A Comprehensive Clinical Evaluation of GlyNAC Supplementation: Stoichiometric Dosage Validation and Multi-Systemic Physiological Impact in the Geriatric Population

The biological imperative to address the progressive decline of physiological function in the elderly has led to the emergence of glutathione (GSH) restoration as a primary therapeutic target in modern geroscience. As the human body undergoes senescence, it experiences a systemic shift in its redox balance, characterized by the accumulation of reactive oxygen species (ROS) and a concomitant failure in the synthesis of endogenous antioxidants. Central to this failure is the depletion of intracellular glutathione, a tripeptide consisting of glutamic acid, cysteine, and glycine, which serves as the premier guardian of cellular integrity and mitochondrial efficiency.[1] While glutathione deficiency has long been observed in older adults, contemporary research, primarily led by investigators at institutions such as the Baylor College of Medicine, has elucidated that this deficiency is not an inevitable consequence of aging but rather a result of diminished precursor availability, specifically the amino acids glycine and cysteine.[3] The supplementation strategy known as GlyNAC—the co-administration of glycine and N-acetylcysteine (NAC)—represents a stoichiometric intervention designed to bypass these metabolic bottlenecks, thereby restoring youthful levels of GSH and correcting multiple hallmarks of aging.[4]

The Stoichiometric Rationale for GlyNAC Dosage and Protocol

The clinical efficacy of GlyNAC is fundamentally tied to the precision of its dosage and the subsequent availability of its constituent precursors. In traditional clinical settings, NAC has been utilized primarily as a mucolytic agent or as an antidote for acetaminophen toxicity, typically at doses ranging from $600~mg$ to $1,800~mg$ daily.[6] However, the geroscience paradigm for GSH restoration requires significantly higher concentrations to overcome the chronic synthetic deficits seen in the elderly. The research materials indicate a primary clinical protocol utilizing $100~mg/kg/day$ of each component.[3] For a standard adult weighing 70 to $80~kg$, this translates to a daily intake of $7,000$ to $8,000~mg$ of glycine and $7,000$ to $8,000~mg$ of NAC.[4]

A critical refinement of this protocol appears in more granular metabolic studies, which distinguish between weight-based dosing and molar-based dosing. Some evidence suggests

that the optimal ratio may involve $1.33~mmol/kg/day$ of glycine and $0.81~mmol/kg/day$ of cysteine, provided in the form of NAC.[8] Given that NAC is approximately 74% cysteine by weight, this stoichiometric adjustment results in a dosage of approximately $100~mg/kg/day$ of glycine paired with approximately $133~mg/kg/day$ of NAC.[8] While the $100/100$ protocol has demonstrated profound success in correcting GSH deficiency, the $100/133$ ratio may offer a more precise alignment with the daily metabolic requirements of cysteine and glycine in older individuals, particularly those with significant oxidative burdens.[3]

Comparative Analysis of GlyNAC Dosing Regimens

The following table contextualizes the various dosing tiers observed across the limited but rigorous body of research, identifying the threshold for functional restoration.

Dosing Tier	Total Daily Active Intake (Combined)	mg/kg/day (Approximate)	Primary Observations
Low Dosage	$2.4~g$	$15-20~mg/kg$	Generally insufficient to raise systemic GSH in healthy cohorts.[9]
Medium Dosage	$4.8~g$	$30-35~mg/kg$	Effective in subgroups with high baseline oxidative stress and low GSH.[9]
Standard Clinical	$7.2~g$	$45-50~mg/kg$	Safe and well-tolerated; serves as the lower boundary for observed efficacy.[10]
Therapeutic High	$14-16~g$	$100~mg/kg$	Corrects GSH deficiency to youthful levels; reverses aging hallmarks.[1]
Stoichiometric Peak	$18-20~g$	$100/133~mg/kg$	Aligns with the $1.33/0.81$ molar ratio for optimized precursor delivery.[8]

The necessity of high-gram dosing is underscored by findings that GSH synthesis in older adults is impaired by approximately 66% compared to young adults.[12] Lower doses, while providing some antioxidant support, may fail to satisfy the cellular demand required for the comprehensive restoration of mitochondrial function and the suppression of systemic inflammation.[4] Therefore, the recommendation for older adults (age $50+$) seeking significant healthspan benefits is to target the $100~mg/kg/day$ threshold for both

compounds, ensuring that the intervention transitions from mere supplementation to biological correction.

Metabolic and Molecular Mechanisms of Action

The mechanism of action for GlyNAC is rooted in the "Power of 3" paradigm, which asserts that the combined benefits of glycine, NAC, and the synthesized glutathione are greater than the sum of their parts.[14] Glutathione synthesis is a two-step process. In the first step, the enzyme glutamate-cysteine ligase (GCL) facilitates the condensation of glutamate and cysteine to form γ-glutamylcysteine. In the second step, glutathione synthetase (GS) adds glycine to the dipeptide to complete the GSH molecule.[16] Because glutamate is typically abundant in the human diet, the availability of glycine and cysteine remains the limiting factor for synthesis. Older adults exhibit a marked reduction in the activity of these enzymes and a concomitant decrease in the intracellular pool of these precursor amino acids.[3]

Restoring Mitochondrial Integrity and Fuel Oxidation

Mitochondrial dysfunction is a central hallmark of aging, leading to decreased energy generation and the accumulation of lipid peroxides. GSH adequacy is critically important for optimal and efficient mitochondrial fatty-acid oxidation (MFO).[18] Older adults often suffer from metabolic inflexibility, where the mitochondria lose the ability to switch effectively between carbohydrate and lipid fuels, as evidenced by a higher fasting respiratory quotient (RQ).[3] Supplementation with GlyNAC for 16 weeks has been shown to normalize the RQ from a baseline of 0.85 to 0.77, a value that aligns with young adult levels.[20] This shift indicates a 78% upregulation in MFO, allowing the cells to efficiently utilize stored fat for energy while sparing glucose pathways.[13]

Furthermore, GlyNAC influences nutrient-sensing pathways that are frequently dysregulated in aging. Evidence suggests that GlyNAC supplementation trended favorably toward improving mitochondrial regulators such as $PGC-1\alpha$ and increasing $AMPK$ phosphorylation.[4] By improving the redox status, GlyNAC appears to alleviate the oxidative stress that inhibits these master regulators of metabolic health, thereby fostering an environment conducive to mitochondrial biogenesis and mitophagy—the selective clearing of damaged mitochondria.[13]

The Role of Glycine as a Bioactive Substrate

While NAC is often highlighted for its role as a cysteine donor, glycine’s contribution to the GlyNAC protocol is equally multi-faceted. Beyond GSH synthesis, glycine serves as a key component in collagen synthesis and act as an inhibitory neurotransmitter in the central nervous system.[17] Clinical studies have shown that high-dose glycine (up to $10~g/day$) is necessary to support optimal collagen production, which may assist in maintaining joint integrity and cartilage health in the elderly.[25] Moreover, glycine's anti-inflammatory properties and its ability to act as a physical barrier in the extracellular matrix provide additional defense against viral infections and tissue damage.[25] In obese cohorts, glycine supplementation alone

has been shown to reduce plasma triglycerides and improve liver transaminases, suggesting that the glycine component of GlyNAC independently contributes to the correction of metabolic syndrome and non-alcoholic fatty liver disease.[26]

Physiological and Functional Outcomes: Correcting the Hallmarks of Aging

The impact of GlyNAC supplementation on functional outcomes in older adults is robust and encompasses a wide spectrum of physical and cognitive markers. Randomized clinical trials involving adults with a mean age of approximately 71 have demonstrated that 16 to 24 weeks of GlyNAC supplementation can improve or even reverse several age-associated defects.[3]

Physical Performance and Sarcopenia Mitigation

One of the most clinically relevant findings in the Sekhar trials is the improvement in gait speed. Gait speed is widely considered a "sixth vital sign" in geriatrics, as it is a strong predictor of survival and functional independence.[1] After 16 weeks of GlyNAC, the gait speed of older participants increased to match the levels seen in young adults.[1] This improvement is likely the result of a synergistic effect: reduced oxidative stress in the muscles, improved mitochondrial energy production, and decreased systemic inflammation.[26]

Performance Marker	Observed Improvement in OA	Comparison to YA Baseline
Gait Speed	Significant Increase	Matched YA [13]
Grip Strength	Significant Increase	Improved toward YA [4]
6-Minute Walk Distance	Trending Improvement	Improved toward YA [1]
Lower Extremity Strength	4-Fold Improvement (Chair Rise)	Improved significantly [13]
Muscle GSH Levels	$+164\%$	Matched YA [12]

The mitigation of sarcopenic obesity is another notable outcome. GlyNAC has been shown to decrease waist circumference and total body fat modestly, even in the absence of caloric restriction.[3] This effect is likely mediated by the restoration of fatty acid oxidation and the improvement in insulin sensitivity.[13] In rodent models, NAC has also been shown to attenuate muscle fiber branching and splitting, which are pathological signs of dystrophic muscle wasting.[30] In humans, GlyNAC appears to promote muscle health by increasing muscle stem-cell markers such as $PAX7$ and reducing muscle protein breakdown rates.[4]

Cognitive Function and Neuroprotection

Cognitive decline is a primary concern in the aging population, and the pilot trials for GlyNAC show promising neuroprotective effects. In a 24-week study, older adults exhibited significant improvements in cognitive scores, specifically in the MOCA (Montreal Cognitive Assessment),

Trails A and B, and Digit-Symbol Substitution tests.[4] These improvements are thought to be driven by the reduction in oxidative damage within the hippocampus and the normalization of tau phosphorylation and amyloid peptide oligomerization—biomarkers typically associated with Alzheimer's disease.[17] By enhancing GSH synthesis in the brain, GlyNAC may provide a defense against the neuro-inflammation that drives dementia and age-related memory impairment.[5]

Clinical Validation of Safety and Potential Contraindications

The safety profile of GlyNAC at high doses is a subject of significant scrutiny, particularly given the discrepancy between clinical research doses and general regulatory recommendations. While bodies such as the RIVM suggest a maximum daily NAC intake of $1,200~mg$ for the general public, the Sekhar trials utilized nearly seven times that amount without reporting severe adverse effects.[1]

Gastrointestinal Tolerance and Bioavailability

NAC is an FDA-approved drug with a well-established safety profile, but its oral bioavailability is notoriously low—often estimated at less than 10%.[32] High doses are frequently necessary to ensure that sufficient cysteine reaches the plasma and tissues to drive GSH synthesis. The most common side effect reported at these high levels is gastrointestinal distress, including nausea, vomiting, and abdominal discomfort.[7] These symptoms are typically dose-dependent and often resolve upon splitting the daily intake into two or more doses or taking the supplement with meals.[4] In the lupus trial using $4.8~g/day$ of NAC, a small percentage of participants discontinued due to heartburn and nausea, suggesting that the upper limit of comfort may vary significantly between individuals.[33]

Organ Function and Renal Health

Concern regarding the impact of multi-gram glycine and NAC on kidney and liver function has been addressed in multiple human trials. Comprehensive safety panels in older adults showed no adverse changes in liver enzymes (ALT, AST) or renal markers (Creatinine, BUN) after months of supplementation.[4] In fact, NAC may have a renoprotective effect; in patients with chronic kidney disease (CKD), NAC was found to improve estimated glomerular filtration rates ($eGFR$) and reduce cardiovascular events.[35] Similarly, glycine is naturally excreted by the kidneys, and high-dose studies have shown no biochemical evidence of increased risk for renal lithiasis (kidney stones) in healthy volunteers.[24]
However, the protocol must be cautious regarding specific populations:

- **Cystinuria:** Individuals with this genetic disorder, which predisposes them to cystine stones, should exercise caution, as NAC interacts with the sulfur-containing amino acid pathways.[7]
- **Severe Organ Impairment:** Those with end-stage renal disease ($ESRD$) or severe

liver cirrhosis exhibit significantly altered pharmacokinetics for NAC, including a half-life that can be 13 times longer than healthy controls.[32] Dosages in these populations must be strictly managed by medical professionals.

The Oncological Context: Antioxidants in Cancer

The role of antioxidants in cancer remains one of the most debated topics in metabolic pharmacology. While antioxidants protect healthy cells from DNA damage, they may inadvertently support the survival of existing tumor cells.

- **Promotion of Metastasis:** Studies in mice and human lung cancer cell lines have suggested that antioxidants like NAC can reduce the expression of the tumor suppressor protein $p53$, potentially accelerating the growth of early lung tumors and doubling the rate of melanoma metastasis.[38]
- **Chemoprevention:** Conversely, a large multivariate Cox regression analysis of $COPD$ patients found that long-term NAC use was associated with a 31% *lower* risk of developing certain cancers, including colorectal and breast cancer.[41]
- **Synthesis:** The current consensus recommends that individuals with active cancer or high risk (e.g., heavy smokers for lung cancer) should avoid high-dose antioxidant supplements, as they may protect undetectable micro-metastases from oxidative stress.[38] However, for the general aging population, the reduction in genomic damage (measured by $8-OHdG$ and $\gamma H2AX$) achieved by GlyNAC may serve a preventative role against the initiation of tumorigenesis.[4]

The Interference Effect: GlyNAC and Exercise Adaptations

A secondary concern for the geriatric population involves the "interference effect"—the possibility that high-dose antioxidants might blunt the adaptive response to exercise. Since ROS serve as signaling molecules that trigger muscle hypertrophy and mitochondrial biogenesis following a workout, excessively neutralizing them could theoretically reduce the benefits of resistance training.[43]

Research on this topic is conflicting. Some studies suggest that NAC can negatively affect muscle adaptations to training by disrupting the skeletal muscle's repair and remodeling process.[45] For instance, a meta-analysis found no clear evidence of performance benefits from NAC in elite athletes and noted that it could blunt the inflammatory signals required for maximal hypertrophy.[44]

However, in the context of the older adult, the situation is markedly different. Older adults already suffer from "anabolic resistance" and chronic "inflammaging," where the baseline oxidative stress is so high that it impairs muscle function and insulin sensitivity independently of exercise.[27] For this population, GlyNAC appears to be ergogenic. By reducing the excessive oxidant burden, GlyNAC improves muscle strength and gait speed significantly compared to placebo.[13] A recent meta-analysis concluded that while antioxidants may have mixed results in young athletes, they have positive effects on muscle condition and physical function in the

elderly, and the combination of antioxidants and exercise is more effective than either intervention alone.[26]

Interaction with Master Regulators: mTOR and Autophagy

The protocol's impact on $mTOR$ (mechanistic target of rapamycin) is a central question in longevity science. $mTOR$ is a master regulator of cell growth, and its chronic hyperactivation is linked to accelerated aging and the inhibition of autophagy—the body's cellular "cleanup" process. GlyNAC presents a balancing act in this regard.

Glycine has been shown to activate $mTORC1$ in muscle cells, which underlies its ability to protect against muscle wasting in catabolic states.[4] In contrast, NAC has been observed to *inhibit* $mTOR$ signaling in T cells and other tissues.[4] In patients with systemic lupus erythematosus, NAC was found to block $mTOR$ and improve disease outcomes.[33]

The aggregate human data suggest that GlyNAC at the $100~mg/kg/day$ dose does not drive harmful chronic $mTOR$ activation. Instead, the protocol appears to improve metabolism through the activation of $AMPK$ and $sirtuins$, which are traditionally associated with longevity and calorie restriction.[4] GlyNAC also upregulates mitophagy—the selective degradation of mitochondria—which is essential for maintaining a healthy mitochondrial pool and preventing the buildup of senescent cells.[13] This metabolic profile aligns more closely with healthspan promotion than with unchecked anabolism.

Corrected Protocol and Dosage Guidelines

Based on a thorough synthesis of the research material, the following protocol represents the current evidence-based standard for older adults seeking to address GSH deficiency and the hallmarks of aging.

Primary Dosing Recommendation

The data overwhelmingly concur with a high-gram protocol. The effective dose is $100~mg/kg/day$ of glycine and $100~mg/kg/day$ of NAC. For individuals with higher oxidative stress or those seeking molar precision, the $100~mg$ glycine and $133~mg$ NAC per kilogram ratio is a valid stoichiometric correction.[3]

Standardized Supplementation Schedule

Parameter	Guideline	Justification
Daily Dose	$100~mg/kg$ each	Threshold for cellular GSH correction.[3]
Frequency	2-3 times daily	Counteracts low NAC bioavailability and half-life.[4]
Timing	With meals	Improves gastrointestinal

		tolerance.[4]
Duration	16-24 weeks	Required for functional gains in strength and cognition.[4]
Washout	Continuous use	Benefits reverse within 12 weeks of discontinuation.[5]

Monitoring and Risk Mitigation

While GlyNAC is safe for the majority of healthy older adults, specific monitoring parameters should be observed:

1. **GI Tolerance:** Monitor for nausea or diarrhea; if present, further divide the dose throughout the day or adjust the timing relative to meal intake.[7]
2. **Blood Pressure:** Monitor for hypotension, particularly in individuals taking antihypertensive medications or nitroglycerin.[52]
3. **Blood Clotting:** Due to NAC's antiplatelet effects, monitor for easy bruising and discontinue use at least 14 days prior to any elective surgical procedure.[34]
4. **Cystinuria/Kidney Stones:** Individuals with a history of cystine or calcium oxalate stones should monitor urinary markers and maintain high fluid intake (at least $2.5-3~L/day$) to minimize crystallization risk.[37]
5. **Active Malignancy:** Consult an oncologist before use if a diagnosis of cancer is present, as antioxidants may interfere with certain chemotherapy regimens or facilitate metastasis.[38]

Conclusion: The Therapeutic Potential of GlyNAC in Geroscience

The transition of GlyNAC from an experimental pilot to a randomized clinical trial success represents a significant advancement in the field of longevity medicine. By addressing the root cause of glutathione deficiency—precursor insufficiency—GlyNAC provides a multi-targeted intervention that reaches across the diverse hallmarks of aging. The research underscores that "correcting" these defects is a function of stoichiometry and duration; low-dose interventions are largely symbolic, while the high-dose $100~mg/kg$ protocol offers a biological "reset" of mitochondrial function, insulin sensitivity, and physical strength.[1]
The fact that these benefits are reversible upon discontinuation suggests that the aging body remains in a state of high demand for these amino acids, likely due to a persistent decline in endogenous synthetic efficiency and a chronic environmental and metabolic oxidative load.[5] As such, GlyNAC should be considered a long-term nutritional foundation for the elderly rather than a temporary fix. Future research into its impact on specific diseases such as Alzheimer's, non-alcoholic fatty liver disease, and diabetes will likely further refine these protocols, but the current data strongly support the $100~mg/kg$ daily regimen as a safe and powerful strategy for promoting healthy aging and expanding the human healthspan.[14]

Works cited

1. Supplementing Glycine and N-Acetylcysteine (GlyNAC) in Older Adults Improves Glutathione Deficiency, Oxidative Stress, Mitochondrial Dysfunction, Inflammation, Physical Function, and Aging Hallmarks: A Randomized Clinical Trial - PubMed, accessed February 8, 2026, https://pubmed.ncbi.nlm.nih.gov/35975308/
2. Top 9 Benefits of NAC (N-Acetyl Cysteine) - Healthline, accessed February 8, 2026, https://www.healthline.com/nutrition/nac-benefits
3. GlyNAC and Healthy Aging: A Review of New Clinical Data - ReachMD, accessed February 8, 2026, https://reachmd.com/programs/medical-industry-feature/glynac-and-healthy-aging-a-review-of-new-clinical-data/13420/transcript/31612/?action=view
4. GlyNAC Supplementation Protocol (Glycine + N-Acetylcysteine) for Older Adults.pdf
5. GlyNAC improves multiple defects in aging to boost strength and cognition in older humans, accessed February 8, 2026, https://www.sciencedaily.com/releases/2021/03/210329122746.htm
6. N-Acetylcysteine benefits, dosage, and side effects - Examine.com, accessed February 8, 2026, https://examine.com/supplements/n-acetylcysteine/
7. N-acetylcysteine (NAC): Health Benefits, Side Effects, Dosage, and More - WebMD, accessed February 8, 2026, https://www.webmd.com/diet/health-benefits-nac
8. GlyNAC benefits, dosage, and side effects - Examine.com, accessed February 8, 2026, https://examine.com/supplements/glynac/
9. A Randomized Controlled Clinical Trial in Healthy Older Adults to ..., accessed February 8, 2026, https://pmc.ncbi.nlm.nih.gov/articles/PMC9261343/
10. A Randomized Controlled Clinical Trial in Healthy Older Adults to Determine Efficacy of Glycine and N-Acetylcysteine Supplementation on Glutathione Redox Status and Oxidative Damage - Frontiers, accessed February 8, 2026, https://www.frontiersin.org/journals/aging/articles/10.3389/fragi.2022.852569/full
11. A Randomized Controlled Clinical Trial in Healthy Older Adults to Determine Efficacy of Glycine and N-Acetylcysteine Supplementation on Glutathione Redox Status and Oxidative Damage - ResearchGate, accessed February 8, 2026, https://www.researchgate.net/publication/359070680_A_Randomized_Controlled_Clinical_Trial_in_Healthy_Older_Adults_to_Determine_Efficacy_of_Glycine_and_N-Acetylcysteine_Supplementation_on_Glutathione_Redox_Status_and_Oxidative_Damage
12. A Combination of NAC and Glycine Promotes Healthy Aging in Older Adults, accessed February 8, 2026, https://naturalhealthresearch.org/a-combination-of-nac-and-glycine-promotes-healthy-aging-in-older-adults/
13. Supplementing Glycine and N-Acetylcysteine (GlyNAC) in Older Adults Benefits both Health Span and Lifespan | USC Longevity Institute, accessed February 8, 2026,

https://gero.usc.edu/longevity-institute/supplementing-glycine-and-n-acetylcysteine-glynac-in-older-adults-benefits-both-health-span-and-lifespan/
14. GlyNAC improves multiple defects in aging to boost strength and cognition in older humans, accessed February 8, 2026, https://www.eurekalert.org/news-releases/864962
15. GlyNAC improves strength and cognition in older humans | BCM, accessed February 8, 2026, https://www.bcm.edu/news/glynac-improves-strength-and-cognition-in-older-humans
16. Glycine and N-acetylcysteine (GlyNAC) supplementation in older adults improves glutathione deficiency, oxidative stress, mitoc - Cloudfront.net, accessed February 8, 2026, https://d1xe7tfg0uwul9.cloudfront.net/sbgg.org.br/wp-content/uploads/2021/04/6-GlyNAC.pdf
17. Effect of N-Acetyl Cysteine as an Adjuvant Treatment in Alzheimer's Disease - MDPI, accessed February 8, 2026, https://www.mdpi.com/2076-3425/15/2/164?type=check_update&version=1
18. GlyNAC (Glycine and N-Acetylcysteine) Supplementation Improves Impaired Mitochondrial Fuel Oxidation and Lowers Insulin Resistance in Patients with Type 2 Diabetes: Results of a Pilot Study - PMC, accessed February 8, 2026, https://pmc.ncbi.nlm.nih.gov/articles/PMC8773349/
19. (PDF) GlyNAC (Glycine and N-Acetylcysteine) Supplementation Improves Impaired Mitochondrial Fuel Oxidation and Lowers Insulin Resistance in Patients with Type 2 Diabetes: Results of a Pilot Study - ResearchGate, accessed February 8, 2026, https://www.researchgate.net/publication/357818246_GlyNAC_Glycine_and_N-Acetylcysteine_Supplementation_Improves_Impaired_Mitochondrial_Fuel_Oxidation_and_Lowers_Insulin_Resistance_in_Patients_with_Type_2_Diabetes_Results_of_a_Pilot_Study
20. Supplementing Glycine and N-Acetylcysteine (GlyNAC) in Older Adults Improves Glutathione Deficiency, Oxidative Stress, Mitochondrial Dysfunction, Inflammation, Physical Function, and Aging Hallmarks: A Randomized Clinical Trial - PMC, accessed February 8, 2026, https://pmc.ncbi.nlm.nih.gov/articles/PMC9879756/
21. CA2579962A1 - Glycine as a diet supplement for the treatment of health problems that result from underlying metabolic disorders - Google Patents, accessed February 8, 2026, https://patents.google.com/patent/CA2579962A1/en
22. Effects of N-acetylcysteine on aging cell and obesity complications in obese adults: a randomized, double-blind clinical trial - Frontiers, accessed February 8, 2026, https://www.frontiersin.org/journals/nutrition/articles/10.3389/fnut.2023.1237869/full
23. GlyNAC (Glycine and N-Acetylcysteine) Supplementation in Mice Increases Length of Life by Correcting Glutathione Deficiency, Oxi - DigitalCommons@TMC, accessed February 8, 2026,

https://digitalcommons.library.tmc.edu/cgi/viewcontent.cgi?article=2105&context=baylor_docs
24. Glycine Safety: Everything You Need to Know - Ace Blend, accessed February 8, 2026, https://aceblend.com/blogs/daily-vitality/glycine-safety-everything-you-need-to-know
25. Glycine side effects and correct dosage to address deficiency - Purovitalis, accessed February 8, 2026, https://purovitalis.com/glycine-dosage/
26. Supplementing Glycine and N-Acetylcysteine (GlyNAC) in Older Adults Improves Glutathione Deficiency, Oxidative Stress, Mitochondrial Dysfunction, Inflammation, Physical Function, and Aging Hallmarks: A Randomized Clinical Trial | Request PDF - ResearchGate, accessed February 8, 2026, https://www.researchgate.net/publication/362747893_Supplementing_Glycine_and_N-Acetylcysteine_GlyNAC_in_Older_Adults_Improves_Glutathione_Deficiency_Oxidative_Stress_Mitochondrial_Dysfunction_Inflammation_Physical_Function_and_Aging_Hallmarks_A_Random
27. Glycine and N-acetylcysteine (GlyNAC) supplementation in older adults improves glutathione deficiency, oxidative stress, mitochondrial dysfunction, inflammation, insulin resistance, endothelial dysfunction, genotoxicity, muscle strength, and cognition: Results of a pilot clinical trial - PubMed, accessed February 8, 2026, https://pubmed.ncbi.nlm.nih.gov/33783984/
28. GlyNAC supplementation reverses aging hallmarks in aging humans | BCM, accessed February 8, 2026, https://www.bcm.edu/news/glynac-supplementation-reverses-aging-hallmarks-in-aging-humans
29. Risk assessment of food supplements containing N-acetylcysteine (NAC) - RIVM, accessed February 8, 2026, https://www.rivm.nl/bibliotheek/rapporten/2024-0086.pdf
30. Six weeks of N-acetylcysteine antioxidant in drinking water decreases pathological fiber branching in MDX mouse dystrophic fast-twitch skeletal muscle - Frontiers, accessed February 8, 2026, https://www.frontiersin.org/journals/physiology/articles/10.3389/fphys.2023.1109587/full
31. GLYNAC: A Pill to Cure the Effects of Aging? - Ivanhoe Broadcast News, Inc., accessed February 8, 2026, https://www.ivanhoe.com/family-health/glynac-a-pill-to-cure-the-effects-of-aging/
32. N-Acetylcysteine (NAC): Impacts on Human Health - PMC, accessed February 8, 2026, https://pmc.ncbi.nlm.nih.gov/articles/PMC8234027/
33. N-ACETYLCYSTEINE REDUCES DISEASE ACTIVITY BY BLOCKING MTOR IN T CELLS OF LUPUS PATIENTS - PMC - PubMed Central, accessed February 8, 2026, https://pmc.ncbi.nlm.nih.gov/articles/PMC3411859/
34. N-acetylcysteine (NAC) monograph - Texas Health and Human Services, accessed February 8, 2026, https://www.hhs.texas.gov/sites/default/files/documents/acetylcysteine-nac-mon

ograph.pdf
35. N-acetylcysteine for chronic kidney disease: a systematic review and meta-analysis - PMC, accessed February 8, 2026, https://pmc.ncbi.nlm.nih.gov/articles/PMC8129408/
36. Glycine loading and urinary oxalate excretion - PubMed, accessed February 8, 2026, https://pubmed.ncbi.nlm.nih.gov/8140673/
37. Cystine stones - National Kidney Foundation, accessed February 8, 2026, https://www.kidney.org/kidney-topics/cystine-kidney-stones
38. Antioxidants cause malignant melanoma to metastasise faster - ecancer, accessed February 8, 2026, https://ecancer.org/en/news/7911-antioxidants-cause-malignant-melanoma-to-metastasise-faster
39. Study Explains Paradox of Antioxidants in Cancer - AACR Journals, accessed February 8, 2026, https://aacrjournals.org/cancerdiscovery/article/4/4/380/4628/Study-Explains-Paradox-of-Antioxidants-in
40. Antioxidants Accelerate the Growth and Invasiveness of Tumors in Mice - NCI, accessed February 8, 2026, https://www.cancer.gov/news-events/cancer-currents-blog/2015/antioxidants-metastasis
41. Original Article Impact of long-term N-acetylcysteine use on cancer risk, accessed February 8, 2026, https://e-century.us/files/ajcr/15/2/ajcr0161234.pdf
42. What is the recommended dose of glycine? - Dr.Oracle, accessed February 8, 2026, https://www.droracle.ai/articles/368101/what-is-the-recommended-dose-of-glycine
43. How N-Acetylcysteine Supplementation Affects Redox Regulation, Especially at Mitohormesis and Sarcohormesis Level: Current Perspective - PMC, accessed February 8, 2026, https://pmc.ncbi.nlm.nih.gov/articles/PMC7909817/
44. Does N-acetylcysteine affect exercise performance? - Examine.com, accessed February 8, 2026, https://examine.com/faq/does-n-acetylcysteine-affect-exercise-performance/
45. Effects of Protein and NAC Co-ingestion on Skeletal Muscle Recovery | ClinicalTrials.gov, accessed February 8, 2026, https://clinicaltrials.gov/study/NCT06367413
46. Effect of N-acetylcysteine on Cycling Performance after Intensified Training - ResearchGate, accessed February 8, 2026, https://www.researchgate.net/publication/260430236_Effect_of_N-acetylcysteine_on_Cycling_Performance_after_Intensified_Training
47. Acute Effect of Oral N-Acetylcysteine Supplementation on Fatigue Effect and Isometric Force Production in Physically Active People - MDPI, accessed February 8, 2026, https://www.mdpi.com/2076-3417/14/22/10399
48. GlyNAC Supplementation Improves Glutathione Deficiency, Oxidative Stress, Mitochondrial Dysfunction, Inflammation, Aging Hallmarks, Metabolic Defects, Muscle Strength, Cognitive Decline, and Body Composition: Implications for

Healthy Aging - PubMed, accessed February 8, 2026, https://pubmed.ncbi.nlm.nih.gov/34587244/
49. The effects of N-acetylcysteine on hepatic, hematologic, and renal parameters in cirrhotic patients: a randomized controlled trial - PMC, accessed February 8, 2026, https://pmc.ncbi.nlm.nih.gov/articles/PMC10835090/
50. Repurposing N-acetylcysteine for management of non-acetaminophen induced acute liver failure: an evidence scan from a global health perspective - Translational Gastroenterology and Hepatology, accessed February 8, 2026, https://tgh.amegroups.org/article/view/8506/html
51. NAC Side Effects: Common, Severe, Long Term - Drugs.com, accessed February 8, 2026, https://www.drugs.com/sfx/nac-side-effects.html
52. N-Acetyl Cysteine (Nac) – Uses, Side Effects, and More - WebMD, accessed February 8, 2026, https://www.webmd.com/vitamins/ai/ingredientmono-1018/n-acetyl-cysteine-nac
53. Glycine: Uses, Side Effects, Dosage & Interactions - Apollo Hospitals, accessed February 8, 2026, https://www.apollohospitals.com/medicines/glycine
54. Current Management Strategies for Cystinuria - American Urological Association, accessed February 8, 2026, https://auanews.net/issues/articles/2024/october-extra-2024/current-management-strategies-for-cystinuria
55. Calcium oxalate stones - National Kidney Foundation, accessed February 8, 2026, https://www.kidney.org/kidney-topics/calcium-kidney-stones
56. Guide To GlyNAC: Benefits, Dosage & Risks | Vitality Pro, accessed February 8, 2026, https://vitality-pro.com/glynac/benefits-dosage-side-effects-gly/