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Sermorelin and Growth Hormone Support:

Safety, Efficacy, and Delivery Approaches

Whitepaper

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Abstract

Shifts in growth hormone (GH) levels can lead to reduced muscle mass, decreased bone strength, altered metabolism, impaired sleep quality, and compromised cognitive performance. Sermorelin, a synthetic peptide that mimics growth hormone–releasing hormone, works by stimulating the body's own production of GH from the pituitary gland in a natural, pulse-like rhythm. This approach helps maintain the body's normal feedback systems and reduces some of the risks associated with GH supplementation. Research shows that sermorelin can safely restore more GH activity, supporting improvements in strength, body composition, recovery, and cognitive function. While sermorelin has traditionally been given by injection, new liposomal delivery methods now make oral use possible, improving convenience and consistency. The StatRX delivery system, in particular, enables a needle-free option that allows for reliable absorption. Overall, sermorelin provides a safe and effective means of supporting hormone balance and promoting healthy aging.

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1 Introduction

Aging is accompanied by widespread physiological changes in the body. From puberty into adulthood and later life, shifts in hormone levels often dictate the profound physiological changes that occur. Growth hormone (GH) plays a crucial role in regulating key aspects of overall strength and fitness. It is essential for driving growth during childhood[1] and continues to help maintain healthy body composition, bone strength, muscle mass, and metabolic function into adulthood[2]. However, GH levels gradually decline with age. This decline is associated with decreases in muscle mass and cognitive function, and an increase in body fat. Sermorelin is a peptide-based therapy that stimulates the natural production of GH, representing a potential mechanism for preventing or reversing some of the impacts of decreased GH and aging.

This article examines the role of GH in physical and mental health, and explores the evidence supporting the use of sermorelin as a tool to enhance strength, metabolism, recovery, and cognitive function.

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2 Background and History of Sermorelin

2.1. Human Growth Hormone Deficiency

Deficiencies in GH in children can lead to short height, low blood sugar, and other developmental issues[3], while a deficiency in adults can result in decreased muscle mass, high cholesterol levels, or poor bone density[4,5]. To combat these effects, GH extracted from pituitary glands was first used to treat growth hormone deficiency in the 1950s[6]. Limited availability and the high cost of this extraction process drove the development of recombinant GH in the 1980s[7], which is still used to treat growth hormone deficiency today[8].

Alternatives for GH were also investigated, and growth hormone-releasing hormone (GHRH), which stimulates the release of GH in the pituitary gland, was identified as a potential candidate for treating growth hormone deficiency[9]. Sermorelin is a synthetic peptide analog of GHRH that mimics its action to stimulate secretion of GH and was approved by the FDA for use in treating children with growth hormone deficiency in 1997[10,11]. Originally sold as Geref, the drug was discontinued by the manufacturer in 2006, although this was not due to safety or efficacy concerns[12]. GHRH and sermorelin are GH secretagogues, meaning they promote its secretion.

2.2. Human Growth Hormone and Aging

Around the same time as GH and its secretagogues were being investigated to treat hormone deficiency, another line of research identified an important role for GH in aging[13]. It was observed that GH levels decrease with age, with daily secretion decreasing from a height of approximately 150 µg/kg/day during puberty to only around 25 µg/kg/day at age 55[14]. This decrease correlates with changes associated with GH deficiency: reductions in lean body mass and muscle strength, increases in body fat, decline in cognitive function, and an increase in sleep disorders[15]. As such, GH and treatments that can stimulate its production emerged as candidates to prevent or slow down physical and mental declines associated with aging.

2.3. Mechanism of Action

GHRH is a 44-amino acid peptide that, following secretion from the hypothalamus, activates GHRH receptors (GHRHR) expressed by somatotropic cells of the pituitary gland[16]. Sermorelin is a 29-amino acid peptide corresponding to the bioactive portion of GHRH, making it the smallest fragment of the molecule necessary for full biological activity[17]. Because it consists of this fragment of GHRH, sermorelin is sometimes referred to as GHRH (1-29). Activation of GHRHR in the pituitary gland,

either by GHRH or sermorelin, results in the secretion of GH into the bloodstream[18].

Following GHRHR activation, for example, by sermorelin, somatotropic cells secrete GH in a pulse-like manner. It is a reduction in the strength of these pulses that is thought to be the cause of reduced GH secretion with aging[19]. The activity of GH, mediated by its receptor on the surface of cells throughout the body, is essential for growth during childhood and adolescence, and has profound impacts on many aspects of adult physiology. The hormone also plays a crucial role in regulating growth and metabolism by stimulating the production of insulin-like growth factor 1 (IGF-1), primarily in the liver[20]. The so-called GH-IGF-1 axis is vital for growth and metabolism, and GH-mediated production of IGF-1 promotes protein synthesis, cell growth, and development[21].

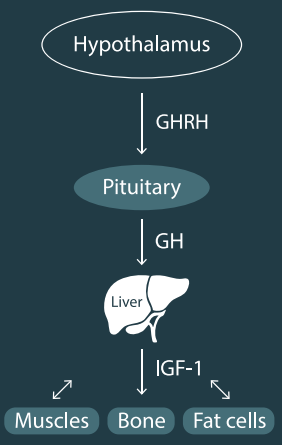

Figure 1. GHRH is secreted from the hypothalamus and activates its receptor in somatotropic cells of the pituitary gland. This stimulates the release of GH into the bloodstream, where it acts on tissues directly or induces the release of IGF-1, primarily in the liver. IGF-1 promotes the growth of muscle and bone, as well as the breakdown of triglycerides in fat cells (adipocytes). Image adapted from Brahmkhatri et al, 2015[22]. Image used under Creative Commons license.

As a therapeutic, GHRH is often preferred over recombinant GH because it stimulates the body's own pituitary gland to produce and release growth hormone in a physiologic, pulsatile manner, more closely mimicking natural secretion dynamics. Research into the effects of sermorelin on hormonal systems suggests that it promotes changes in GH levels similar to those observed with natural GHRH[23,24]. As such, sermorelin stimulates GH production in a way that parallels normal endocrine physiology. This preserves regulatory feedback mechanisms, helps maintain healthy hormone rhythms, and reduces the risk of excessive or inappropriate GH/IGF-1 levels, which sometimes occur with direct administration of GH[25].

3 Evidence for Sermorelin Activity

The roles of GH and IGF-1 in aging are now well established[25]. Treatment of older men with sermorelin has been shown to reverse age-related decreases in GH and IGF-1[26,27], highlighting a potential role for such therapies in supporting healthy aging and long-term wellness. Aging is a multifaceted phenomenon, and this section examines the effects of sermorelin and GHRH on various physiological processes associated with aging. Such treatments can support hormonal balance by restoring GH levels to those seen in younger adults[28,29].

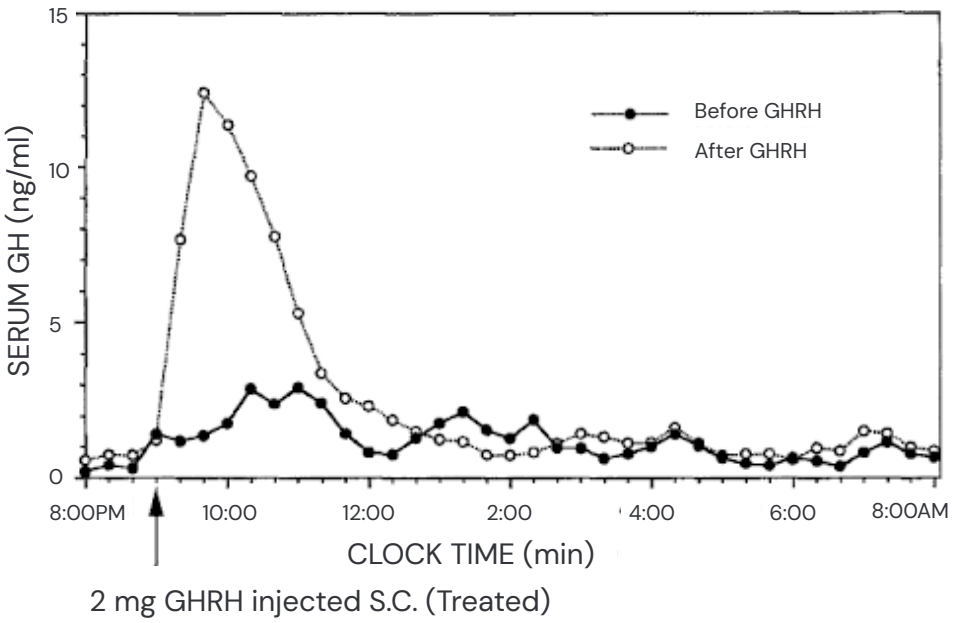

Figure 2. Levels of growth hormone (GH) in serum of non-obese men aged 64 to 76 years following nightly subcutaneous injection of 2mg sermorelin (referred to here generically as GHRH). Injection of sermorelin rapidly and significantly increases levels of GH. Image adapted from Vittone et al, 1997[28]. Image used under Creative Commons license.

3.1. Strength and Fitness

GH regulates skeletal muscle growth and strength directly and via IGF-1[30,31]. Adults who are deficient in GH have reduced muscle mass and increased fat mass, while replacement of GH is known to improve body composition[32]. GH can also help in muscle repair, primarily by stimulating the synthesis of collagen and supporting the connective tissue matrix of muscle and tendon, which is critical for tissue regeneration after injury[33]. Evidence also shows that GH modulates the activity of mesenchymal stem cells, guiding their differentiation and encouraging cellular repair[34]. Furthermore, GH increases lean body mass by promoting muscle hypertrophy and reducing fat mass[35].

As such, GHRH analogs, such as sermorelin, may promote muscle growth and preserve lean mass by inducing GH secretion. One study demonstrated that sermorelin treatment increased aerobic reserve in forearm muscle (indicating a reduced need for anaerobic respiration during exercise) and also improved measures of muscle strength[28]. Another randomized controlled trial showed that sermorelin increased skin thickness and lean body mass in men and women[27]. During childhood and into adulthood, GH is also essential for bone development and remodeling, and GH therapy increases bone density and strength[36–38].

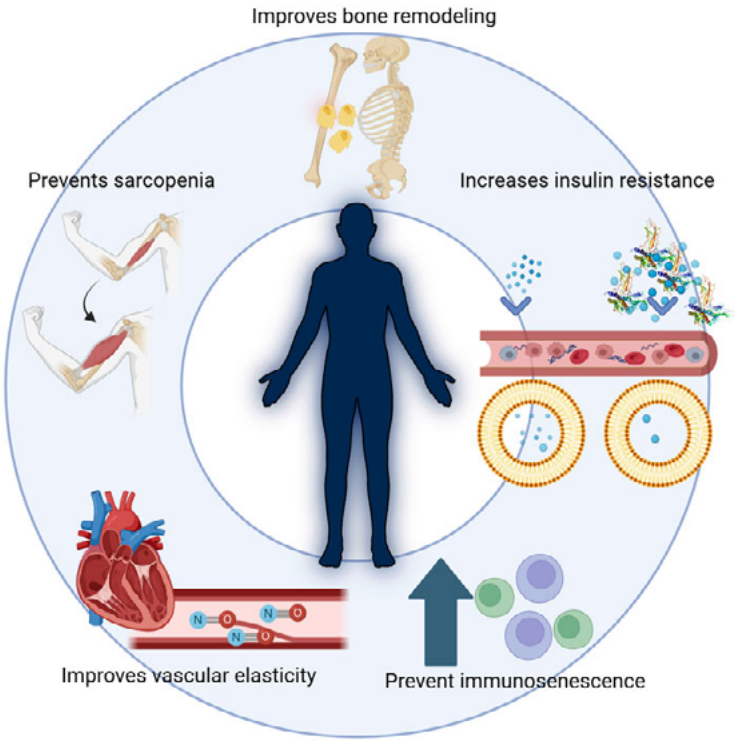

Figure 3. GH supports body composition and sustains overall metabolic balance and well-being. In adults, GH is critical in improving bone remodeling and preventing loss of skeletal muscle mass, strength, and function (sarcopenia). It increases insulin resistance, impacting metabolic balance. Additionally, it improves vascular elasticity and helps prevent immunosenescence, thus supporting overall health during aging. Image adapted from Fernández-Garza et al, 2025[25]. Image used under Creative Commons license.

3 Evidence for Sermorelin Activity

3.2. Metabolism and Weight Loss

The activity of GH promotes lipolysis, directly stimulating the breakdown of triglycerides in fat tissue and enhancing the utilization of fatty acids as an energy source[39]. This can result in a reduction of body fat mass, and targeting GH and IGF-1 has been suggested as a mechanism to combat obesity[40].

A randomized controlled trial of older adults (aged 55 - 87) showed that treatment with GHRH increased IGF-1 levels by 117% and reduced body fat by 7.4%41. Other trials have used a GHRH analog, GHRH (1-44), which increases endogenous secretion of GH and IGF-1 in a manner similar to sermorelin[42]. One study showed that treatment with GHRH (1-44) increased fat-free mass and reduced total abdominal adiposity in middle-aged and older men[43]. This peptide, also known as tesamorelin, is used to reduce excess visceral fat in HIV infection[44]. GHRH treatment has been highlighted for its potential to reduce visceral adiposity, decrease triglycerides, and reduce measures of cardiovascular risk[45].

These studies investigating the impact of sermorelin and other GHRH analogs on muscle building and weight loss suggest that sermorelin is a potent stimulator of GH and IGF-1, which can yield significant improvements in body composition through enhanced metabolism[24].

3.3. Sleep and Recovery

Sleep patterns often change with age and are a significant factor in overall health. This can include more frequent awakenings during the night, less slow-wave sleep, an earlier rise in nighttime cortisol levels, and reduced secretion of GH[46]. Disrupted sleep can lead to reductions in muscular strength, power, speed, endurance, and coordination across a range of sports and activities[47].

One study demonstrated that giving GHRH in pulses to healthy older adults can improve sleep by reducing nighttime awakenings and lengthening the first period of non-rapid eye movement (NREM) sleep[48]. Intranasal GHRH has also been shown to lower cortisol levels at the start of sleep and reduce the typical increase in GH that occurs early in the night. These effects suggest that GHRH may act through both neural and hormonal pathways[49]. Sleep plays a vital role in mental health and cognitive ability[50–52] and nightly GHRH treatment has been shown to improve cognitive function and sleep continuity in individuals with depression[53]. These data suggest a role for sermorelin and GHRH analogs in promoting restful sleep and improved recovery by modulating endogenous GH levels.

3.4. Cognitive Function

GHRH and sermorelin may also play a more direct role in cognitive ability. Levels of GH and IGF-1 also regulate brain structure, function, and plasticity[54]. In older adults, treatment with GHRH was found to slow cognitive decline, regardless of gender, estrogen status, or initial cognitive ability[55]. The GHRH analog tesamorelin also showed benefits for adults with mild cognitive impairment as well as healthy older adults, with the most substantial improvements observed in executive functions[56]. Analyses confirmed that GHRH had a significant positive effect on overall cognition, with similar benefits in both people with MCI and those who were cognitively healthy.

4 Dosage and Safety

Levels of GH in the body naturally fluctuate throughout the day, making the timing of sermorelin delivery crucial. Endogenous GH is secreted in pulses, with maximal release in the second half of the night[20]. As such, sermorelin is typically administered before sleep to achieve its maximum impact on natural cycles. For the treatment of GH deficiency, children would receive around 30 µg/kg once daily[57], while higher concentrations have been used in clinical trials with adults[17]. For adults taking sermorelin to help build muscle and aid in recovery, such as bodybuilders, a dose of 200-300 µg (0.2-0.3mg) is typically taken once daily[58], equating to 2.5-3.75 µg/kg for an 80kg adult. Sermorelin is generally taken via subcutaneous injection, which should be performed precisely as instructed by your prescriber.

Sermorelin is typically well-tolerated and was deemed safe by the FDA in its previous market authorization[12]. Common side effects include redness or pain at the injection site, while headaches, dizziness, nausea, and sleep issues are less common[57]. Sermorelin is a hormonal therapy and can therefore interact with other medications.

While conventional sermorelin delivery is by injection, a new generation of delivery formulations is making injection-free delivery possible. StatRX is a needle-free liquid system that provides medications like sermorelin in simple, precise, single-dose vials. It makes treatment simple, accurate, and convenient for patients at home or on the go.

5 Conclusion

Sermorelin represents a scientifically grounded and clinically validated approach to supporting the production of growth hormone. By stimulating the pituitary gland in a way that closely parallels natural physiology, sermorelin restores more youthful patterns of GH and IGF-1 activity, benefiting strength, metabolism, sleep quality, recovery, and cognitive function. Decades of research confirm that sermorelin is generally safe and well-tolerated, with side effects typically limited to minor and transient issues.

While traditional administration has relied on injection to ensure bioavailability, advances in drug delivery are now expanding access and convenience. Fridays' StatRX oral deliverysystem marks a significant innovation, enabling efficient absorption without the need for needles. This needle-free option lowers barriers to therapy while maintaining reliability, making it an appealing advancement for individuals seeking the benefits of peptide therapy with greater comfort and ease of use.

Taken together, the evidence supports sermorelin as a safe, effective, and patient-friendly therapy for promoting hormone balance and healthy aging. With the added advantage of StatRX delivery, Fridays provides a trustworthy and innovative solution for consumers focused on longevity, vitality, and quality of life.

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6 References

1. Ranke MB. Short and Long-Term Effects of Growth Hormone in Children and Adolescents With GH Deficiency. Front Endocrinol. 2021;12:720419. doi:10.3389/fendo.2021.720419
2. Reed ML, Merriam GR, Kargi AY. Adult Growth Hormone Deficiency – Benefits, Side Effects, and Risks of Growth Hormone Replacement. Front Endocrinol. 2013;4:64. doi:10.3389/fendo.2013.00064
3. Mameli C, Guadagni L, Orso M, et al. Epidemiology of growth hormone deficiency in children and adolescents: a systematic review. Endocrine. 2024;85(1):91-98. doi:10.1007/s12020-024-03778-4
4. Melmed S. Pathogenesis and diagnosis of growth hormone deficiency in adults. N Engl J Med. 2019;380(26):2551-2562.
5. Van Bunderen CC, Olsson DS. Growth hormone deficiency and replacement therapy in adults: Impact on survival. Rev Endocr Metab Disord. 2021;22(1):125-133. doi:10.1007/s11154-020-09599-w
6. Raben MS. Preparation of growth hormone from pituitaries of man and monkey. Science. 1957;125(3253):883-884.
7. Cronin MJ, From the Division of Research Technology G. Pioneering recombinant growth hormone manufacturing: pounds produced per mile of height. J Pediatr. 1997;131(1):S5-S7.
8. Danowitz M, Grimberg A. Clinical indications for growth hormone therapy. Adv Pediatr. 2022;69(1):203-217.
9. Ross RJM, Tsagarakis S, Grossman A, et al. TREATMENT OF GROWTH-HORMONE DEFICIENCY WITH GROWTH-HORMONE-RELEASING HORMONE. The Lancet. 1987;329(8523):5-8. doi:10.1016/S0140-6736(87)90699-4
10. Prakash A, Goa KL. Sermorelin: a review of its use in the diagnosis and treatment of children with idiopathic growth hormone deficiency. BioDrugs. 1999;12(2):139-157.
11. Thorner M, Rochiccioli P, Colle M, et al. Once daily subcutaneous growth hormone-releasing hormone therapy accelerates growth in growth hormone-deficient children during the first year of therapy. Geref International Study Group. J Clin Endocrinol Metab. 1996;81(3):1189-1196. doi:10.1210/jcem.81.3.8772599
12. Determination That GEREF (Sermorelin Acetate) Injection, 0.5 Milligrams Base/Vial and 1.0 Milligrams Base/Vial, and GEREF (Sermorelin Acetate) Injection, 0.05 Milligrams Base/Amp, Were Not Withdrawn From Sale for Reasons of Safety or Effectiveness. Federal Register. March 4, 2013. Accessed September 24, 2025. https://www.federalregister.gov/documents/2013/03/04/2013-04827/determination-that-geref-sermorelin-acetate-injection-05-milligrams-basevial-and-10-milligrams?utm_source=chatgpt.com
13. Corpas E, Harman SM, Blackman MR. Human growth hormone and human aging. Endocr Rev. 1993;14(1):20-39.

14. Hersch EC, Merriam GR. Growth hormone (GH)–releasing hormone and GH secretagogues in normal aging: Fountain of Youth or Pool of Tantalus? Clin Interv Aging. 2008;3(1):121-129. doi:10.2147/CIA.S3247

15. Garcia JM, Merriam GR, Kargi AY. Growth Hormone in Aging. In: Feingold KR, Ahmed SF, Anawalt B, et al., eds. Endotext. MDText.com, Inc.; 2000. Accessed September 22, 2025. http://www.ncbi.nlm.nih.gov/books/NBK279163/

16. Zhou F, Zhang H, Cong Z, et al. Structural basis for activation of the growth hormone-releasing hormone receptor. Nat Commun. 2020;11(1):5205. doi:10.1038/s41467-020-18945-0

17. Merriam GR, Barsness S, Buchner D, et al. Growth Hormone Releasing Hormone Treatment in Normal Aging. J Anti-Aging Med. 2001;4(4):331-343. doi:10.1089/10945450152850650

18. Walker RF. Sermorelin: A better approach to management of adult-onset growth hormone insufficiency? Clin Interv Aging. Published online January 1, 2006. Accessed September 24, 2025. https://www.tandfonline.com/doi/abs/10.2147/ciia.2006.1.4.307

19. Russell-Aulet M, Dimaraki EV, Jaffe CA, DeMott-Friberg R, Barkan AL. Aging-related growth hormone (GH) decrease is a selective hypothalamic GH-releasing hormone pulse amplitude mediated phenomenon. J Gerontol A Biol Sci Med Sci. 2001;56(2):M124-129. doi:10.1093/gerona/56.2.m124

20. Olarescu NC, Gunawardane K, Hansen TK, Møller N, Jørgensen JOL. Normal physiology of growth hormone in adults. Published online 2015.

21. Blum WF, Alherbish A, Alsagheir A, et al. The growth hormone–insulin-like growth factor-I axis in the diagnosis and treatment of growth disorders. Endocr Connect. 2018;7(6):R212-R222. doi:10.1530/EC-18-0099

22. Brahmkhatri VP, Prasanna C, Atreya HS. Insulin-Like Growth Factor System in Cancer: Novel Targeted Therapies. BioMed Res Int. 2015;2015(1):538019. doi:10.1155/2015/538019

23. Gelander L, Lindstedt G, Selstam G, Wide L, Albertsson-Wikland K. Effects of Acute Intravenous Injection of Two Growth Hormone-Releasing Hormones (GHRH 1–40 and 1–29) on Serum Growth Hormone and Other Pituitary Hormones in Short Children with Pulsatile Growth Hormone Secretion. Hormones. 1989;31(5-6):213-220.

24. Sinha DK, Balasubramanian A, Tatem AJ, et al. Beyond the androgen receptor: the role of growth hormone secretagogues in the modern management of body composition in hypogonadal males. Transl Androl Urol. 2020;9(Suppl 2):S149-S159. doi:10.21037/tau.2019.11.30

25. Fernández-Garza LE, Guillen-Silva F, Sotelo-Ibarra MA, Domínguez-Mendoza AE, Barrera-Barrera SA, Barrera-Saldaña HA. Growth hormone and aging: a clinical review. Front Aging. 2025;6:1549453.

26. Corpas E, Harman SM, Piñeyro MA, Roberson R, Blackman MR. Growth hormone (GH)-releasing hormone-(1-29) twice daily reverses the decreased GH and insulin-like growth factor-I levels in old men. J Clin Endocrinol Metab. 1992;75(2):530-535. doi:10.1210/jcem.75.2.1379256

27. Khorram O, Laughlin GA, Yen SSC. Endocrine and Metabolic Effects of Long-Term Administration of[Nle27]Growth Hormone-Releasing Hormone-(1–29)-NH2 in Age-Advanced Men and Women. J Clin Endocrinol Metab. 1997;82(5):1472-1479. doi:10.1210/jcem.82.5.3943

28. Vittone J, Blackman MR, Busby-Whitehead J, et al. Effects of single nightly injections of growth hormone—releasing hormone (GHRH 1–29) in healthy elderly men. Metabolism. 1997;46(1):89-96. doi:10.1016/S0026-0495(97)90174-8

29. Wilton P, Chardet Y, Danielson K, Widlund L, Gunnarsson R. Pharmacokinetics of growth hormone-releasing hormone(1-29)-NH2 and stimulation of growth hormone secretion in healthy subjects after intravenous or intranasal administration. Acta Paediatr Oslo Nor 1992 Suppl. 1993;388:10-15. doi:10.1111/j.1651-2227.1993.tb12827.x

30. Velloso CP. Regulation of muscle mass by growth hormone and IGF-I. Br J Pharmacol. 2008;154(3):557-568. doi:10.1038/bjp.2008.153

31. Young JA, Zhu S, List EO, Duran-Ortiz S, Slama Y, Berryman DE. Musculoskeletal Effects of Altered GH Action. Front Physiol. 2022;13. doi:10.3389/fphys.2022.867921

32. Molitch ME, Clemmons DR, Malozowski S, Merriam GR, Vance ML. Evaluation and Treatment of Adult Growth Hormone Deficiency: An Endocrine Society Clinical Practice Guideline. J Clin Endocrinol Metab. 2011;96(6):1587-1609. doi:10.1210/jc.2011-0179

33. Doessing S, Heinemeier KM, Holm L, et al. Growth hormone stimulates the collagen synthesis in human tendon and skeletal muscle without affecting myofibrillar protein synthesis. J Physiol. 2010;588(Pt 2):341-351. doi:10.1113/jphysiol.2009.179325

34. Bolamperti S, Guidobono F, Rubinacci A, Villa I. The Role of Growth Hormone in Mesenchymal Stem Cell Commitment. Int J Mol Sci. 2019;20(21):5264. doi:10.3390/ijms20215264

35. Tavares ABW, Micmacher E, Biesek S, et al. Effects of Growth Hormone Administration on Muscle Strength in Men over 50 Years Old. Int J Endocrinol. 2013;2013:942030. doi:10.1155/2013/942030

36. Amato G, Carella C, Fazio S, et al. Body composition, bone metabolism, and heart structure and function in growth hormone (GH)-deficient adults before and after GH replacement therapy at low doses. J Clin Endocrinol Metab. 1993;77(6):1671-1676.

37. Clanget C, Seck T, Hinke V, Wüster C, Ziegler R, Pfeilschifter J. Effects of 6 years of growth hormone (GH) treatment on bone mineral density in GH□ deficient adults. Clin Endocrinol (Oxf). 2001;55(1):93-99.

38. Murphy MG, Bach MA, Plotkin D, et al. Oral Administration of the Growth Hormone Secretagogue MK□677 Increases Markers of Bone Turnover in Healthy and Functionally Impaired Elderly Adults. J Bone Miner Res. 1999;14(7):1182-1188.

39. Ottosson M, Lönnroth P, Björntorp P, Edén S. Effects of cortisol and growth hormone on lipolysis in human adipose tissue. J Clin Endocrinol Metab. 2000;85(2):799-803.

40. Al-Samerria S, Radovick S. Exploring the Therapeutic Potential of Targeting GH and IGF-1 in the Management of Obesity: Insights from the Interplay between These Hormones and Metabolism. Int J Mol Sci. 2023;24(11):9556. doi:10.3390/ijms24119556

41. Baker LD, Barsness SM, Borson S, et al. Effects of Growth Hormone–Releasing Hormone on Cognitive Function in Adults With Mild Cognitive Impairment and Healthy Older Adults. Arch Neurol. 2012;69(11):1420-1429. doi:10.1001/archneurol.2012.1970

42. Stanley TL, Chen CY, Branch KL, Makimura H, Grinspoon SK. Effects of a growth hormone-releasing hormone analog on endogenous GH pulsatility and insulin sensitivity in healthy men. J Clin Endocrinol Metab. 2011;96(1):150-158. doi:10.1210/jc.2010-1587

43. Veldhuis JD, Patrie JT, Frick K, Weltman JY, Weltman A. Sustained Growth Hormone (GH) and Insulin-Like Growth Factor I Responses to Prolonged High-Dose Twice-Daily GH-Releasing Hormone Stimulation in Middle-Aged and Older Men. J Clin Endocrinol Metab. 2004;89(12):6325-6330. doi:10.1210/jc.2004-0430

44. Falutz J, Allas S, Mamputu JC, et al. Long-term safety and effects of tesamorelin, a growth hormone-releasing factor analogue, in HIV patients with abdominal fat accumulation. Aids. 2008;22(14):1719-1728.

45. Stanley TL, Grinspoon SK. Effects of Growth Hormone Releasing Hormone on Visceral Fat, Metabolic and Cardiovascular Indices in Human Studies. Growth Horm IGF Res Off J Growth Horm Res Soc Int IGF Res Soc. 2015;25(2):59-65. doi:10.1016/j.ghir.2014.12.005

46. Takahashi Y, Kipnis DM, Daughaday WH. Growth hormone secretion during sleep. J Clin Invest. 1968;47(9):2079-2090. doi:10.1172/JCI105893

47. Charest J, Grandner MA. Sleep and Athletic Performance: Impacts on Physical Performance, Mental Performance, Injury Risk and Recovery, and Mental Health. Sleep Med Clin. 2020;15(1):41-57. doi:10.1016/j.jsmc.2019.11.005

48. Guldner J, Schier T, Friess E, Colla M, Holsboer F, Steiger A. Reduced Efficacy of Growth Hormone-Releasing Hormone in Modulating Sleep Endocrine Activity in the Elderly. Neurobiol Aging. 1997;18(5):491-495. doi:10.1016/S0197-4580(97)00106-1

49. Perras B, Marshall L, Köhler G, Born J, Fehm HL. Sleep and endocrine changes after intranasal administration of growth hormone-releasing hormone in young and aged humans. Psychoneuroendocrinology. 1999;24(7):743-757. doi:10.1016/S0306-4530(99)00027-X

50. Scott AJ, Webb TL, Martyn-St James M, Rowse G, Weich S. Improving sleep quality leads to better mental health: A meta-analysis of randomised controlled trials. Sleep Med Rev. 2021;60:101556. doi:10.1016/j.smrv.2021.101556

51. Shah AS, Pant MR, Bommasamudram T, et al. Effects of Sleep Deprivation on Physical and Mental Health Outcomes: An Umbrella Review. Am J Lifestyle Med. Published online May 27, 2025:15598276251346752. doi:10.1177/15598276251346752

52. Deak MC, Stickgold R. Sleep and Cognition. Wiley Interdiscip Rev Cogn Sci. 2010;1(4):491-500. doi:10.1002/wcs.52

53. Antonijevic IA, Murck H, Frieboes RM, Barthelmes J, Steiger A. Sexually dimorphic effects of GHRH on sleep-endocrine activity in patients with depression and normal controls - part I: the sleep eeg. Sleep Res Online. 2000;3(1):5-13.

54. Ashpole NM, Sanders JE, Hodges EL, Yan H, Sonntag WE. Growth hormone, insulin-like growth factor-1 and the aging brain. Exp Gerontol. 2015;68:76-81. doi:10.1016/j.exger.2014.10.002

55. Vitiello MV, Moe KE, Merriam GR, Mazzoni G, Buchner DH, Schwartz RS. Growth hormone releasing hormone improves the cognition of healthy older adults. Neurobiol Aging. 2006;27(2):318-323.

56. Baker LD, Barsness SM, Borson S, et al. Effects of Growth Hormone–Releasing Hormone on Cognitive Function in Adults With Mild Cognitive Impairment and Healthy Older Adults. Arch Neurol. 2012;69(11):1420-1429. doi:10.1001/archneurol.2012.1970

57. Prakash A, Goa KL. Sermorelin: a review of its use in the diagnosis and treatment of children with idiopathic growth hormone deficiency. BioDrugs Clin Immunother Biopharm Gene Ther. 1999;12(2):139-157. doi:10.2165/00063030-199912020-00007

58. Sermorelin Acetate (Sermorelin): Side Effects, Uses, Dosage, Interactions, Warnings. RxList. Accessed September 23, 2025. https://www.rxlist.com/sermorelin-acetate-drug.htm