

Article

A Study of the Effect of Dietary Supplement Use in Bodybuilders and Its Relationship to Liver Function and Some Physiological and Biochemical Variables

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Abstract: Background: The improved physical performance of bodybuilders following supplement use was associated with changes in laboratory indices. Although these supplements are sometimes associated with both positive and negative effects. Aims of study: to evaluated effects of several regularly consumed supplements in bodybuilders on the liver function and some physiological and biochemical characteristics. Materials and Methods: Ninety male volunteers were divided into three groups for the study. The first group was made up of male bodybuilders who use creatine supplements. The second group consists of bodybuilders who use Whey protein supplements. Those that don't engage in bodybuilding comprise the third group, referred to as the control group. the serum to assess liver function, including AST (GOT) and ALT (GPT) estimations. Additionally, a range of hormones, including testosterone, LH, and FSH, were measured using the Chemistry Analyzer Smart-150 apparatus (GenoTEK, USA) and commercial kits (Biolab, France) for the lipid profile test. The levels of MDA in the serum were evaluated using the thiobarbituric acid (TBA) method developed by Buege and Aust. As well as The concentration of reduced glutathione (GSH) was measured using Ellman's technique, as described by Ellman in 1959. Results: The supplemental assessment revealed a significant difference between the two groups ($P = 0.03$), with whey protein users having higher mean values (28.3 ± 4.2) compared to creatine users (16.7 ± 1.8). In a similar vein, blood pressure varied significantly between the study groups ($P = 0.02$), with the whey protein group having the highest mean value (13.7 ± 0.8), followed by the creatine group (12.8 ± 0.6), and the control group (10.3 ± 0.4). The mean diGOTolic blood pressure values for the whey creatine, protein, and control groups were 8.2 ± 0.5 , 7.9 ± 0.3 , and 8.7 ± 0.4 , respectively. Conclusion: Findings indicate that bodybuilding supplementation, particularly with whey protein and creatine, is associated with significant alterations in several biochemical and hormonal parameters compared with the control group. Supplementation is associated with measurable changes in liver function, lipid metabolism, hormonal profile, and oxidative stress,

with distinct effects observed between whey protein and creatine users. Careful monitoring of supplement intake, dosage, and duration is recommended to minimize potential adverse metabolic effects.

Keywords: bodybuilders, creatine supplementation, whey protein supplementation, biochemical variables, hormone levels. Lipid profile.

Introduction

Supplements are available in a range of nutritional forms and formulations to boost ξ nutrient intake, maintain normal levels across age groups or physiological states, and address deficiencies or pathological disorders [1].

Depending on their intended use and the subjects they target, supplements can improve general health and physical well-being, address dietary deficiencies, and encourage sports and exercise [2].

In order to prevent deficiencies, enhance physical and athletic performance, and preserve good health under increased demands, people who exercise, especially athletes, need certain dietary supplements [3].

To address the specific needs of specific populations, supplements must be balanced, varied, and taken at the right times and in the right context [4].

These individuals gain from supplementation in a variety of ways related to their power and strength, increased endurance, and increased muscle growth [5]. In terms of the quantity, quality, and exact ratios of different supplements as well as the timing of their intake in relation to athletic or competitive activity, supplementation is crucial for athletes. This is particularly important for elite or competitive athletes [6]. Nutritional supplementation has become the norm in circumstances such as these, where maintaining athletic performance and competitive competence is becoming increasingly challenging. Because of this, a wide range of supplements are now produced and marketed for use in exercise and sports [7]. While a number of studies have demonstrated the safety of supplements in terms of general health, hormones, lipid profiles, and liver function [8], other research indicate that abusing certain supplements can overload liver functions through several routes. Intense bodybuilding regimens and heavy resistance training increase reactive oxygen species (ROS), which lead to two significant changes in oxidative stress markers: raised MDA, a biomarker of lipid peroxidation and damage, and depleted GSH, an intracellular antioxidant that neutralizes this damage. According to studies, taking supplements like protein, vitamins, creatine, and sport drinks can cause an acute kidney injury. The research examined the relationship between creatine supplementation and poor renal function [9]; However, the findings only considered one case, necessitating a cautious interpretation. Another study found that dietary and pharmaceutical supplements, such as vitamins, minerals, and botanical extracts, may be responsible for liver injury cases (moderate elevations in alanine aminotransferase (ALT) and aspartate aminotransferase (AST) values). Therefore, more research is needed to determine whether supplements are safe for gym patrons. The purpose of this study was to investigate the relationship between dietary supplement consumption and changes in liver function indicators among gym patrons [10].

Aims of the study

In this study, bodybuilders who consume whey protein or creatine were compared to healthy controls in terms of liver function, lipid profile, reproductive hormone levels, oxidative stress biomarkers, and supplementation patterns. The study also aimed to assess the possible physiological impacts on metabolic, hepatic, hormonal, and oxidative stress parameters of long-term usage of nutritional supplements.

Materials and Methods

Design and setting

The study involved three groups of ninety men.

People who participate in bodybuilding and take creatine as a sport are included in the first group (G1).

Bodybuilders who take Whey protein supplements make up the second category (G2).

The third group is the control group, which consists of people who don't participate in bodybuilding (G3).

The bodybuilders have used a range of dietary supplements, including whey protein, whey protein isolate, mass gainer, Big mass, creatine monohydrate, and branched-chain amino acids (BCAA). We used the conventional techniques to determine our patients' height and weight.

The subjects' weight and height were used to calculate the body mass index (BMI). The World Health Organization's (WHO) definitions of underweight, normal weight, overweight, and obese were used to establish the reference ranges [11]. The most popular measure of weight status is still the body mass index (BMI), which is calculated as weight (kg)/height (m²). A BMI of 18.5–24.9 kg/m² indicates normal weight, 25.0–29.9 kg/m² indicates overweight, and 30.0 kg/m² indicates obesity. Blood collection and examination. Each person's venous blood was collected and placed in sterile tubes. Each sample was centrifuged to extract the serum. After that, additional tests were performed on the serum to assess liver function, including AST and ALT estimations. Additionally, a range of hormones, including testosterone, LH, and FSH, were measured using the Chemistry Analyzer Smart-150 apparatus (GenoTEK, USA) and commercial kits (Biolab, France) for the lipid profile test.

The levels of MDA in the serum were evaluated using the thiobarbituric acid (TBA) method developed by Buege and Aust [12]. Furthermore the concentration of reduced glutathione (GSH) was measured using Ellman's technique, as described by Ellman in 1959 [13].

Ethical considerations

Every participant in our study completed a consent form after the ethical community approved our research project.

Statistical Analysis

For the statistical analysis, we employed Spss version 26. The mean $\pm$ standard deviation (SD) were used to express clinical data.

Result

The primary features of the 90 study participants are shown in Table 1. The subjects were split up into three groups: the control group (G3), the whey protein supplementation group (G2), and the creatine supplementation group (G1).

The whey protein group had the highest mean BMI (30.2 ± 3.6), followed by the creatine group (28.5 ± 2.5), and the control group (25.3 ± 2.1). There was a statistically significant difference between the groups ($P = 0.01$). In terms of smoking status, there was a statistically significant difference ($P = 0.01$) between smokers' and non-smokers'.

Participants who had been bodybuilding for three to six months had the greatest mean value (18.6 ± 3.2), followed by those who had been training for more than six months (14.7 ± 2.4), while those who had been bodybuilding for one to three months had the lowest mean value (12.5 ± 1.1). $P = 0.01$ indicated that these differences were statistically significant.

Whey protein users had higher mean values (28.3 ± 4.2) than creatine users (16.7 ± 1.8), according to the supplemental assessment, which showed a significant difference between the two groups ($P = 0.03$). Similarly, there was a significant difference in blood pressure across the study groups ($P = 0.02$), with the whey protein group having the highest mean value (13.7 ± 0.8), followed by the creatine group (12.8 ± 0.6), and the control group having the lowest mean value (10.3 ± 0.4). According to DiGOTolic blood pressure with the whey creatine, protein and control group having the mean value (8.2 ± 0.5 , 7.9 ± 0.3 and 8.7 ± 0.4) respectively.

Table 1. Fundamental attributes of the individuals involved

Characteristics NO=90		Mean (SD)	P value
BMI	G1= Creatine	28.5 $\pm$ 2.5	0.01
	G2= Whey protein	30.2 $\pm$ 3.6	

Characteristics NO=90		Mean (SD)	P value
G3= Control		25.3 ±2.1	
Smoking	Yes	60%	0.01
	No	40%	
Duration of bodybuilding (months)	1-3	12.5±1.1	0.01
	3-6	18.6±3.2	
	>6	14.7±2.4	
Supplement	Creatine	16.7 ±1.8	0.03
	Whey protein	4.2 4.±28.3	
Systolic blood pressure mmHg	Creatine	12.8±0.6	0.02
	Whey protein	13.7±0.8	
	Control	10.3± 0.4	
Diastolic blood pressure mmHg	Creatine	8.2± 0.5	0.1
	Whey protein	7.9 ± 0.3	
	Control	8.7± 0.4	

G1= Creatine, G2= Whey protein, G3= Control, P value < 0.05 *significant difference

The descriptive and analytical statistics comparing bodybuilders utilizing whey protein, bodybuilders using creatine, and the control group are compiled in Table 2. The majority of biochemical markers showed significant differences.

In terms of liver function, both the whey protein and creatine groups had significantly higher serum GOT and ALT levels than the control group (GOT: $P = 0.01$; ALT: $P = 0.02$), with the whey protein group showing the highest values, suggesting a potential impact of supplementation on liver enzyme activity. There were notable variations in the lipid profile amongst the research groups. The whey protein and creatine groups had significantly lower LDL values than the control group ($P = 0.02$). HDL was lowest in the whey protein group and highest in the control group ($P = 0.01$). When compared to the controls, the supplement users' total cholesterol and triglyceride concentrations were significantly higher, especially in the creatine group ($P = 0.01$).

Regarding the hormonal profile, neither LH nor FSH levels showed statistically significant variations between the groups ($P = 0.20$ for both). Testosterone levels, however, varied considerably ($P = 0.01$), with the whey protein group having the highest mean value, followed by the creatine group, and the control group having the lowest..

MDA and glutathione levels, two indicators of oxidative stress, differed statistically significantly between the groups ($P = 0.01$). While glutathione levels were highest in the whey protein group and lowest in the creatine group, indicating differences in antioxidant status linked to supplement use, MDA, an indication of lipid peroxidation, was highest in the creatine group and lowest in the control group.

Overall, the results show that while LH and FSH levels were unchanged, the use of whey protein and creatine supplements is linked to notable changes in liver function tests, lipid profiles, testosterone levels, and oxidative stress biomarkers.

Table 2 presents the distribution of participants according to the daily quantity consumed (g/day) and duration of consumption (months). Regarding the daily quantity, the highest proportion in the first group consumed more than 20 g/day (19, 63%), whereas the largest proportion in the second group consumed 5–10 g/day (14, 47%). Smaller percentages of participants consumed 10–20 g/day, accounting for 2 (7%) and 4 (13%) in the first and second groups, respectively. The difference in the distribution of daily consumption between the groups was statistically significant ($P = 0.01$).

With respect to the duration of consumption, most participants in both groups had been consuming the product for 3–6 months, representing 15 (50%) in the first group and 16 (53%) in the second group. Consumption for 6–12 months was reported by 9 (30%) and 8 (27%), while more than one year of consumption was observed in 6 (20%) participants in each group. The comparison of consumption duration showed a statistically significant difference between the groups ($P = 0.002$).

Table 2. Comparing the findings of descriptive and analytical statistics between the bodybuilders ($n = 60$) and controls ($n = 30$) groups

Analytical statistics		Mean (SD)			P value
		Whey Protein	Creatine	Control	
liver function					
AST		22.0±2.25a	20.7±3.45b	12.6±1.58c	0.01
ALT		21.7±3.07a	20.8±3.68b	12.1±1.90c	0.02
Lipid Profile					
LDL		53.2±21.85b	47.5±16.82c	62.3±4.95a	0.02
HDL		89.7±17.90c	91.2±16.99b	101.6±6.17a	0.01
Cholesterol		150.3±14.31b	160.4±13.74a	120.2±6.73c	0.01
Triglycerides		121.37±18.40c	148.31±4.98a	131.16±4.26b	0.01
Hormone Test					
LH		7.9±3.2a	3.2±0.08b	2.1±0.23c	0.2
FSH		5.7±0.23a	4.3±0.27b	5.7±0.23a	0.2
TESTSTERON		6.2 ±0.28	4.9±0.56	2.1±0.2	0.01
Oxidative Stress					
MDA		7.7 ±0.66b	9.1±0.71a	4.8±0.45c	0.01
Glutathione		6.9 ±1.68a9	71.2±1.55c	81.5±0.96b	0.01
Quantity g/day	5-10	9 (30%)	14 (47%)	--	0.01
		2 (7%)	4 (13%)	---	
	10-20				
	>20	19 (63%)	12 (40%)	----	
Duration: month	3-6	15(50%)	16(53%)	----	0.002
	6-12	9(30%)	8(27%)	---	
	More one years	6(20%)	6(20%)	-----	

Means followed by different superscript letters (a, b, c) in the same row differ significantly at $P < 0.05$; means with the same letter are not significantly different.

Correlation MDA oxidative stress in bodybuilders levels

The scatter figure indicates a very modest positive connection between MDA oxidative stress Whey Protein (y-axis) and MDA oxidative stress Creatine (x-axis), according to the fitted regression line's small upward slope and extremely high coefficient of determination ($R^2 = 0.004$). There may be a significant linear association MDA oxidative stress between the two bodybuilders levels since the data points are widely distributed around the regression line.

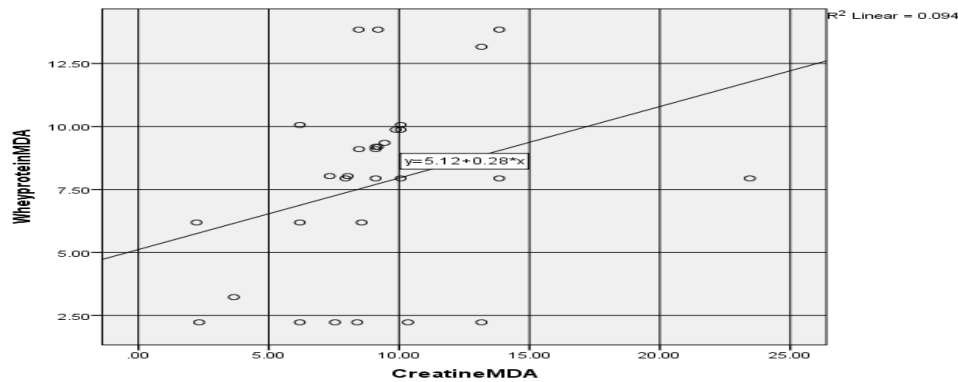


Figure 1. Correlation between in bodybuilders levels according to MDA oxidative stress

Correlation Glutathione oxidative stress in bodybuilders levels

The scatter figure indicates a very modest positive connection Glutathione oxidative stress in Whey Protein (X-axis) and Glutathione oxidative stress Creatine (Y-axis), according to the fitted regression line's small upward slope and extremely high coefficient of determination ($R^2 = 0.0003$). There may be a significant linear association Glutathione oxidative stress between the two bodybuilders levels since the data points are widely distributed around the regression line.

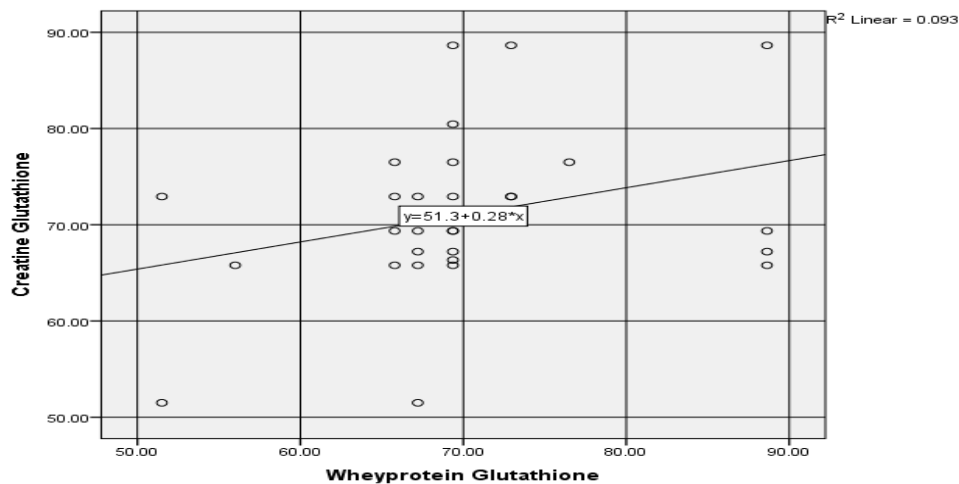


Figure 2. Correlation between in bodybuilders levels according to Glutathione oxidative stress

Correlation BMI in bodybuilders levels

The scatter figure indicates a very modest Negative connection BMI in Whey Protein (X-axis) and BMI Creatine (Y-axis), according to the fitted regression line's small downward slope and extremely low coefficient of determination ($R^2 = 0.149$). There may be a significant linear association BMI between the two bodybuilders levels since the data points are widely distributed around the regression line.

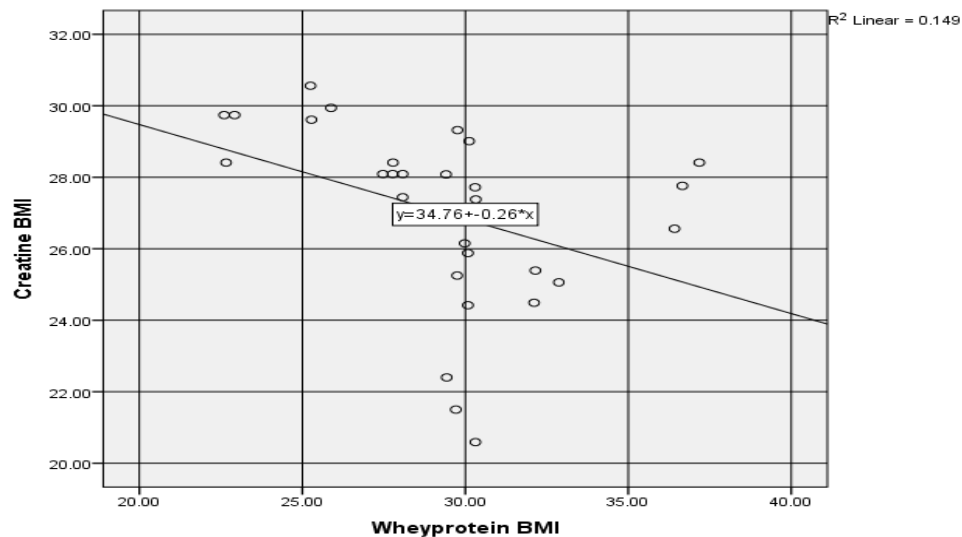


Figure 3. Correlation between in bodybuilders levels according to BMI

The scatter figure indicates a very modest positive connection between FSH Whey Protein (X-axis) and FSH Creatine (Y-axis), according to the fitted regression line's small upward slope and extremely high coefficient of determination ($R^2 = 7.72$). There may be a significant linear association FSH between the two bodybuilders levels since the data points are widely distributed around the regression line.

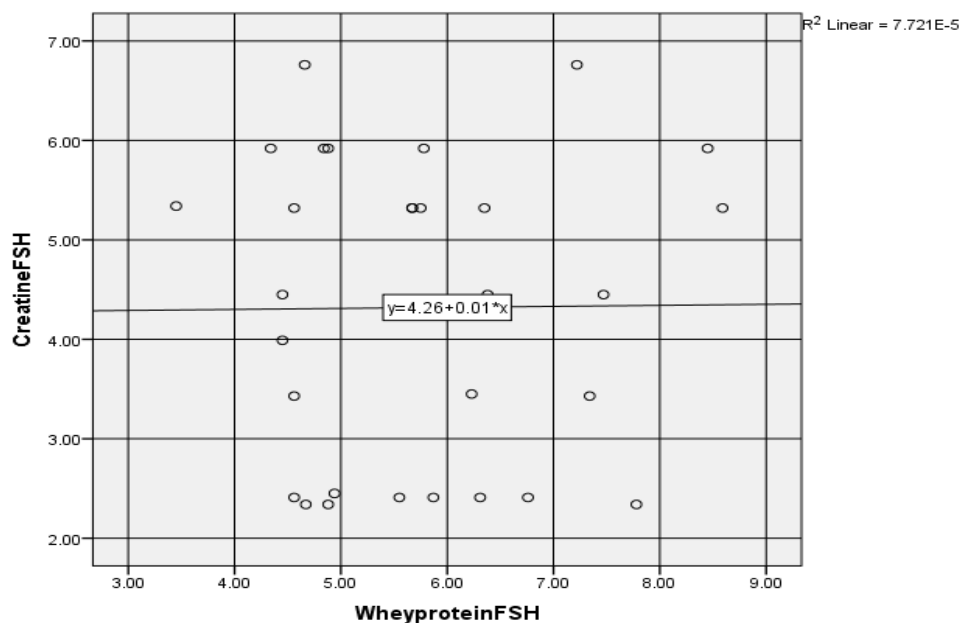


Figure 4. Correlation between in bodybuilders levels according to FSH

The scatter figure indicates a negative connection between LH Whey Protein (Y-axis) and LH Creatine (X-axis), according to the fitted regression line's small upward slope and extremely high coefficient of determination ($R^2 = 0.004$). There may be a significant linear association LH between the two bodybuilders levels since the data points are widely distributed around the regression line.

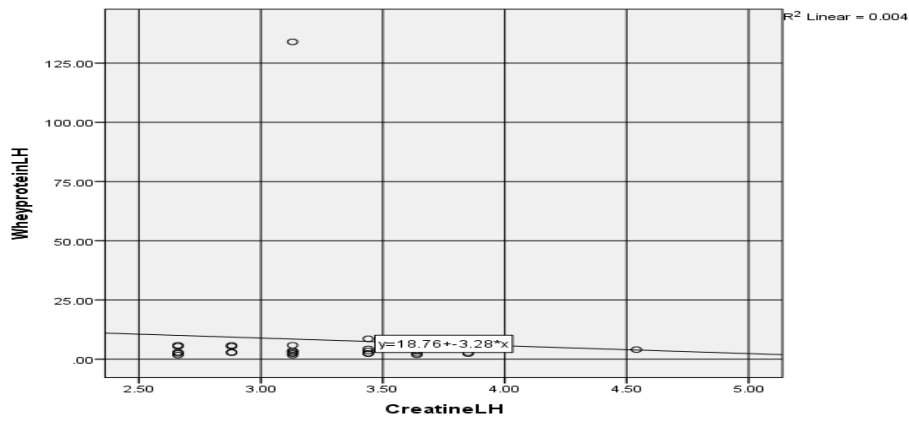


Figure 5. Correlation between in bodybuilders levels according to LH

The scatter figure indicates a positive connection between AST Whey Protein (Y-axis) and AST Creatine (X-axis), according to the fitted regression line's small upward slope and extremely high coefficient of determination ($R^2 = 0.0014$). There may be a significant linear association AST between the two bodybuilders levels since the data points are widely distributed around the regression line.

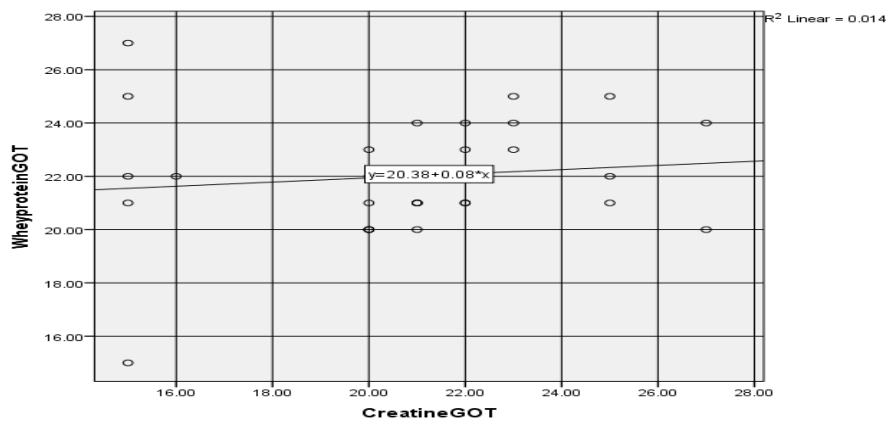


Figure 6. Correlation between in bodybuilders levels according to AST

The scatter figure indicates a negative connection between ALT Whey Protein (X-axis) and ALT Creatine (Y-axis), according to the fitted regression line's small upward slope and extremely high coefficient of determination ($R^2 = 0.055$). There may be a significant linear association ALT between the two bodybuilders levels since the data points are widely distributed around the regression line.

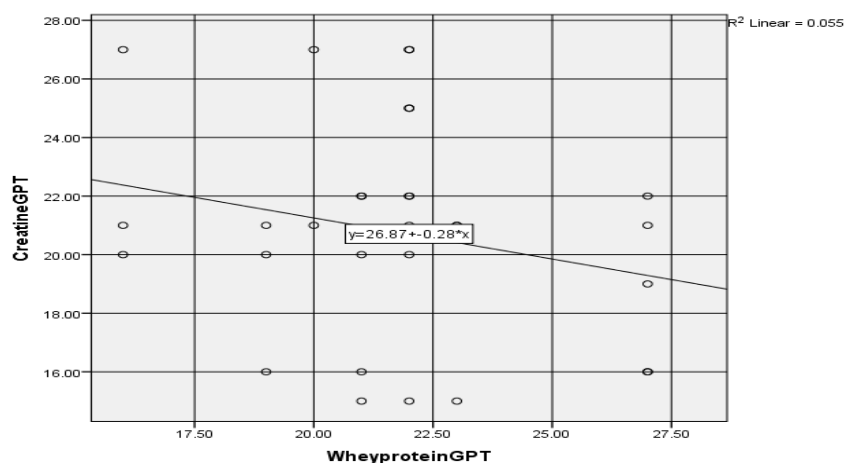


Figure 7. Correlation between in bodybuilders levels according to ALT

The scatter figure indicates a positive connection between LDL Whey Protein (X-axis) and LDL Creatine (Y-axis), according to the fitted regression line's small upward slope and extremely high coefficient of determination ($R^2 = 1.103E-4$). There may be a significant linear association LDL between the two bodybuilders levels since the data points are widely distributed around the regression line.

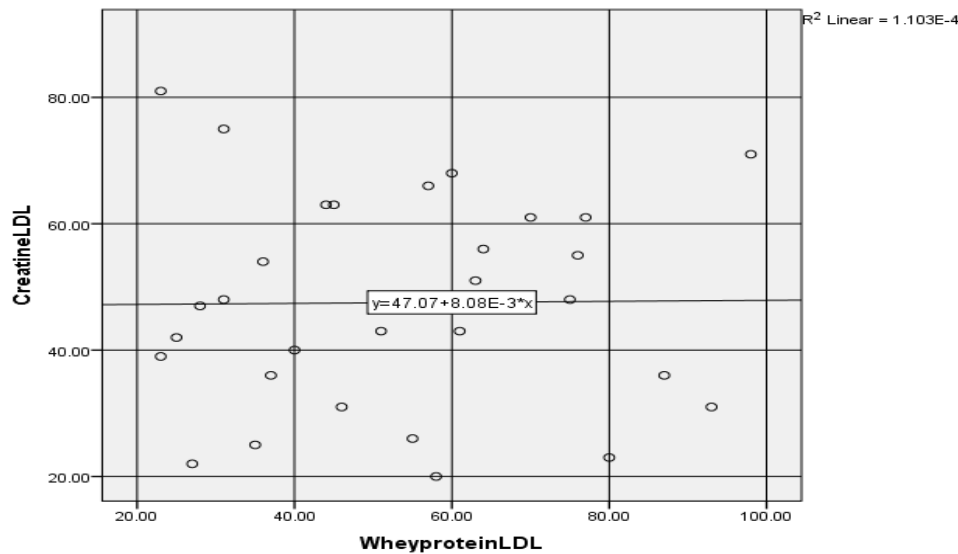


Figure 8. Correlation between in bodybuilders levels according to LDL

The scatter figure indicates a positive connection between Chol. Whey Protein (Y-axis) and Chol. Creatine (X-axis), according to the fitted regression line's small upward slope and extremely high coefficient of determination ($R^2 = 0.025$). There may be a significant linear association Chol. between the two bodybuilders levels since the data points are widely distributed around the regression line.

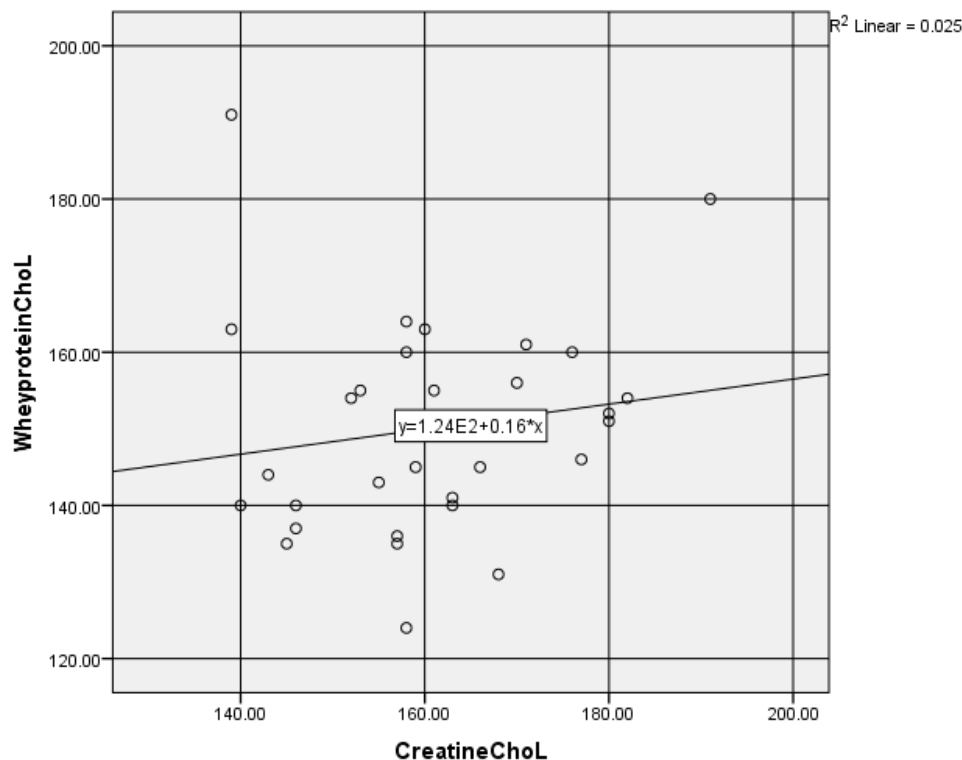


Figure 9. Correlation between in bodybuilders levels according to Chol.

Discussion

The present study showed that whey protein and creatine use is associated with significant differences in BMI, blood pressure and supplement use in bodybuilders compared to the control group. The results of this study align with those of other studies that found whey protein supplementation boosts muscle protein synthesis and leads to muscle growth and higher BMI in resistance trained people. Similarly, the effects of creatine supplementation that have been observed are in line with the results of Kreider et al. [14], which demonstrated that creatine supplementation has a beneficial effect on phosphocreatine availability, exercise performance, and muscle strength.

The present study findings however, partially contradict the study by Candow et al. [15] which found no significant changes in cardiovascular parameters such as blood pressure after moderate creatine supplementation. The increase in blood pressure seen in the current study could be due to intensity of training, length of time on the supplement, hydration status or body composition of the participants.

Regarding liver function, serum AST and ALT levels were significantly higher in both supplement groups than in the control group ($P = 0.01$ and $P = 0.02$, respectively). The whey protein group exhibited the highest enzyme levels, suggesting that intensive resistance training combined with protein supplementation may increase hepatic enzyme activity or reflect exercise-induced muscle damage rather than true liver injury. Similar observations have been reported in resistance-trained athletes who consume high-protein diets and dietary supplements [16].

Protein supplements (such as whey protein) are effective tools for supporting muscle mass. Although they have a positive effect on promoting satiety and improving insulin sensitivity, excessive consumption especially in the presence of impaired kidney function may lead to a buildup of uric acid. They further increase the feeling of fullness, thereby reducing total calorie intake. They contribute to building muscle mass, which raises the resting metabolic rate (calorie burning) and thus helps reduce fat accumulation [17].

In the lipid profile, study participants who took dietary supplements had significantly higher levels of total cholesterol and low-density lipoprotein-cholesterol (LDL-C) than those who did not ($P < 0.05$). Dairy products, especially milk proteins like casein and lactalbumin, have been shown to have a uricosuric effect. It has been demonstrated that dietary supplements, particularly whey protein, improve lipid metabolism. It is suggested that these supplements' functional ingredients, like beta-lactoglobulin and sphingolipids, limit the colon's ability to absorb cholesterol [16].

The lipid profile also differed significantly among the groups. LDL cholesterol was significantly lower in both bodybuilding groups compared with controls, whereas HDL cholesterol was significantly higher. Total cholesterol and triglyceride concentrations were also significantly altered ($P = 0.01$ – 0.02). These findings indicate that regular resistance exercise combined with nutritional supplementation may improve lipid metabolism, particularly by increasing HDL and reducing LDL concentrations, although dietary habits may also contribute to these changes [17]. Thus, it appears that these bodybuilding athletes' patterns of supplement use during the bulking and reducing phases were similar to those in other regions of the world. Nutritionists can use the data from this study to determine which supplements bodybuilders most frequently take, and counselors can use this knowledge to assist bodybuilders adopt healthier eating habits.. Athletes are using supplements more frequently, thus it's critical to evaluate the motivations behind supplement use. According to the current study, health-related concerns were the main justification for supplement use, followed by boosting immunity and enhancing sports performance. According to K  rlund et al. [18], adult athletes view supplements as tools for enhancing both athletic performance and healing/rehabilitation. Other reasons athletes use supplements include boosting energy, enhancing performance, enhancing health, preventing nutritional deficiencies, preventing disease, gaining muscular mass, and enhancing recuperation. When counseling juvenile and adolescent athletes who are highly driven to utilize supplements, nutritionists may find it useful to take these factors into account [18].

The research's decision to evaluate MDA and glutathione oxidative stress in bodybuilders was a restriction even though it probably increased variability in the final measurements [19]. GSH supplementation may have short-term beneficial effects on postprandial oxidative stress and/or endothelial function, which was not assessed in this trial, given that postprandial oxidative stress occurs and affects short-term vascular function. Thirty While N-acetylcysteine is used in

acetaminophen toxicity, as a mucolytic in respiratory conditions, and in experiments to prevent contrast-induced nephropathy, the therapeutic application of MDA and GSH precursors is very restricted [20]. In nontraditional health care fields like alternative and complementary health care, where oral nutritional supplements are frequently used, this study has significant clinical ramifications for both patients and healthcare professionals.

In terms of hormonal status, bodybuilders had significantly higher testosterone levels than controls ($P = 0.01$), but LH and FSH showed no statistically significant differences ($P = 0.20$). The observed testosterone difference requires cautious interpretation because training, diet, and possible androgen exposure were not controlled [21]. The absence of significant LH and FSH differences does not establish that supplementation has no pituitary effect.

The oxidative stress markers showed notable variations [19]. The creatine group had the highest levels of malondialdehyde (MDA), a sign of lipid peroxidation, whereas the whey protein group had the highest levels of glutathione ($P = 0.01$). These results imply that vigorous exercise raises oxidative stress; nevertheless, whey protein may improve endogenous antioxidant defenses by encouraging glutathione synthesis because of its high cysteine concentration.

Additionally, the present study found different daily dosages and durations between the supplement groups ($P = 0.01$ and $P = 0.002$). These differences may contribute to the observed biochemical patterns. Overall, these results imply that considerable changes in liver enzymes, lipid metabolism, testosterone levels, and oxidative stress indicators are linked to nutritional supplements in bodybuilders. Both supplements should be taken under proper dietary guidance to prevent potential negative metabolic consequences, even though whey protein seems to offer more antioxidant benefits [17].

Conclusion

Therefore, it should not be shocking that using nutrition supplements has an impact on the liver, oxidative stress, Hormones profile and lipid profile. High levels of vitamins, hormones, and supplements will undoubtedly put undue strain on the liver's ability to detoxify and the kidneys' ability to eliminate them. Individual consumers' health is further endangered by the combined use of these materials.

Significantly elevated AST and ALT levels were seen in both supplement groups compared to controls, indicating a minor impact on liver function. The lipid profile also showed significant alterations, with supplement users having higher levels of triglycerides and total cholesterol as well as different concentrations of LDL and HDL.

In terms of hormonal status, bodybuilders had considerably greater testosterone levels than the control group, although there were no significant variations in LH or FSH levels between the groups. Whey protein users had the highest glutathione concentrations, indicating a stronger antioxidant defense, while creatine users had the highest MDA levels, indicating greater oxidative stress, according to oxidative stress indicators.

REFERENCES

- [1] Tirla, A., Islam, F., Islam, M. R., Vicas, S. I., and Cavalu, S. 2022. New Insight and Future Perspectives on Nutraceuticals for Improving Sports Performance of Combat Players: Focus on Natural Supplements, Importance and Advantages over Synthetic Ones. *Applied Sciences*, 12(17), 8611. doi: 10.3390/app12178611.
- [2] Peeling, P., Castell, L. M., Derave, W., De Hon, O., and Burke, L. M. 2019. Sports Foods and Dietary Supplements for Optimal Function and Performance Enhancement in Track-and-Field Athletes. *International Journal of Sport Nutrition and Exercise Metabolism*, 29(2), 198–209. doi: 10.1123/ijnsnem.2018-0271.
- [3] Jahan, S., Fatima, A., Alam, I., Ullah, A., Rehman, H., Afsar, T., Almajwal, A., and Razak, S. 2018. Effects of dietary supplements on selected hematological and biochemical parameters of Pakistani athletes. *BMC Nutrition*, 4(1). doi: 10.1186/s40795-018-0250-y.

- [4] KHATI, Awesh; DAS, Anindita; KARMAKAR, Debajit. Importance of individualized nutrition plans in athletes. In: Evaluating the effectiveness of functional ingredients in sports nutrition. IGI Global Scientific Publishing, 2025. p. 279-306.
- [5] Shcheglevatyh, A. N., and Ovechkin, S. A. 2021. Endurance product for sprinters. Proceedings of the Voronezh State University of Engineering Technologies, 83(1), 253–257. doi: 10.20914/2310-1202-2021-1-253-257.
- [6] Barrack, M., Fredericson, M., Dizon, F., Tenforde, A., Kim, B., Kraus, E., Kussman, A., Singh, S., and Nattiv, A. 2021. Dietary Supplement Use According to Sex and Triad Risk Factors in Collegiate Endurance Runners. Journal of strength and conditioning research, 35(2), 404–410. doi: 10.1519/JSC.0000000000003848.
- [7] Naderi, A., de Oliveira, E. P., Ziegenfuss, T. N., and Willems, M. T. 2016. Timing, Optimal Dose and Intake Duration of Dietary Supplements with Evidence-Based Use in Sports Nutrition. Journal of exercise nutrition, and biochemistry, 20(4), 1–12. doi: 10.20463/jenb.2016.0031.
- [8] Roschel, H., Gualano, B., Ostojic, S. M., and Rawson, E. S. Creatine Supplementation and Brain Health. Nutrients, 2021. 13(2), 586. doi: 10.3390/nu13020586.
- [9] MORTON, James P., et al. UCI sports nutrition project: Nutritional periodization: Strategies to enhance training adaptation and recovery. International Journal of Sport Nutrition and Exercise Metabolism, 2025, 36.3: 279-304.
- [10] De Meo, C., de Waure, C., De Meo, C., Terracciano, E., Di Nardo, F., and Ricciardi, W. 2022. Does the use of dietary supplements enhance athletes' sport performances? A systematic review and a meta-analysis. Epidemiology, Biostatistics, and Public Health, 12(4). doi: 10.2427/11593.
- [11] SULAIMAN, Saman, et al. Effects of Dietary Supplements and Anabolic Hormones on Hematological and Biochemical Parameters among Young Bodybuilders in Kurdistan Region of Iraq. Journal of Medicinal and Chemical Sciences, 2023, 6.9: 2242-2248.
- [12] Buege JA, Aust SD. Microsomal lipid peroxidation. Methods Enzymol, 1978; 52: 302-310 Doi: 10.1016/S0076-6879(78)52032-6.
- [13] Ellman, G.L. Tissue sulfhydryl groups. Arch Biochem Biophys, 1959;82(1):70-77.
- [14] Kreider RB, Kalman DS, Antonio J, et al. International Society of Sports Nutrition position stand: safety and efficacy of creatine supplementation in exercise, sport, and medicine. J Int Soc Sports Nutr. 2022;19(1):1-46.
- [15] Candow DG, Chilibeck PD, Forbes SC. Creatine supplementation and cardiovascular health in resistance-trained adults. Nutrients. 2021;13(6):1915.
- [16] Amirani E, Milajerdi A, Reiner Ž, et al. Effects of whey protein on glycemic control and serum lipoproteins in patients with metabolic syndrome and related conditions: a systematic review and meta-analysis of randomized controlled clinical trials. Lipids Health Dis 2020;19(1):209.
- [17] Vasconcelos QDJS, Bachur TPR, Aragão GF. Whey protein supplementation and its potentially adverse effects on health: a systematic review. Appl Physiol Nutr Metab 2021;46(1):27-33.
- [18] Kårlund A, Gómez-Gallego C, Turpeinen AM, et al. Protein supplements and their relation with nutrition, microbiota composition and health: Is more protein always better for sports people? Nutrients 2019;11(4):829.
- [19] SALMAN, Hana Attiya; HUSSEIN, Farhan Khaleel; ABDULRAHMAN, Sahib Jumaah. A comparison of glutathione and malondialdehyde concentrations in athletes engaged in certain sports. Tamar University Journal of Natural, and Applied Sciences, 2024, 9.1: 39-42.
- [20] ZARE, Reza, et al. Effect of soy protein supplementation on muscle adaptations, metabolic and antioxidant status, hormonal response, and exercise performance of active individuals and athletes: a systematic review of randomised controlled trials. Sports Medicine, 2023, 53.12: 2417-2446.
- [21] DE VELASCO, Luis M. Canal, et al. Testosterone replacement therapy in athletes: implications for injury recovery and musculoskeletal performance. Cureus, 2026, 18.2.
- [22] ZARE, Reza, et al. Effect of soy protein supplementation on muscle adaptations, metabolic and antioxidant status, hormonal response, and exercise performance of active individuals and athletes: a systematic review of randomised controlled trials. Sports Medicine, 2023, 53.12: 2417-2446.