

Measuring the health effects of excessive consumption of protein supplements among bodybuilders in Pakistan- A comprehensive review

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Abstract

As bodybuilding and fitness culture gains favor among youths and young adults in Pakistan, there has been a sudden upsurge of the consumption of dietary supplements mainly whey protein. Both praised as beneficial to muscle building, strength, and recovery time, whey protein is most commonly abused and without medical and nutritional advice. While moderate use can aid in the development of muscle mass and sports performance, excess use poses numerous risks to health, especially when used inappropriately for extended periods of time. This review article critically discusses the health effects of excess use of whey protein among Pakistani bodybuilders with reference to physiological, metabolic, and sociocultural contexts. Liver enzyme activity is also impacted because of the added metabolic stress placed on the hepatic pathways, and increased liver enzymes like ALT and AST are very frequent with chronic abuse. Other common reported side effects include gastrointestinal upset, bloating, insulin resistance, nutrient imbalance, and in certain cases, increased cardiovascular risk. This article stresses the necessity for an all-encompassing public health response. Proposed solutions include more government control over the retail sale of supplements, labeling and quality control of both imported and domestically produced products, public education regarding the dangers of excessive use, and the presence of certified nutritionists and dietitians within gyms. Moreover, the paper sees a clear gap in locally relevant clinical studies of the long-term consequences of excess consumption of protein in Pakistani participants. The future research should focus on determining the impact of excess use of whey protein on organ systems, particularly under influence of other elements of lifestyle like diet, amount of water consumed, and activity levels. Encouraging the safe and evidence-based usage of supplements is necessary to ensure the health and well-being of Pakistan's increasing bodybuilding population.

INTRODUCTION

In Pakistan, bodybuilding and fitness culture have emerged very rapidly over the past decade within large cities like Lahore, Karachi, Islamabad, and Peshawar. With greater availability of gyms, social media also helps to promote it, and with the demand for Western beauty standards of muscularity, more and more young men and now increasingly women are turning to the use of dietary supplements to speed up muscle growth and enhance physique. Of these, whey protein supplements are widespread, viewed in many instances as a "short-cut" to making the quick gains [1]. Yet the habit of overconsumption of taking significantly higher than suggested dosages is of great concern regarding total health dangers. This opening establishes the setting, physiological, and societal context for the reason that it is necessary to explore the impact of whey protein excessive use on Pakistani bodybuilders [2].

Whey protein is obtained from the liquid fraction of milk that separates when cheese is produced and is composed of high-quality, rapid-absorbing essential amino acids. Whey protein is popular among individuals in the fitness community due to its capacity to stimulate muscle protein synthesis, promote recovery, and augment resistance training [3]. Nevertheless, whereas most studies indicate that, in the case of taking moderate, guideline-suggested dosages (e.g., 20–40 g postexercise), whey protein supplementation will be effective and harmless, at doses above that, side effects will start to develop [4].

Although whey protein has had well-documented, beneficial effects in regulated, guideline-calibrated intake such as on exercise-induced muscle protein synthesis, recovery, and body composition unregulated intake could have potential health-damage, particularly among groups where regulatory control and nutrition education are weaker [5]. The problem at its essence is that most consumers take an enormous amount of more protein than their body actually needs, usually based on the false assumption that '**more protein equals more muscle**'. This is fueled by marketing, gym subculture, and peer pressure, and is usually not evident because there is not enough information on

what is safe. When protein consumption significantly exceeds the demands for muscle restoration and development, the excess has to be metabolized and eliminated, further taxing physiological processes like the liver and kidneys [6].

In Pakistan, the culture of supplements is driven by several home-grown factors: aggressive marketing on the part of supplement suppliers, negligible regulatory control on the nutraceutical industry, and an underclass of unlicensed trainers and social media personalities who advocate for excessive doses wholesale. The users prefer to think "**more protein = more muscle**" without thinking as much about the law of diminishing returns as about the danger of over-reliance [7].

When protein intake far exceeds the body's needs, the body needs to metabolize excess nitrogenous waste mainly by breaking down amino groups into urea, which the kidneys excrete. This adds renal load and, in vulnerable individuals, can lead to increased blood urea nitrogen (BUN) or creatinine levels and ultimately loss of glomerular filtration rate [8]. Indeed, one systematic review of the side effects of whey protein concluded that kidney and liver are the primary organs affected due to long-term, uncontrolled use of the supplement.

Additionally, excessive whey protein intake can be metabolically stressful to the liver. The liver's urea cycle will have to deal with excessive ammonia loads, leading to heightened hepatic demand [9]. Elevated transaminases have been observed in abusers, particularly in the presence of other supplement consumption or inadequate hydration. Taken to organs, excessive whey protein intake has been attributed to gastrointestinal side effects (bloating, diarrhea, cramping) particularly in lactose intolerant individuals as well as metabolic abnormalities such as insulin resistance when diet homeostasis is deranged [10].

At the psychological and social level, the body image expectations and peer pressure that fuel the "**faster, bigger, better**" imperative ensure that social media icons, who possess little in the way of evidence-based

credentials, hawk extreme supplementation protocols. It is a myth that the more one supplements, the more one gains, when after a point more protein will not add up to more gain but will contribute to more risk. The net result is a normalization of "**megadosing**" (multiple scoops, multiple times daily) unregulated and uncontrolled [11].

There is also adulteration and contamination problem with poor-quality protein products. Some powders contained heavy metals (lead, cadmium, arsenic), undeclared steroids, or microbial contamination risks compounded by a breakdown of effective regulatory monitoring in most markets. Anecdotal evidence and consumer complaint in the Pakistani context indicate that poor product or counterfeiting is rampant in gyms or online. For example, consumers advise that products offered at extremely low prices are found to be counterfeit or adulterated [12].

Second, beyond insulin action effects, there is also potential for systemic effects via hormonal or metabolic mechanisms. High amino acids, particularly branched-chain amino acids (BCAAs), could affect insulin signaling, mTOR pathway activation, or insulin-like growth factor 1 (IGF-1) kinetics, with potential impact on insulin resistance risk, dysglycemia, or other metabolic disturbances. The microbiome is also a potential target candidate; high protein loads have reviews cited for gut flora modulation and perhaps perilous shifts in microbial balance.

A Pakistani case report describes a 37-year-old male bodybuilder with acute kidney injury (AKI) following concomitant intensive exercise routine and indiscriminate use of whey protein, with the presenting features of face and leg edema, flank tenderness, nausea, and raised renal markers. This shocking example shows that localized, real-world side effects already are taking place but underreported [13].

Aside from the biological processes involved, the Pakistani fitness culture itself is also vulnerable. There are no certified nutritionists present in gyms, and most users of the gym are following anecdotal recommendation by trainers or influencers, not evidence-based recommendations. The users might use more than one scoop, possibly combined with added

protein isolate or creatine, without realizing cumulative load or their tolerance.

Regulation of protein powders in Pakistan is lax. Most protein powders are imported into the country with little regulation, and quality control measures are carried out erratically. This leaves the door open for contaminated, stale, or mislabeled products. Education to the general population about safe consumptions of protein is also non-existent in the popular media or the gyms [14].

To this is a deficiency in local clinical studies. The majority of existing studies on whey protein side effects are carried out in Western or other Asian populations and fail to account for heterogeneity in Pakistani diet, genetics, hydration status, or co-consumption of indigenous herbs or drugs. This contributes to a deficiency in contextualized guidance by local health bodies in relation to the local situation [15].

Considering the widespread application of whey protein among Pakistani bodybuilders, overuse risk, and discussed physiological side effects, the initiation of a timely and needed review is beneficial [14,15]. This article will explain the physiological effects and processes of whey protein overuse with focus on renal, hepatic, gastrointestinal, and metabolic systems. Provide evidence from Pakistan (case reports, consumer complaints, market questionnaires) to appreciate local trends and hazards. Describe regulatory, educational, and market issues that contribute to misuse in Pakistan. Make recommendations for safe use, public health interventions, regulation, and future research in the context of Pakistan. In all this, this review aims at rewriting the story away from unrestricted promotion of protein supplements and towards scientifically informed and judicious use, particularly in a situation where regulation and education are limited. There has to be a balanced response recognition of the rightful advantage of whey protein if used prudently along with a warning against indiscriminate and unregulated use. By integrating mechanistic understanding, global evidence, and local contexts, this article will attempt to protect the health of Pakistan's fast-expanding bodybuilding community.

Overview of Protein and its role in the human body:

Protein is one of the three macronutrients required for human well-being, the other two being carbohydrates and fat. It is a basic building and functional block of all cells in living organisms and a growth, maintenance, and repair requirement for body tissues. Made of long amino acid chains bound by peptide bonds, proteins exist in thousands of structures and carry out an enormous array of biological processes in the human body [16].

- **Amino Acids: Building blocks of Protein**

The building blocks of protein, amino acids, are divided into **essential** and **non-essential amino acids**. The essential amino acids are not produced by the body and need to be supplemented with food, while non-essential amino acids are produced inside the body. There are nine essential amino acids: leucine, isoleucine, and valine, among others, which play a critical role in muscle protein synthesis and can be found in high-quality protein sources such as meat, milk, and whey supplements [16,17].

- **Biological functions of protein in Human Body:**

Protein has many basic physiological functions. Most notably, it is necessary for repairing and building muscle, and for these reasons, it is so essential for athletes and bodybuilders. Muscle hypertrophy, or the increase in muscle size, is based on the ratio between the break-down and synthesis of muscle protein, both of which are determined by protein consumption through diet and resistance training. In addition to the function of muscle, proteins also exist as enzymes, hormones, neurotransmitters, immune molecules (antibodies), and other nutrient carriers in the blood [17].

- **Protein Requirements and Athlete Needs:**

The Recommended Dietary Allowance (RDA) in healthy adults for protein is about **0.8 grams/kg** body weight daily. This is boosted for those who exercise with frequent resistance training, heavy exercise, or for gain in muscle or injury recovery. Protein intake in athletes is between **1.2 and 2.0 grams/kg/day** based on volume of training and purpose [18].

Though it is essential, protein needs to be ingested within physiologic amounts. The human body can use a limited amount of dietary protein for anabolic purposes. More intake than that is not stored as protein but metabolized for energy or deposited as fat, and the nitrogenous byproduct is eliminated predominantly by the kidneys. Thus, excessive intake of protein, especially supplements, can burden metabolic pathways and organ systems, as detailed below.

- **Relevance to Supplement Use and Overconsumption:**

Understanding the physiological function and limits of protein use is key to assessing overconsumption risk. Although protein in the diet is important for muscle growth, uncontrolled or extreme usage, particularly in supplement forms like whey protein, is more than the body can safely use. Within bodybuilding and the subculture of fitness, there exists this general misunderstanding that additional protein always means improved results. In fact, after protein needs on an individual basis are fulfilled, additional consumption will no longer be adding to muscle gain but may instead be adding the potential for negative health consequences, especially when such consumption is regularly sustained over time [16,17,18].

Protein Requirements in Bodybuilders:

- **Recommended Dietary Allowance (RDA) vs. Bodybuilding Needs:**

The Recommended Dietary Allowance (RDA) for protein in the general healthy adult population is 0.8 grams per kilogram of body weight per day for the prevention of deficiency and not for muscle building or maximal recovery. Resistance-trained individuals, on the other hand, need so much more protein to provide for enhanced muscle protein synthesis, repair training-induced micro-tears, and accommodate the stress of heavy exercise [18].

A number of studies and opinions from experts propose that bodybuilders usually need **1.6 to 2.2 grams** of protein per kilogram of body weight every day, subject to training frequency and volume, caloric availability, as well as specific goals regarding body composition. When in cutting or energy-restricted

states, intake will increase to 2.3–3.1 g/kg/day to maintain muscle mass during caloric deficit [19].

• **Actual Protein Intake Among Bodybuilders:**

Even though guidelines suggest otherwise, most bodybuilders, particularly where there is no regulation such as at local gyms in Pakistan, intake significantly more than these recommendations. 3.5–4.0 g/kg/day intake on a daily basis is not uncommon, as much as due to the assumption that additional protein will mean additional or quicker muscle development. This excess typically is in the form of multiple servings of whey protein shakes added to a high-protein intake. Such doses, while far beyond the body's ability to effectively use the protein for muscle building, may also create metabolic and renal stress in the long term [17].

• **Differences Based on Training Level:**

Protein requirements are different among novice, intermediate, and advanced bodybuilders.

➤ **Novice participants** will be undergoing accelerated adaptation of the musculature to training and possibly will need greater protein intake (~2.0–2.2 g/kg/day) because of increased muscle protein turnover and recovery demands.

➤ **Intermediate to advanced** bodybuilders, who already have a high degree of lean mass, generally need a little less intake (~1.6–2.0 g/kg/day) since progress is gradual. However, their caloric and protein needs in general might be high because of increased muscle mass and volume of training [17,19].

In practice, beginners are more likely to overeat because of ignorance as well as peer pressure, whereas advanced competitors might adhere to rationed regimen through experience or counsel.

• **Timing and Distribution of Protein Intake:**

Although overall daily protein is of greatest importance to muscle growth, muscle protein synthesis (MPS) effectiveness is maximized with timing and distribution throughout meals.

➤ **Post-Workout Protein:** Protein intake during the recovery window immediately following resistance exercise, preferably within 1–2 hours, is useful for recovery. An intake of 20–40 grams of quality protein (such as whey protein) after exercise is generally advised.

➤ **Even Intake:** Instead of eating huge quantities at once, research has revealed that taking protein in an even amount over 4–5 meals increases MPS more. Target 0.4–0.55 g/kg/meal to maximize uptake and utilization.

Sadly, most Pakistani bodybuilders take very high amounts of protein directly after their workout but neglect regular intake over the course of the day, which can decrease overall anabolic effect and efficiency of protein utilization [20].

• **Protein Quality and Digestibility:**

Very well-qualified proteins, those that contain a balanced amino acid profile with good digestibility, are even more effective for inducing muscle growth. Whey protein is among the most popular supplements among Pakistani bodybuilders due to its high rate of absorption and its rich concentration of BCAAs, especially leucine, which is an important MPS trigger. Still, excessive dependence on supplements, particularly low-standard or fake kinds of them, will erode gains and pose greater health threats. Whole foods like eggs, chicken, milk, fish, and beans should remain the focal point in protein consumption, with the supplements being appropriately utilized but not excessively [20].

Group	RDA (g/kg/day)	Average Intake (g/kg/day)
Sedentary Adult	0.8	0.8
Recreational lifter	1.2-1.6	1.5
Professional Bodybuilder	1.6-2.2	2.5-3.5

Source: Phillips, S. M. (2012). Dietary protein requirements and adaptive advantages in athletes. *British Journal of Nutrition*, 108(S2), S158-S167.

Types of Protein Supplements:

Protein supplements have become an integral part of bodybuilding and sports nutrition in present times. They are a rapid, but concentrated, source of high-quality protein that allows for muscle repair, recovery, and growth. In Pakistan, their consumption among bodybuilding enthusiasts has become extremely widespread, particularly in cities. Yet, there are fewer consumers who are well-informed about the distinction between protein varieties, rate of absorption, and utilizing them effectively. Data on various types of protein supplements need to be obtained to determine their effect on health and avoid abuse or misuse [19,20].

1. **Whey Protein:**

Whey protein is the most popular bodybuilding supplement on the planet, even in Pakistan. Whey protein is an entire milk protein that is produced from milk during cheese manufacturing and has all nine essential amino acids with an abundance of branched-chain amino acids (BCAAs), primarily leucine.

There are **three principal forms** of whey protein:

- **Whey Protein Concentrate (WPC):** 70–80% protein, with a bit of lactose and fat. Very affordable and very commonly used.
- **Whey Protein Isolate (WPI):** 90–95% protein with very little fat and lactose. More quickly digested and commonly suggested for the lactose intolerant.
- **Whey Protein Hydrolysate (WPH):** Pre-digested for quicker assimilation. Perhaps less upset stomach but more costly [20].

Whey has been found to be perfect for post-exercise consumption because it is easily absorbed and can effectively activate muscle protein synthesis.

2. **Casein Protein:**

Casein, another dairy derivative, is a slow-digesting protein that releases amino acids slowly over a period of several hours. It is generally taken before bed in an effort to recover overnight muscle. While less popular than whey in Pakistan, casein is useful for keeping a positive protein balance for extended periods of fasting, like between meals or overnight [19,20].

3. **Soy Protein:**

Soy protein is an important whole-plant protein rich in essential amino acids, especially arginine and glutamine. It is commonly used by vegetarians and

vegans. Usage is maintained at low levels among Pakistani bodybuilders because of low availability and dietary habits. Soy is controversial because of its phytoestrogenic content, although research indicates that it is safe to use in moderation [20].

4. **Pea, Rice, and Other Plant-Based Proteins:**

Pea, rice, hemp, or blended source plant-based protein powders are increasingly mainstream among health enthusiasts and individuals with dairy allergies or lactose intolerance. Most plant proteins being incomplete (carrying less than a sufficient amount of one or more of the essential amino acids), blends can supply a complete amino acid profile. They are not employed as much in Pakistan's bodybuilding culture, though awareness is gradually spreading [20].

5. **Egg Protein:**

Egg white protein is a very bioavailable and highly digestible animal-derived protein. Egg white protein is free of lactose and filled with essential amino acids. Egg protein supplements are very effective but not as commercially available and used in Pakistan as whey-derived products, perhaps because of the reason of cost and accessibility. Many Pakistani bodybuilders take whole eggs as a natural source of protein rather than powdered egg protein [20].

6. **Mass Gainers:**

Although not pure protein powder supplements, mass gainers find extensive use among Pakistan's bodybuilding community. They are high-calorie powders that have a mix of protein (most often whey), carbohydrates (often sugars or maltodextrin), and fats. They are to be consumed by individuals with high metabolic rates or individuals interested in weight gain. Their misuse can result in consuming excess calories and proteins, with a greater risk of metabolic and renal stress [17,20].

7. **Protein Blends:**

Blended proteins have multiple sources (i.e., whey, casein, soy, egg) to offer fast- and slow-digesting proteins. They are sold for improved day-long amino acid delivery and muscle repair. Though effective, less frequent in Pakistan because of price and reduced availability compared with single-source products [19].

8. Ready-to-Drink (RTD) Protein Shakes and Bars: RTD protein shakes and bars are ready-to-eat foods providing ease of quick nutrition on the go. They usually have added ingredients like sweeteners, preservatives, and fillers. They are found more and more in urban stores and gyms in Pakistan but can also lead to undue over intake of hidden sugar and additives if consumed excessively [21].

Motivation for Misuse of Protein Supplements:

The emergent pattern of protein supplement misuse among Pakistani bodybuilders is the product of a multifaceted interaction of psychological, social, cultural, and commercial determinants. Knowing what drives excessive intake of protein is key to the development of effective education, medical, and regulatory interventions. Although protein is actually necessary for the repair and growth of muscle, the 'more is better' ideology has caused many gym users, especially young and novice users, to take more than the recommended doses, frequently without regard to the health consequences [21].

1. Social Pressure and Body Ideals:

Idealized body is one of the major reasons for excess protein consumption. In the age of hyper-muscularized body ideals with incessant aggressive advertising in social media, films, and bodybuilding culture, adolescents and youth are directly targeted for spreading unrealistic ideals. The pressure is further amplified in Pakistani city gym cultures where body appearance is generally identified with discipline, masculinity, and power.

Young adults are particularly susceptible to muscle dysmorphia and dissatisfaction with the body, a psychiatric condition in which individuals feel their body is not good enough even though they are muscular. Excessive self-confidence most commonly results in overtraining and excessive supplement intake, where proteins have been considered an easy and effective way for a quick gain in muscle [21].

2. Misinformation and Inadequate Nutritional Training:

Most people taking protein supplements in Pakistan make the decision to do so following gym trainers'

recommendations, buddies, or unverified online sources instead of those of certified nutritionists or doctors of medicine. Misinformation concerning protein intake is rampant. One of the most prevalent myths is that very high amounts of protein, most typically in the type of whey powder scoops several times each day, will lead to faster muscle gain regardless of training intensity or overall nutrition.

Further, terms like 'anabolic window', 'muscle loss', or 'catabolism' are regularly misinterpreted, leading to gym enthusiasts freaking out and overconsuming protein immediately following a workout, even when they exceed their requirements [21].

3. Role of Gym Culture and Trainers:

Trainers at most gyms in Pakistan have an important function to advise clients' workout routine and supplement selection. The majority of trainers are not, however, sports nutrition-trained and will have a greater tendency to suggest based on experience or personal belief. Some others are compensated by supplement businesses or local health shops for recommending certain brands, which presents a conflict of interest that could lead to overuse.

Peer pressure is also at play. When a gym user sees other individuals taking a lot of supplements and achieving muscle bodies, they may feel pressured to do the same in order to keep up the pace despite their individual physiological needs or aims [20,21].

4. Supplement Industry, Advertising, and Marketing:

The international and domestic supplement market supplies protein powders as needed for building muscles and recovery. Terms like 'fast muscle gain', 'ripped body', or 'scientific formula' are used to generate panic and induce consumption on a daily basis. In Pakistan, with the boom of the fitness sector and online stores offering supplements, aggressive promotion on social media sites and celebrities has been popular.

Most of these products do not come with dosing information or warning, and some oversell muscle-building capacity, to which the latter are abused. Imported or local supplement products, unregulated in Pakistan under weak monitoring, are shelved and kept

with little scrutiny, hence providing entry into the market for uncontrolled products [21].

5. Accessibility and Perceived Convenience:

Protein powders, particularly whey and mass gainers, are now easily accessible in Pakistani urban gyms, sports supplement stores, and on the internet. Their convenience; quick to consume, simple to consume, and labeled as ‘meal replacements’, is alluring for active lifestyles.

Some body builders substitute a few meals with shakes or even use them as snacks during the day. It's a healthy and effective replacement, they think. Believing that supplements are more effective than foods cooked naturally is a factor that leads to their overuse [22].

6. Fear of Muscle Loss and Decline in Performance:

For most bodybuilders, particularly those working hard or contesting, fear of muscle loss or performance plateau is a strong driving force. The fear leads them to take protein supplements a few times daily even when nutritional intake is already adequate.

There is also a common fallacy that not drinking a post-workout shake, or failing to consume protein every few hours, will result in instant muscle breakdown. While muscle preservation does demand required protein, such things are usually overstated and lacking in scientific fact [22].

7. Lack of Regulatory Control and Expert Advice:

There are no guidelines from the regulatory agencies nor large-scale health education programs for safety and consumption of supplements in Pakistan. Unlike prescription medication, items like protein powders are available to anyone without expert counsel. Additionally, most gym-goers lack access to trained dietitians or sports nutritionists and are compelled to make use of anecdotal information [21,22].

In addition, there are limited educational activities at gyms or schools about evidence-based nutrition, which results in blind reliance on supplements for enhancing performances [22].

Metabolism of Excess Intake of Dietary Protein:

Dietary protein is essential to the repair of muscle, growth, and overall physiological function. However, when consumed in excess of the body's immediate need

for tissue repair and enzyme synthesis, the metabolism of protein differs. It is from gaining insight into how the body utilizes excessive protein that an appraisal may be made of the danger of chronic overconsumption, especially as supplementation among bodybuilders [23].

1. Protein Digestion and Absorption:

The digestion of dietary protein starts in the stomach, with pepsin and hydrochloric acid breaking down protein into polypeptides. This is followed in the small intestine where pancreatic enzymes like trypsin, chymotrypsin, and carboxypeptidase break down polypeptides to amino acids that are absorbed and short peptides.

These amino acids are then absorbed by the blood through the intestinal mucosa and transported to the liver by the hepatic portal vein and made available in the amino pool of amino acids for various physiological processes like protein synthesis, enzyme formation, hormone regulation, and neurotransmitter synthesis [23].

2. Anabolic Utilization vs. Catabolic Breakdown:

When protein consumption equals the body's need, amino acids are directed towards anabolic functions such as:

- Muscle protein synthesis
- Synthesis of enzymes and hormones
- Immune response
- Repair of cells

But when protein is taken in amounts greater than the body's anabolic needs, excess amino acids cannot be stored as carbohydrates (glycogen) or fats (triglycerides). Rather, the body directs them towards catabolic processes for energy generation or conversion of macronutrients [23].

3. Deamination and Excretion of Nitrogen:

The most important metabolic reaction for the removal of excess amino acids is deamination, which takes place in the liver. Through this reaction, the amino group (-NH₂) is removed from the amino acid to produce a carbon skeleton (keto acid).

The amino group is transformed into ammonia (NH₃), which is a toxic substance.

The liver rapidly oxidizes ammonia to urea through the urea cycle, which is subsequently excreted in the urine by the kidneys.

The process puts extra workload on the kidneys, and the kidneys have to filter and excrete more nitrogenous waste. Protein-rich diets over the long run can thus result in renal stress, particularly in patients with underlying renal disease or when there is insufficient hydration [23].

4. The Fate of the Carbon Skeleton:

Following deamination, the rest of the amino acid's carbon skeleton may take any one of a number of routes:

- **Gluconeogenesis:** Metabolism to glucose, especially in times of low carbohydrate consumption.
- **Lipogenesis:** Metabolism to fatty acids and storage in triglyceride form in adipose tissue.
- **Synthesis of ATP:** Storage in the citric acid (Krebs) cycle to generate energy.

So, when in a calorie surplus, excess dietary protein can ultimately be stored as fat, debunking the common theory that high-protein diets are always lean or fat-burning [23].

5. Thermic Effect and Energy Concerns:

Protein also has an elevated thermic effect of food (TEF) and accomplishes this at some 20–30% of its energy value used up in digestion, absorption, and assimilation. This is more than from carbohydrates (5–10%) and fat (0–3%). Extremely high protein intakes therefore enhance total energy expenditure modestly.

Although this is encouraged in weight loss diets, it cannot be used as a replacement for overindulgence. Any excess protein beyond that required for muscle maintenance or growth will still be broken down and, if overall caloric intake exceeds caloric expenditure, stored as fat [23].

6. Health Consequences of Excess Protein Metabolism:

Excess protein metabolism uses intricate physiological mechanisms that put stress upon large organs, including the kidneys and liver. In bodybuilders consuming 3-4 times the normal diet as supplements and powder on a daily basis, the long-term effects can be:

- Moderately elevated urea and nitrogenous waste, resulting in renal stress
- Hepatic stress evidenced by increased liver enzyme activity
- Dehydration risk through greater urinary output
- Loss of calcium and potential effect on bone health (but data conflicting)
- Being stored as fat, compromising body composition objectives

These dangers are increased if protein is added largely from supplements that lack micronutrients or where water consumption is poor [23].

Mechanism of Overconsumption of Protein:

Protein is needed for various physiological processes, especially in the case of resistance-trained people. Nonetheless, when taken in excess, especially as supplements, protein can be very taxing on the body's metabolism. Stress takes many forms, such as increased renal and hepatic load, endocrine changes, acid-base imbalances, and disturbed calcium homeostasis. Knowledge of these physiological processes is vital in avoiding the risks associated with bodybuilding-induced chronic protein overconsumption, particularly in an uncontrolled setup like the Pakistani gyms [24].

1. Elevated Metabolic Load:

When protein consumption surpasses the body's anabolic need for the production of muscle protein, tissue repair, and enzyme production, the surplus amino acids are neither stored nor utilized. Instead, they are broken down in the larger organs, the liver, through deamination to produce ammonia, which is processed to urea to be discarded by the kidneys.

The process has a number of metabolic implications:

- Production of urea increases renal excretory load.
- Excessive urinary nitrogen excretion can cause dehydration if fluid consumption is incommensurate with it.
- Increased hepatic enzyme activity can signify liver stress secondary to ongoing deamination and ureagenesis.

These activities are metabolically expensive and, with repeated exposure, can be stressful to liver and renal function, especially in those with underlying subclinical organ compromise or under-hydration [24].

2. Hormonal Changes:

Protein consumption influences the discharge of various hormones involved in the regulation of growth, metabolism, and nutrient homeostasis. Excessive protein intake, especially from rapid-absorbing sources such as whey, compromises normal hormonal control [24].

- **Insulin and IGF-1 (Insulin-like Growth Factor-1):**

Increased protein consumption, with BCAA-enriched supplements, triggers insulin secretion through elevated plasma amino acids (mainly leucine). Prolonged stimulation can:

- Increase anabolic signaling via the mTOR pathway to induce muscle growth.
- Increase levels of IGF-1, a powerful anabolic hormone that plays a role in cell growth and cell division.

Although ideal for muscle development, chronically high IGF-1 levels have been linked with higher risk for some cancers (e.g., prostate, colorectal), particularly when they are sustained for long durations without control [24].

- **Glucagon:**

Protein intake also causes the release of glucagon, which opposes insulin by elevating gluconeogenesis and lipolysis. In low-carbohydrate, high-protein diets, elevated levels of glucagon maintain blood glucose levels. But overstimulation can give rise to metabolic dysregulation, particularly if carbohydrate intake is restricted in reaction to an excess of protein [23,24].

3. Acid-Base Disturbance:

A second indirect, less-well-known effect of high protein consumption is its effect on acid-base balance. Animal protein specifically has sulfur amino acids (e.g., methionine, cysteine), which, when metabolized, produce acidic end-products like sulfate and hydrogen ions.

This results in:

- Increased acid load to the body, especially the kidneys.
- Benign metabolic acidosis, especially when intake is chronically high and not counteracted by alkaline foods (e.g., vegetables and fruits).
- Compensatory mechanisms such as urinary calcium excretion, hyper-respiration, and bone buffering.

This chronic but mild acid load over time may result in decreased bone mineral density, especially in those persons not ingesting sufficient dietary calcium or engaging in weight-class activities with very restricted diets [24].

Calcium Homeostasis:

An intake of high protein, especially of animal origin, can affect calcium metabolism in a number of ways:

- **Increased urinary excretion of calcium:** Calcium released from bone and eliminated by the kidneys during acid buffering.
- **Decreased calcium retention:** Maintenance of calcium balance may be disrupted by prolonged high-protein intake, particularly in low-calcium diets.
- **Possible risk of bone demineralization:** While controversial, chronic high-protein intake has been linked to reduced bone mineral density (BMD) in some research.

In Pakistani bodybuilders with already deficient calcium intake through diet because of low vegetable or dairy consumption, protein-caused loss of calcium can contribute to the risk of osteopenia or premature osteoporosis, especially in young gym enthusiasts who are not concerned about bone health for the sake of muscle size [24].

Short-Term Effects of Excess Protein Consumption:

Although protein is a useful nutrient for athletes and bodybuilders alike, excess consumption, particularly from supplements, is liable to bring about numerous short-term physiological disturbances. Most Pakistani bodybuilders, under the influence of inaccurate information or novice coaches, take protein in amounts much larger than their bodies could ever use. This supra-physiological intake will not result in acute chronic disease but can introduce certain acute effects on everyday well-being and training performance. These are generally missed or attributed to other causes, which postpones the necessary nutritional adaptation [25].

1. Gastrointestinal Disturbance:

One of the most frequent immediate consequences of surplus protein consumption is GI distress. This usually ensues as a result of both the amount of protein

ingested and quality—with poor-quality protein powders, artificial products, and absence of dietary fiber the culpable factors.

• **Bloating and Gas:**

High protein diets, particularly those with low fiber content and high contents of artificial sweeteners (more frequently seen in flavored protein powders), may lead to bloating, gas, and abdominal fullness. Increased protein in the colon is likely to lead to fermentation, yielding gases such as hydrogen and methane.

• **Diarrhea or Loose Stools:**

Some people develop diarrhea, especially after ingesting excessive amounts of whey protein isolate or mass gainers with considerable amounts of lactose or sugar alcohols (e.g., sorbitol, maltitol). In lactose-intolerant persons, a fairly prevalent disorder in South Asia, this is aggravated.

• **Constipation:**

Conversely, individuals who substitute protein shakes with balanced meals but forego fruits, vegetables, and whole grains can develop constipation through decreased water and fiber intake [25,26].

2. **Dehydration and Electrolyte Disbalance:**

Increased protein catabolism results in excessive urea and other nitrogenous wastes that need to be removed by the kidneys. This results in increased urine output and water loss, particularly when fluid replacement is imbalanced [26].

Dehydration can take the form of a state of fatigue, dry skin, muscle spasms, or dizziness.

Bodybuilders might be unaware of the relationship between protein overtraining and fluid imbalance,

especially in hot climatic regions such as Pakistan's, where sweating additionally leads to fluid loss.

Coupled with increased loss of urea and electrolytes (sodium, potassium, magnesium), this can cause electrolyte imbalance and impact muscle contraction, nerve transmission, as well as overall performance.

Dramatic imbalances, particularly with severe training or pre-contest dehydration, can lead to muscle spasms, headache, or irregular heartbeat [27].

3. **Short-term Weight Changes:**

One of the usual misinterpreted short-term effects of excessive protein consumption is the temporary illusory change in body weight, which can confuse or deceive bodybuilders who are monitoring their weight.

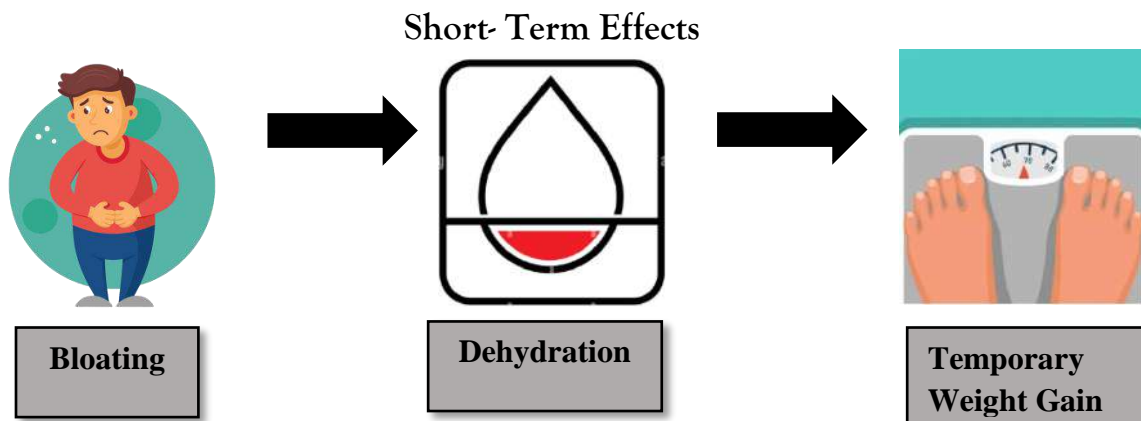
• **Alteration in Water Weight:**

Protein's increased metabolism causes excess urea production, which attracts water to the kidneys for its excretion, usually causing short-term water weight reduction. This can create an illusion of "leaning out," but is not indicative of fat loss.

Alternatively, high sodium or additives in some protein foods cause water retention with a resulting temporary weight and puffy increase [25].

• **Fluid and Muscle Glycogen Changes:**

With very high-protein, low-carbohydrate diets often used by bodybuilders, muscle glycogen levels can be reduced. Because water is drawn along with glycogen, depletion causes further loss of water that is responsible for abrupt decreases in weight that are falsely attributed to fat loss [25].



Short-term	Long-term
1-7 days	>3 Months

Source: Boettcher, E., & Crowe, S. E. (2013). Dietary proteins and functional gastrointestinal disorders. *Official journal of the American College of Gastroenterology* | ACG, 108(5), 728-736.

Long-Term Result of Excessive Consumption of Protein on Health:

Renal System Impact:

The kidneys are responsible for homeostasis, elimination of metabolic waste products, regulation of electrolytes, and control over fluid balance. The function most important in kidneys is the excretion of nitrogenous waste—mainly as urea, which is a byproduct of amino acid metabolism. When protein consumption exceeds anabolic requirements of the body, excess amino acids get catabolized for use elsewhere and increase urea production and thus put additional pressure on the renal system. Overdependence on protein consumption through food as supplements in the long run can thus be harmful to the kidney system, particularly by bodybuilders without medical oversight [26].

1. Hyperfiltration and Increased Glomerular Filtration Rate (GFR):

Protein diets sharply increase glomerular filtration rate (GFR) a state referred to as hyperfiltration. Although this is an adaptive, normal state in healthy persons, chronic hyperfiltration may:

- Cause chronic glomerular injury.
- Manufacture glomerular basement membrane thickening.
- Manufacture proteinuria (protein in urine), an early sign of renal stress or damage.

Within Pakistani gym environments, where long-term dietary patterns are unregulated and physician visits are infrequent, such insidious renal injury may go unnoticed until it reaches clinically meaningful levels [26].

2. Enhanced Nitrogenous Waste and Renal Workload:

During the breakdown of protein, the amino group (NH₂) is eliminated by deamination in the form of ammonia (NH₃), which is a poisonous substance.

Ammonia is converted to urea by the liver and excreted via the kidneys [25].

Consumption of high protein amounts results in:

- Enhanced production of urea.
- Enhanced urinary elimination of nitrogenous waste.
- Enhanced renal workload and urine production.

With time, this heightened demand on the kidneys has the potential to accelerate functional impairment, especially in those who have subclinical or undiagnosed kidney disease that is common in groups with poor access to healthcare or education [26].

3. Vulnerable Population Risk for Chronic Kidney Disease (CKD):

Although there is minimal evidence supporting that high-protein diets lead to chronic kidney disease in healthy people, evidence indicates that vulnerable groups such as:

- Individuals with established renal insufficiency
- Having hypertension, diabetes, or renal disease in their family,
- Or low fluid consumption and high use of supplements,
- Chances of CKD progression are significantly higher.

Many users of gyms and bodybuilders in Pakistan are not regularly medically screened, with poor hydration and high use of low-cost or fake supplements that can have contaminants that are harmful to renal function [24].

4. Dehydration and Concentrated Urine:

Protein metabolism increases urea concentration in urine, which needs higher water consumption to dilute and pass it in a proper manner. Failing this, it leads to:

- Concentrated urine,
- Increased risk of kidney stone formation (especially uric acid stones),
- Dehydration, in turn, placing further stress on the kidneys [23,24].

This is especially a problem during Pakistan's hot season, when fluid loss through sweat is high and water consumption might not be sufficiently sustained in athletes or bodybuilders attempting to "cut" for looks [25].

5. Possible Biomarker Changed Alterations:

Increased long-term protein consumption changes the important biomarkers of kidney function that are:

- Raised blood urea nitrogen (BUN),
- Raised serum creatinine,
- Changed glomerular filtration rate (eGFR)

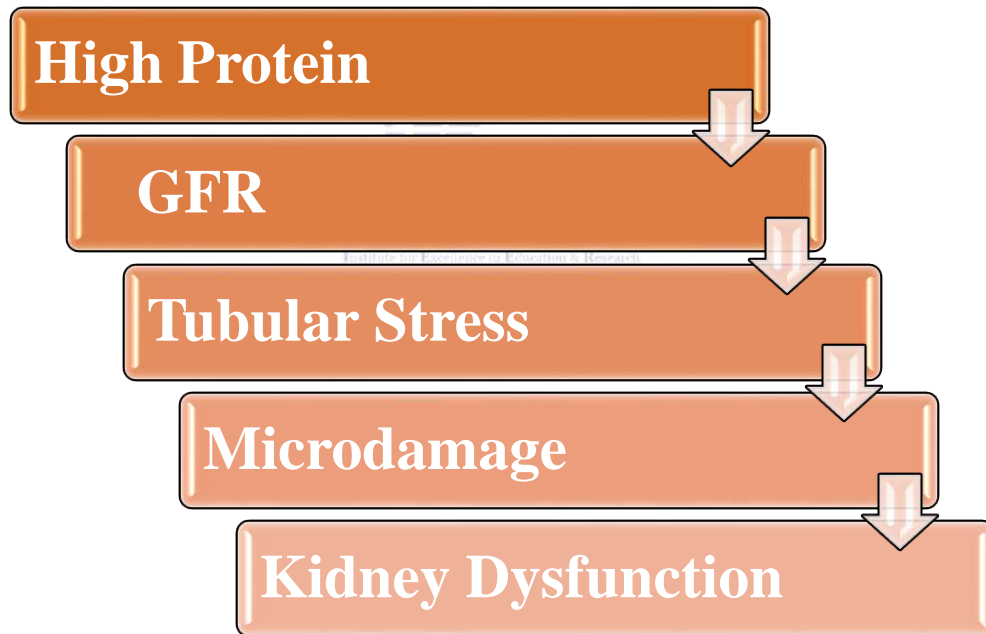
Although these biomarkers increase at times with augmented muscle mass or excessive training volume, chronically elevated levels could be an indication of renal compromise at the initial stage. In most of the

Pakistani gyms, though, these medical tests are never undertaken unless symptoms arise [25].

6. Absence of Medical Supervision and Precarious Behavior:

In Pakistan, the common lack of supervised intake of protein supplements and inadequate dietary variety, inadequate fluid consumption, and lack of clinical monitoring provide a high-risk situation for renal health. Most bodybuilders might not feel the early manifestations of kidney damage, like fatigue, swelling, or alterations in urination, until extensive harm is induced.

Additionally, the simultaneous use of other nephrotoxic substances; such as anabolic steroids, NSAIDs, or unrestricted fat burners, can potentially add to kidney stress when combined with a high-protein diet [26].



Source: Martin, W. F., Armstrong, L. E., & Rodriguez, N. R. (2005). Dietary protein intake and renal function. *Nutrition & metabolism*, 2(1), 25.

Hepatic Consequences:

The liver is the center of protein metabolism, ranging from deamination of amino acids to ammonia to urea conversion, gluconeogenesis, and plasma protein synthesis. Long-term excessive protein intake, particularly from the high-concentrate form of protein

supplements, can prove to be a heavy metabolic load on the liver. Although healthy livers are capable of supporting augmented burdens of protein in the short term, chronic excessive consumption does result in hepatic stress, liver enzyme changes, lipid deposition, and even liver dysfunction in extreme cases. These are of particular concern in the Pakistani bodybuilding

scenario, where excessive and unregulated supplementation of protein is prevalent and substandard or spurious supplements are widely available for use [27].

1. Rise in Hepatic Burden Due to Nitrogen Metabolism:

When dietary protein is higher than the anabolic requirement of the body, there is a necessity to catabolize excess amino acids. This is brought about by deamination, which is largely done in the liver, and gives off ammonia (NH₃); a toxic substance, which is then metabolized to urea via the urea cycle for renal excretion [27].

Chronic overnutrition increases:

- Deamination process and enzymatic demand,
- Urea formation, with additional hepatic and renal stress,
- Exposure to ammonia, which may cause hepatic encephalopathy risk to susceptible individuals.

While a healthy liver is able to support moderate increases, excess in the long term is certain to result in oxidative stress, inflammation, and elevated activity of liver enzymes, especially in persons with underlying hepatic pathology [28].

2. Liver Enzyme and Biomarker Alterations:

Enhanced intake of protein, especially from dietary supplements containing additives or contaminants, is certain to result in:

Elevation of:

- Alanine aminotransferase (ALT),
- Aspartate aminotransferase (AST),
- Alkaline phosphatase (ALP),
- Gamma-glutamyl transferase (GGT).

These spikes are reflective of hepatic stress or mild hepatocellular damage. Although these are generally subclinical and correctable with diet alone, chronic exposure, in the anabolic steroid abuser, in hepatotoxic supplements, or alcohol, may lead to chronic liver damage [28,29].

3. Risk of Non-Alcoholic Fatty Liver Disease (NAFLD):

Though high-protein diets are generally linked to enhanced body composition, excessive protein consumption, particularly with concomitant high overall caloric intake and poor fiber content, is

associated with hepatic steatosis formation (fat storage in the liver). This is more likely to occur when:

- The animal proteins utilized are high in saturated fat,
- In conjunction with very low activity levels during off-seasons,
- Or in conjunction with processed supplements containing too much sugar or fillers [28].

New animal evidence shows that long-term consumption of high-protein diets may lead to:

- Lipid accumulation in the liver,
- Hepatocyte insulin resistance,
- Mitochondrial damage and oxidative stress,
- Enhancing the risk of non-alcoholic fatty liver disease (NAFLD) or non-alcoholic steatohepatitis (NASH) [29].

4. Hepatotoxicity from Contaminated or Poor-Quality Supplements:

In countries like Pakistan, developing nations, the vulnerability to hepatotoxicity is enhanced with the lack of regulation on the supplement industry. Imported and locally produced protein powders may:

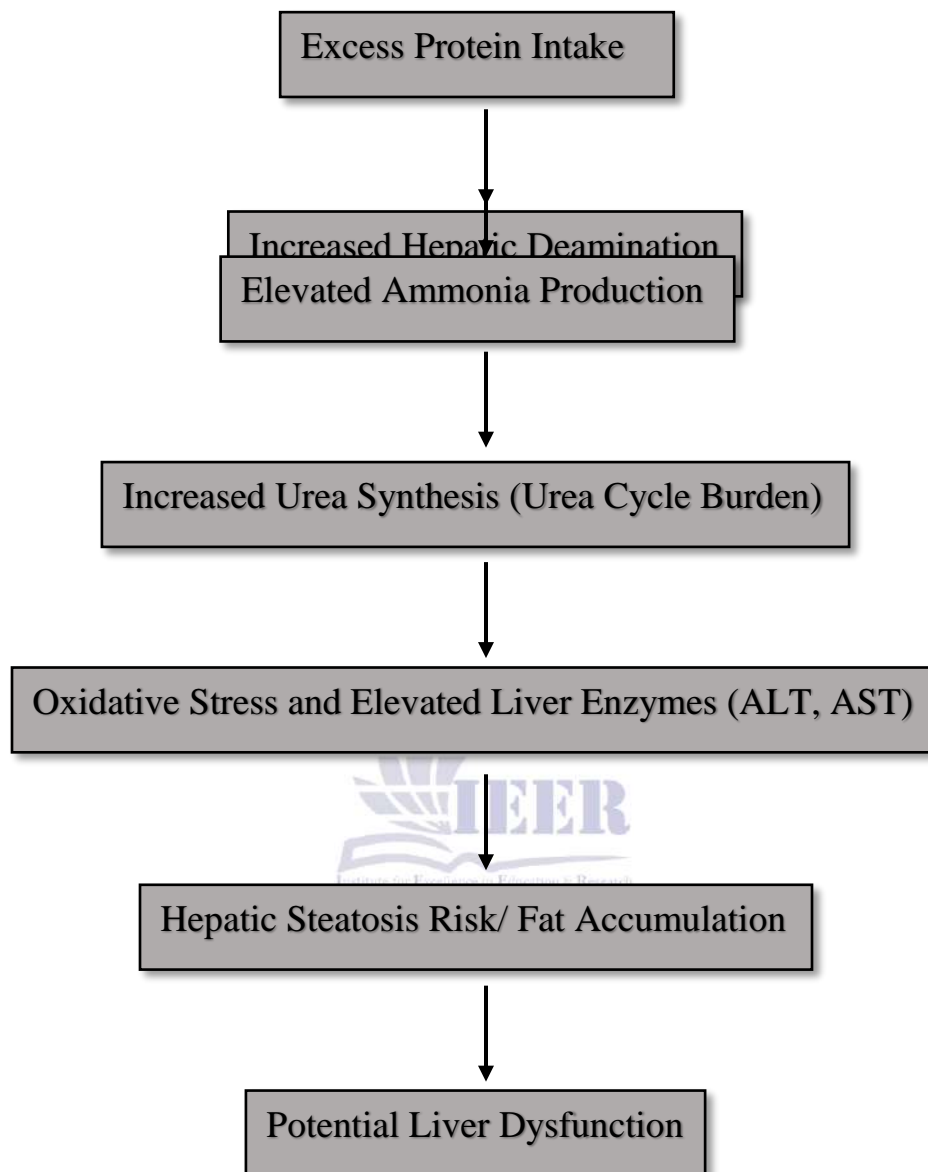
- Carrying heavy metals (e.g., lead, arsenic),
- Contaminated with illicit steroids, stimulants, or unlabeled drugs,
- Carrying synthetic amino acids or preservatives that are toxic after extended exposure.

There have been reports of acute liver damage and transaminitis following ingestion of "mass gainers", some of which contain high concentrations of local anesthetics, antidepressants, or antihistamines that are present unlabeled [29].

5. Liver Stress and Coincident Risk Factors:

A number of factors can increase hepatic stress in protein-overloading bodybuilders:

- Anabolic steroid misuse, which is hepatotoxic on its own.
 - Dehydration, which decreases hepatic and renal clearance.
 - Cutting or fasting intervals, which might deprive other nutrients responsible for liver detoxification.
 - Alcohol consumption, which, when combined with excessive protein, places further hepatic burden.
- These concurrent activities are prevalent in gym settings far from professional feedback, subjecting livers to damage even among adolescents [29].



Source: Kondrup, J., & Müller, M. J. (1997). Energy and protein requirements of patients with chronic liver disease. *Journal of hepatology*, 27(1), 239-247.

Cardiovascular Effects:

It is generally most frequently prescribed to bodybuilders in their bid to provide muscle synthesis, weight retention, and lean body mass. Nevertheless, chronic excess protein consumption, especially from animal sources and processed foods, has long-term cardiovascular effects with multifaceted clinical implications [29]. Although adequate protein consumption has neutral or even protective effects on

the cardiovascular system, high levels and frequent intake, particularly in the framework of unbalanced diet and inadequate controlled supplementation, can produce undesirable cardiovascular events. It is especially important in Pakistan, where professional nutritional guidance is not typically accessible to most bodybuilders and, occasionally, excessive amounts of animal protein and protein powder are freely used [30].

1. Effect on Lipid Profile:

Among the most important long-term cardiovascular diseases associated with high-protein diets, particularly those that include high red meat, full-fat dairy, or animal-derived protein powders, is the modification of blood lipid profiles.

High intakes of saturated fats of animal proteins have a tendency to raise low-density lipoprotein (LDL) cholesterol, a proven risk factor for atherosclerosis [30]. Certain high-protein diets tend to lower high-density lipoprotein (HDL) levels, impairing the body's ability to eliminate excess cholesterol.

Raised triglycerides can also result from excess protein consumption coupled with too much caloric or fat intake.

These lipid profile changes are linked to augmented long-term risk for coronary artery disease (CAD), stroke, and hypertension [31].

2. Atherosclerosis and Arterial Stiffness:

Another of the main worries with regard to excessive animal protein intake is the development of atherosclerosis, a condition when plaques get deposited in the arterial walls. Recent evidence indicates that:

Excessive consumption of red meat and processed meat has the potential to enhance the concentration of trimethylamine N-oxide (TMAO), an intestinal microbial metabolite which promotes arterial inflammation and plaque [31].

Excess insulin and IGF-1 signaling (usually triggered by reactive protein and amino acids) has the potential to stimulate proliferation of smooth muscle cells in the arteries, leading to thickening and hardening of the arteries.

These changes in the vasculature can predispose to hypertension and heart failure with the passage of time, particularly with coexistent risk factors such as stress,

dehydration, or poor sleep, sadly, too common among competitive bodybuilders [31].

3. Stress and Vascular Health:

High-protein diets can have the short-term effect of lowering blood pressure through enhanced satiety and weight loss. Long-term intake, particularly in combination with low potassium, high sodium (processed), and low fiber, can potentially:

- Contribute to endothelial dysfunction, with resultant impaired blood vessel dilation.
- Contribute to chronic low-grade inflammation, influencing vascular tone and reactivity.
- Increase risk for essential hypertension in genetically susceptible individuals.

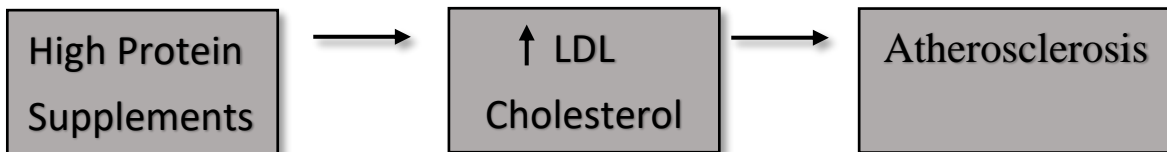
In the Pakistani setting, low dietary diversity (infrequent use of fruit and vegetables), poor hydration, and poor awareness of the sodium content in supplements may lead to blood pressure dysregulation [31].

4. Supplements' Contaminants and Cardiovascular Risk:

Unregulated supplements can contain:

- Stimulants (synephrine, excessive caffeine),
- Steroid contaminants,
- Heavy metals (lead, mercury),
- all of which are cardiotoxic in effect. They consist of acceleration of heart rate, rise in blood pressure, arrhythmias, and cardiomyopathy or sudden cardiac event in the most severe cases.

Case reports have occurred to blame association between such contaminated supplements with myocardial infarction and sudden cardiac death, particularly when high-level exercise is involved [31].



Source: Vega-López, S., & Lichtenstein, A. H. (2005). Dietary protein type and cardiovascular disease risk factors. *Preventive cardiology*, 8(1), 31-40.

Gastrointestinal Tract Effects:

Protein is a macronutrient, though long-term excessive use, particularly of concentrated or isolated

supplements, is potentially GI-damaging [32]. Bodybuilding is prevalent among Pakistani communities where they consume excess amounts of protein powders, mass gainers, and meat-based high-protein foods with low dietary fiber, water intake, or professional advice. While acute effects such as diarrhea and bloating are primarily reported, the potential long-term gastrointestinal effect is less known with consequences for digestive efficacy, gut microbiota, and metabolic disease [33].

1. Changes in Gut Microbiota Composition:

A healthy gut microbiome is critical to digestion, immunity, and nutrient uptake. Regular excessive protein consumption, particularly from animal protein or fiber-free supplements, compromises microbial equilibrium by:

- Favoring the proliferation of putrefactive bacteria (e.g., Clostridium, Bacteroides) that ferment unabsorbed protein in the colon,
- Decreasing beneficial short-chain fatty acid (SCFA) producers like Lactobacillus and Bifidobacterium,
- Forming toxic byproducts such as ammonia, phenols, indoles, and hydrogen sulfide.

This imbalance of microbes, also referred to as dysbiosis, is linked with higher risks of:

- Irritable bowel syndrome (IBS),
- Inflammatory bowel disease (IBD),
- Colorectal cancer over long durations [32].

2. Increased Intestinal Permeability ("Leaky Gut"):

Protein fermentation by the colonic bacteria may result in the production of toxic metabolites in the colon. Toxins have the ability to cause inflammation of the intestinal lining and impairment of tight junctions between epithelial cells, leading to increased intestinal permeability.

A "leaky gut" permits endotoxins (e.g., lipopolysaccharides) and antigens to enter systemic circulation, which has the potential to lead to:

- Chronic low-grade inflammation,
- Autoimmune reactions,
- Food hypersensitivities.

This state, if persistent, is the etiology of systemic states such as metabolic syndrome and chronic fatigue—both

of which have the potential to influence athletic performance [32,33].

3. Constipation and Decreased Bowel Motility:

Diet high in protein tends to replace in foods fiber-containing foods such as fruits, vegetables, and whole grains. Inadequate fiber:

- Reduces stool bulk,
- Shortens transit time,
- Increases constipation.
- Chronic constipation may lead to:
 - Hemorrhoids,
 - Diverticulosis,
 - Abdominal distension and cramps,
 which can impact quality of life and athletic performance.

In the Pakistani bodybuilding subculture, in which protein consumption is generally low and diet is meat-dominated, this is a common but hidden occurrence [33].

4. Gastrointestinal Disorder Risk:

High-protein diet over an extended period has been accused of an increased prevalence of various gastrointestinal disorders, such as:

- Gastroesophageal reflux disease (GERD),
- Functional dyspepsia,
- Gastritis, especially where protein consumption is followed by repeated consumption of NSAID or stimulants.

Additionally, in the lactose-intolerant (which is prevalent among South Asians), overuse of whey protein, particularly non-isolate types, will result in ongoing gastrointestinal discomfort and bloating [33].

Skeletal System and Bone Health:

Protein plays a role in the formation and bone remodeling by its facilitation of collagen synthesis, calcium absorption, and maintenance of muscle mass. However, overconsumption in the long term—specifically not compensated for by adequate intake of alkalizing compounds such as calcium, potassium, and magnesium—may prove to be harmful to bones. To Pakistani bodybuilders, high-protein, low-carbohydrate, and sometimes low-vegetable diets with over-reliance on protein supplements can inadvertently elevate long-

term skeletal risks such as loss of calcium, reduced bone mineral density (BMD), and osteoporosis [33].

1. Loss of Calcium and Increased Urinary Calcium Excretion:

Among the main issues with excess protein consumption is its effect on rising urinary loss of calcium. During the metabolism of excess amounts of food protein, mainly sulfur amino acids such as methionine and cysteine, an excess of sulfuric acid is released, contributing to the body's acid load [34].

As a counter for this acid:

- Bone calcium is mobilized into the circulation.
- This leads to excessive loss of calcium in urine.

Chronic calcium insufficiency has been found to weaken the bone density, particularly in subjects with low dietary calcium intake, which is a prevalent situation among South Asians.

Consumption of high protein without sufficient calcium has been found to increase bone resorption and hence osteopenia or osteoporosis, particularly with increasing age in sports individuals or decreasing level of activity [34,35].

2. Acid Load and Bone Resorption Mechanism:

Acid-ash hypothesis proposes that dietary proteins raise the body's acid load, which has to be buffered to keep the body at physiological pH. Without sufficient sources of alkalis (such as vegetables and fruits), buffering is performed by the bones by releasing alkaline minerals like calcium, magnesium, and phosphate.

The process entails:

- Activation of osteoclasts for bone matrix resorption.
- Release of calcium carbonate to buffer systemic acidity.
- Increased bone resorption and turnover in long-term high-protein conditions.

While resistance exercise typically enhances BMD, excessive protein consumption, particularly from acid foods such as red meat and supplements, in the absence of sufficient buffer minerals has the opposite effect, enhancing the long-term risk of bone brittleness [35].

3. Osteoporosis and Fracture Risk:

In the long term, mobilization of calcium from bone in response to reduced absorption of calcium (resulting

from insufficiency of vitamin D or excess phosphate intake from supplements) can lead to:

- Loss of open bone architecture trabecular bone,
- Reduced BMD,
- Osteoporosis risk is enhanced, particularly in elderly or hormone-imbalanced subjects (e.g., testosterone suppression from steroid use).

In Pakistan, where there is not typically proper sun exposure (for vitamin D production) and milk consumption may be restricted, the risk is even higher. In addition, the majority of bodybuilders do not consume sufficient amounts of alkaline foods such as green vegetables, fruits, or whole grains necessary to balance the acid load [35].

Hormonal and Reproductive Consequences:

Protein is an important component in hormone production and endocrine function. Yet, when taken in excess, particularly from animal products and isolated supplements, it can potentially cause hormonal imbalance in the long term. In bodybuilders, where excessive protein use is frequently combined with intense training, low-carb diets, or the use of performance-enhancing drugs, the long-term hormonal and reproductive consequences can be considerable [36].

1. Testosterone Alterations:

Testosterone is essential for muscle growth, sex drive, mood, and fertility. Though normal protein consumption is conducive to testosterone production, extremely high protein intakes, particularly under carbohydrate and fat restriction, will inhibit endogenous testosterone production due to:

- Decreased insulin and leptin signaling,
- Chronic energy deficit,
- Excess cortisol (stress hormone) from rigorous training and protein metabolism.

Other research indicates that very high protein consumption with inadequate caloric consumption or fat reduces free testosterone, impacting muscle healing and reproductive status [36].

2. Estrogen and Hormonal Disruption:

Overconsumption of animal protein can affect estrogen metabolism by:

- Modifying liver enzyme function, which impacts hormone clearance,

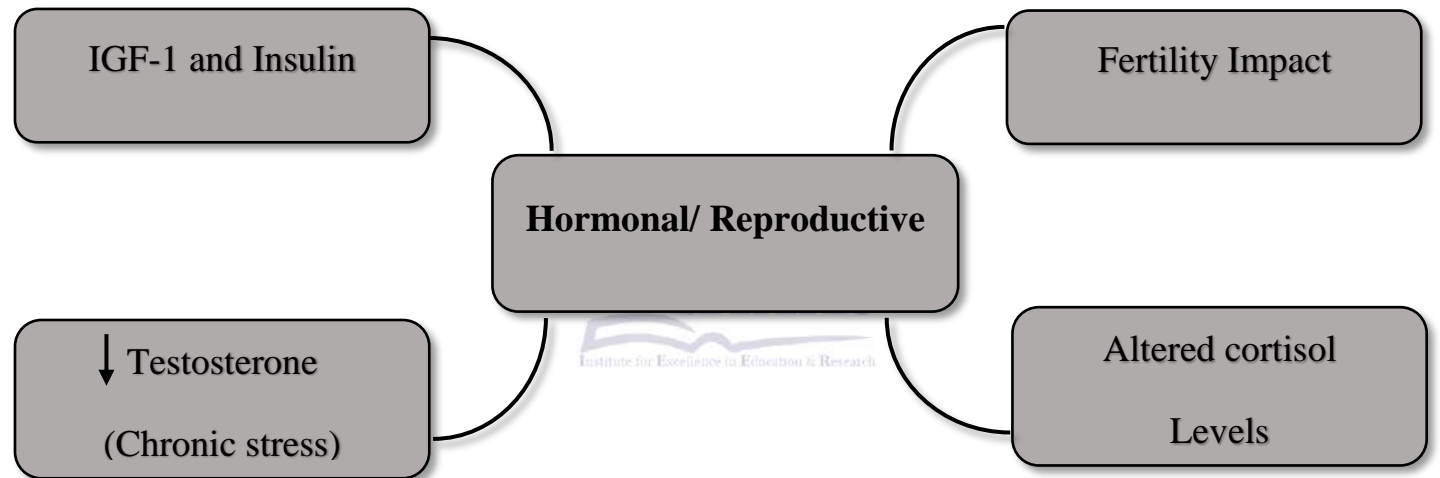
- Attacking the gut microbiota, which regulates estrogen reabsorption through the enterohepatic circulation.

In men, this may result in estrogen dominance 4. symptoms (e.g., gynecomastia, weight gain), particularly when compounded by uncontrolled supplement use or anabolic steroid use [37,38].

3. Enduring Cortisol and Catabolic Effects:

High-protein, low-carbohydrate diets, which many bodybuilders adopt, can stimulate chronically increased levels of cortisol, the main catabolic hormone. Enduring high cortisol levels:

- Induce muscle loss,
- Suppress testosterone production,
- Undermine sleep, mood, and immune function.



Source: Kalman, D., Feldman, S., Martinez, M., Krieger, D. R., & Tallon, M. J. (2007). Effect of protein source and resistance training on body composition and sex hormones. *Journal of the International Society of Sports Nutrition*, 4(1), 4.

Comparative Analysis: Protein Diet and Protein Supplements:

Nutrient Content and Bioavailability:

Protein from whole foods such as eggs, dairy, meat, legumes, and nuts contains a broad range of nutrients as well as amino acids such as vitamins (e.g., B12), minerals (e.g., iron, zinc), and dietary fiber (in plant foods). These play a role in metabolic health, digestion,

This imbalance can compromise physical performance and reproductive hormone control in the long term [36,37].

Effects on Fertility and Reproductive Function:

Hormonal imbalances due to excessive protein intake, inadequate fat consumption, or contaminant effects of supplements may influence:

- Spermatogenesis and male sperm quality,
- Ovulation and menstrual cyclicality in women,
- General fertility as a result of suppression of hormonal axes.

In Pakistan, lack of awareness about these potential hazards and lack of regulation over supplement use could result in silent reproductive morbidity among young athletes [37].

and overall health. Whole foods yield high-biological-value protein and superior absorption patterns. Conversely, protein foods such as whey, casein, and soy isolates are absorbable and convenient but deficient in many micronutrients present in whole foods. Although beneficial after exercise or with high-demand activity periods, excessive dependence on them will lead to nutrient imbalance and gut stress when used as meal replacements [38].

Feature	Whole Food Protein	Supplements
Nutrient synergy	Yes	No
Absorption rate	Moderate	Fast
Fiber/ Vitamins	High	Low
Cost	Low	High

Source: Cintineo, H. P., Arent, M. A., Antonio, J., & Arent, S. M. (2018). Effects of protein supplementation on performance and recovery in resistance and endurance training. *Frontiers in nutrition*, 5, 400140.

Recommendations for Safe Use of Protein Supplements:

Protein supplements must be consumed moderately and based on one's need, not more than 2 g/kg body weight daily. Whole foods must always take precedence over protein, and supplements must be consumed following exercise or during times of reduced food intake. Only quality products must be consumed to prevent harmful additives. Bodybuilders should consume plenty of fluids, eat a balanced diet, and have regular health check-ups to ensure kidney and liver function. Professional guidance is highly recommended in order to use it safely and successfully [39].

Research gap:

There is limited data on long-term health effects of high protein supplement consumption, especially in developing nations such as Pakistan. Population-based data accounting for regional diet, type of supplement, and bodybuilding training culture should be the direction of future research.

There is an urgent need for longitudinal clinical trials to determine over time; namely kidneys, liver, cardiovascular system, and hormonal axis, the effect of long-term consumption of high protein. Comparative studies of food and supplement sources of protein also will identify relative risks and benefits.

Investigating the microbiome changes, immune response, and reproductive health implications of excessive protein intake will also complete the knowledge gaps. Finally, public health-focused investigation shall be utilized for establishing gaps in knowledge, abuse patterns, and regulatory status of supplements found within the domestic market.

Such information will be invaluable in guiding policy, directing safe practice, and designing education programs for players and coaches within Pakistan [40].

Conclusion:

Protein is a macronutrient that performs a crucial role in muscle building, recovery, and athletic performance of bodybuilders and athletes. Excessive intake of protein (mostly supplements) has gone through a

massive surge fueled by the consideration that "more is better" to gain muscle quickly in recent years. This trend has accelerated at a really quick rate in Pakistan with support from social media, peer pressure, absence of expert nutritional advice, and easy availability of unregulated protein products.

This article brings to the forefront the serious medical issues that are linked with long-term protein overconsumption, particularly among Pakistani bodybuilders. Although excess in the short term will not right away be anything negative, excess over an extended duration impacts numerous organ systems. These include the negative impacts on the renal and hepatic systems, gastrointestinal changes, cardiovascular stress, bone demineralization, hormonal disruption, and reproductive impairment. These all worsen when the supplements are taken in excess or combined with poor hydration, poor dietary fiber, and poor macronutrient balance.

The contrast between whole food protein and protein supplements also underscores the importance of nutrient synergy to health. In contrast to whole foods, supplements contain no obligatory micronutrients and potentially carry hidden threats from pollutants or excessive additives. Medical or dietary counsel is avoided by bodybuilders, elevating the threat of subtle, cumulative damage to health.

For all of these issues, enhanced awareness, health education, and rigid control of protein supplement quality are sorely required in Pakistan. Bodybuilders must be advised along with evidence-based recommendations on protein intake, prioritize whole foods, and take advice from professionals according to their training and health status. Regular monitoring of renal, liver, and hormonal function is also necessary for those who consume high doses of protein for extended periods.

Briefly, though protein is still a staple of sports diets, moderation is the watchword. Balanced eating, well-informed choosing, and nationwide public information

campaigns can prevent the gain of protein's advantages being made at the cost of long-term health.

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