115	.735
MG	20.00 ± 4.86	19.52 ± 4.15	-0.48 ± 4.22	-0.11	-2.15 1.19	.558		
	Alanine transaminase (ALT) (U/L)							
CG	18.03 ± 7.42	16.43 ± 8.32	-1.60 ± 6.39	-0.25	-3.99 to 0.79	.181	.225	.637
MG	19.44 ± 8.31	18.67 ± 9.51	-0.78 ± 6.68	-0.12	-3.42 to 1.87	.551		
	Gamma-glutamyl transferase (GGT) (U/L)							
CG	21.97 ± 12.86	23.23 ± 15.81	1.27 ± 8.41	0.15	-1.87 to 4.41	.416	.395	.532
MG	22.81 ± 16.09	25.56 ± 18.17	2.74 ± 9.30	0.29	-0.94 to 6.42	.138		

Data are expressed as mean ± SD. CG, placebo control group; MG, mixed protein group.
[a]Paired *t*-test.
[b]Two-way repeated measures analysis of variance (ANOVA).

lack of extra resistance exercise was speculated to lead to an unchanged muscle mass in our study. An increase in muscle strength and exercise performance does not necessarily occur as a result of an increase in muscle mass. Although there is a general positive correlation between muscle size and strength, a number of studies have shown a clear dissociation with an increase in muscle size with no change or even a decrease in strength, and vice versa, an increase in strength without an increase in size [26]. In a previous study, no change in muscle mass was

identified after 8 weeks of casein protein intake, but maximal voluntary contraction during isometric knee extension significantly increased [27]. Additionally, although skeletal muscle mass remained unchanged, muscle strength and physical performance improved in elderly individuals after a 24-week intervention with protein supplementation [28]. These results are consistent with the findings regarding muscle strength and muscle mass in the present study. Clark and Manini speculated that such improvements in physical performance in the protein-supplemented group could be attributed to improvements in neuromuscular action and/or skeletal muscle quality [29].

It is important to note the study limitations. Only healthy adults with a handicap index of 20 or less were recruited, and thus the results may not be applicable to other populations, such as competitive and senior golfers. Next, no comparisons were made between 100% animal- or plant-based proteins and the mixed proteins. Therefore, the results cannot suggest superior benefits of mixed proteins over traditional proteins. Consequently, future research should examine the effects of different types of proteins in various populations.

5. Conclusion

In conclusion, the intake of a mixed protein diet containing both animal and plant proteins had positive effects on golf performance and muscle function, although it did not lead to an increase in muscle mass. Therefore, mixed proteins could offer a safe and effective approach for golf players to improve skeletal muscle health and golf performance.

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Ethical statement

This study was reviewed and approved by the Institutional Review Board of Seoul National University (IRB No. 2201/001–013). The trial was conducted in accordance with the ethical principles of the Declaration of Helsinki. Informed consent was obtained from all the participants.

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