



proactive paws

VETERINARY FORMULATED NUTRITION

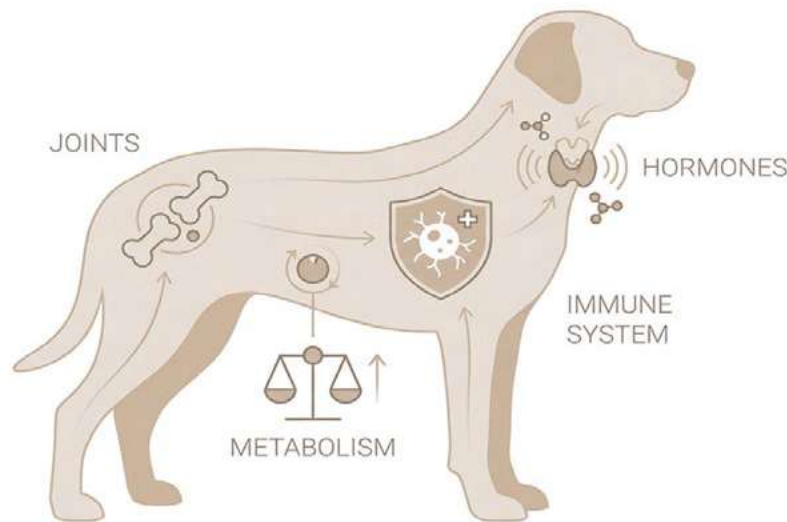
VETERINARY SCIENCE RESEARCH

Spay/Neuter Health Effects

2026 EVIDENCE-BASED REVIEW



Spay/Neuter Research



This 2026 multinational cohort study found that neutered dogs had significantly higher rates of chronic health conditions, including orthopedic disease, obesity, endocrine disorders, and immune-mediated disease, compared with intact dogs, with risks varying by sex and neutering age. Key findings:

- 1 Neutered dogs, both males and females, showed markedly higher rates of musculoskeletal disorders (especially CCL disease and osteoarthritis).
- 2 Neutered dogs had a significantly greater likelihood of obesity and metabolic dysfunction than intact dogs.
- 3 Endocrine disorders, including hypothyroidism, occurred more frequently in neutered dogs.
- 4 Immune-mediated disease risk was elevated, particularly in neutered females.
- 5 Earlier neutering (pre-pubertal) produced the highest lifetime disease risks across categories.

[Walsh CJ, García-San José M, Menchetti L, Bowen J, Fatjó J. Associations between neuter status and chronic disease risk in companion dogs across multiple European populations. Front Vet Sci. 2025;12:1532039.](#)

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- Parsemus Foundation (Veterinary Directory) - HormoneHealthForDogs.org (Educational Video Library)	



Musculoskeletal / Orthopedic Effects



Age of neutering contributes to risk of cruciate ligament rupture in Labrador Retrievers

[DeForge, T. L., Momen, M., Conidi, G., Muir, P., & Sample, S. J. \(2025\). Age of neutering contributes to risk of cruciate ligament rupture in Labrador Retrievers. Journal of the American Veterinary Medical Association, 263\(3\), 318-322. Retrieved Aug 4, 2026, from](#)

Influence of gonadectomy and age at gonadectomy on the risk of developing intervertebral disc herniation in French Bulldogs: a retrospective study

[Tabbì M, Troisi A, Fugazzotto D, Marcoccia R, Pettina G, Minniti S, Messina G, Coppola T, Principato G, Arrigo F, Barillaro G, Troiano D, Polisca A and Zappone V \(2025\) Influence of gonadectomy and age at gonadectomy on the risk of developing intervertebral disc herniation in French Bulldogs: a retrospective study. Front. Vet. Sci. 12:1729833.](#)

Labrador Retrievers neutered before 12 months of age had a significantly increased risk of cranial cruciate ligament rupture compared to intact dogs.

[DeForge TL, et al. Age of neutering contributes to risk of cruciate ligament rupture in Labrador Retrievers. J Am Vet Med Assoc. 2024;262\(5\):619–627.](#)

Gonadectomized dogs had a higher risk of osteoarthritis diagnosis, partly related to altered skeletal development and increased body weight.

[Graves JL, McKenzie BA, Koch Z, et al. Body weight, gonadectomy, and other risk factors for diagnosis of osteoarthritis in companion dogs. Front Vet Sci. 2023;10:1275964.](#)

Across 35 dog breeds, early neutering (first year of life) was associated with increased risks of joint disorders (hip dysplasia, CCL rupture, elbow dysplasia) in a breed-specific manner.

[Hart BL, Hart LA, Thigpen AP, Willits NH. Assisting decision-making on age of neutering for 35 breeds of dogs: associated joint disorders, cancers, and urinary incontinence. Front Vet Sci. 2020;7:388.](#)

German Shepherd Dogs neutered before 1 year of age showed markedly higher rates of joint disorders than intact dogs.

[Hart BL, Hart LA, Thigpen AP, Willits NH. Neutering of German Shepherd Dogs: associated joint disorders, cancers and urinary incontinence. Vet Med Sci. 2016;2\(3\):191–199.](#)

Golden Retrievers neutered early had significantly increased rates of hip dysplasia and cranial cruciate ligament tears versus intact dogs.

[Torres de la Riva G, Hart BL, Farver TB, et al. Neutering dogs: effects on joint disorders and cancers in Golden Retrievers. PLoS One. 2013;8\(2\):e55937.](#)

Gonadectomy altered ligament collagen characteristics in sexually immature male rabbits, supporting a hormone-linked weakening of cruciate ligaments.

[Light VA, Montgomery RD, Wright GM, et al. Sex hormone regulation of collagen concentrations in cranial cruciate ligaments of sexually immature male rabbits. Am J Vet Res. 2012;73\(8\):1186–1191.](#)

Neutering before growth plate closure delays physeal fusion, predisposing large-breed dogs to orthopedic injury.

[Root Kustritz MV. Determining the optimal age for gonadectomy of dogs and cats. J Am Vet Med Assoc. 2007;231\(11\):1665–1675.](#)

Early neuter was associated with an excessive tibial plateau angle in large-breed dogs with cranial cruciate ligament disease, predisposing to joint instability.

[Duerr FM, Duncan CG, Savicky RS, Park RD, Egger EL, Palmer RH. Risk factors for excessive tibial plateau angle in large-breed dogs with cranial cruciate ligament disease. J Am Vet Med Assoc. 2007;231\(11\):1688–1691.](#)

Spay/neuter procedures were associated with a markedly higher prevalence of anterior cruciate ligament injury compared with intact dogs.

[Slauterbeck JR, Pankratz K, Xu KT, Bozeman SC, Hardy DM. Canine ovariohysterectomy and orchiectomy increases the prevalence of ACL injury. Clin Orthop Relat Res. 2004;\(429\):301–305.](#)

Neutering significantly increased the risk of cranial cruciate ligament rupture, with breed, sex, and body weight also contributing.

[Duval JM, Budsberg SC, Flo GL, Sammarco JL. Breed, sex, and body weight as risk factors for rupture of the cranial cruciate ligament in young dogs. J Am Vet Med Assoc. 1999;215\(6\):811–814.](#)

Neutered large-breed dogs had a markedly increased risk of osteosarcoma compared with intact dogs.

[Ru G, Terracini B, Glickman LT. Host related risk factors for canine osteosarcoma. Vet J. 1998;156\(1\):31–39.](#)

Neutering before 12 months of age significantly increased the risk of cranial cruciate ligament rupture in Labrador

[Retrievers.DeForge TL, et al. Age of neutering contributes to risk of cruciate ligament rupture in Labrador Retrievers. J Am Vet Med Assoc. 2024.](#)

Across 35 dog breeds, early neutering (in the first year) was associated with increased risks of joint disorders (hip dysplasia, cranial cruciate ligament rupture, elbow dysplasia) in a breed-specific manner.Hart BL, et al.

[Assisting Decision-Making on Age of Neutering for 35 Breeds of Dogs. Front Vet Sci. 2020.](#)

Updated breed-specific guidance emphasizes delaying neuter to ≥ 12 months in several large breeds due to joint and cancer risk patterns, with notable urinary incontinence prevalence observed when females were spayed <1 year.

[Hart LA, et al. Assisting decision-making on age of neutering for German Short/Wirehaired Pointer, Mastiff, Newfoundland, Rhodesian Ridgeback, Siberian Husky. Front Vet Sci. 2024.](#)

Early spay/neuter delays growth plate closure, increasing risks of joint disorders and long bone injuries. Kustritz MV.

[Determining the optimal age for gonadectomy of dogs and cats. J Am Vet Med Assoc. 2007.](#)

Neutered dogs, especially large breeds, are at significantly increased risk of cranial cruciate ligament rupture.

[Duval JM, et al. Breed, sex, and body weight as risk factors for rupture of the cranial cruciate ligament in young dogs. J Am Vet Med Assoc. 1999.](#)

Spay/neuter procedures are associated with a marked rise in anterior cruciate ligament injuries. Slauterbeck JR, et al.

[Canine ovariectomy and orchiectomy increases the prevalence of ACL injury. Clin Orthop Relat Res. 2004.](#)

Osteoarthritis risk is significantly higher in gonadectomized dogs compared to intact animals. Graves JL, et al.

[Body weight, gonadectomy, and other risk factors for diagnosis of osteoarthritis in companion dogs. Front Vet Sci. 2023.](#)

Experimental gonadectomy altered cruciate ligament collagen homeostasis in male rabbits, supporting hormone-linked ligament weakening and instability. Light VA, et al.

[Sex hormone regulation of collagen concentrations in cranial cruciate ligaments of sexually immature male rabbits. Am J Vet Res. 2012.](#)



Metabolic Effects

(Obesity and Energy Balance)

Spaying and neutering significantly increased the risk of obesity in dogs by altering hormonal control of appetite and metabolism.

[Palestrini C, Mazzola SM, Caione B, et al. The influence of gonadectomy on canine bodyweight. Animals \(Basel\). 2021;11\(2\):553.](#)

Dogs neutered at a younger age had reduced activity levels, which can contribute to post-gonadectomy weight gain and obesity.

[Harrison JL, et al. Association between neuter status and physical activity in companion dogs. Front Vet Sci. 2021;8:696902.](#)

Experimental gonadectomy in cats led to rapid visceral fat accumulation and metabolic dysregulation, supporting a direct role of sex hormones in energy balance.

[Wei A, Fascetti AJ, Villaverde C, et al. Effect of gonadectomy on body weight, body composition, and energy expenditure in adult cats. J Anim Sci. 2014;92\(5\):1999–2007.](#)

After gonadectomy, overweight status was significantly more common, linking spay/neuter with later life body-condition problems.

[Lefebvre SL, Yang M, Wang M, Elliott DA, Buff PR, Lund EM. Effect of age at gonadectomy on the probability of dogs becoming overweight. J Am Vet Med Assoc. 2013;243\(2\):236–243.](#)

Neutered dogs were more likely to become obese than intact dogs, even when eating similar diets.

[Colliard L, Ancel J, Benet JJ, Paragon BM, Blanchard G. Risk factors for obesity in dogs in France. J Nutr. 2006;136\(7 Suppl\):1951S–1954S.](#)

Removal of gonads predisposed animals to metabolic changes that increase the risk of weight gain and obesity.

[German AJ. Obesity in companion animals: what is happening and what can be done? J Nutr. 2006;136\(7 Suppl\):1940S–1946S.](#)

In Australian veterinary practices, neutered dogs were significantly more likely to be obese than intact dogs.

[McGreevy PD, Thomson PC, Pride C, Fawcett A, Grassi T, Jones B. Prevalence of obesity in dogs examined by Australian veterinary practices and the risk factors involved. Vet Rec. 2005;156\(22\):695–702.](#)

Gonadectomy increased food intake and body fat percentage, contributing to rapid weight gain.

[Kanchuk ML, Backus RC, Calvert CC, Morris JG, Rogers QR. Weight gain in gonadectomized cats fed ad libitum. J Nutr. 2003;133\(6\):1866–1874.](#)



Neutering elevated leptin concentrations, favoring fat storage and making weight management more difficult.

[Martin L, Siliart B, Dumon H, Backus R, Biourge V, Nguyen P. Leptin, body fat content and energy metabolism in neutered dogs. J Anim Physiol Anim Nutr \(Berl\). 2001;85\(7-8\):195–199.](#)

After spaying or neutering, dogs showed decreased energy requirements, increasing their risk of weight gain if fed as before surgery.

[Flynn MF, Hardie EM, Armstrong PJ. Effect of ovariectomy on maintenance energy requirement in dogs. J Am Vet Med Assoc. 1996;209\(9\):1572–1581.](#)

Obesity following neutering predisposes dogs to additional chronic conditions like diabetes, arthritis, and urinary issues.

[Weeth LP. Vet Clin North Am Small Anim Pract. 2016;46\(5\):843–853.](#)

Large-scale veterinary surveys consistently show neutered dogs have the highest obesity rates compared to intact populations. Banfield® Pet Hospitals. State of Pet Health Report, 2024.

[Buller K, Fajt V, Gale S, et al. Assessing the risk of becoming overweight or obese among spayed or neutered dogs. PLOS ONE. 2025.](#)

Neutering significantly increases the risk of several immune-mediated diseases, including lupus and hypothyroidism.

[Sundburg CR, Belanger JM, Bannasch DL, Famula TR, Oberbauer AM. BMC Vet Res. 2016;12:278.](#)



Endocrine Effects

(Thyroid, Adrenal, and Diabetes)

Understanding the effects of sustained supraphysiologic concentrations of luteinizing hormone in gonadectomized dogs: What we know and what we still need to learn

[Kutzler MA. Understanding the effects of sustained supraphysiologic concentrations of luteinizing hormone in gonadectomized dogs: What we know and what we still need to learn. Theriogenology Vol 196, 15 January 2023 Pages 270-274](#)

Exploring How Spay/Neuter Impacts Long-Term Health in Dogs

American Kennel Club Canine Health Foundation

[AKC Canine Health Foundation | Exploring How Spay/Neuter Impacts Long-Term Health in Dogs](#)

Possible relationship between long-term adverse health effects of gonad-removing surgical sterilization and luteinizing hormone in dogs

[Kutzler MA. Possible Relationship between Long-Term Adverse Health Effects of Gonad-Removing Surgical Sterilization and Luteinizing Hormone in Dogs. Animals. 2020; 10\(4\):599.](#)

Hypoadrenocorticism (Addison's disease) occurred more frequently in neutered animals than in intact dogs.

[Hupfeld J, Dölle M, Volk H, Rieder J. Evaluation of risk factors for hypoadrenocorticism in dogs. Vet Rec. 2022;191\(10\):e1977.](#)

Sustained supraphysiologic LH concentrations after gonadectomy were suggested to negatively affect multiple endocrine organs, including adrenal glands.

Romagnoli S, et al. Understanding the effects of sustained supraphysiologic concentrations of luteinizing hormone in gonadectomized dogs: what we know and what we still need to learn. Theriogenology. 2022;188:159–168.

Neutered dogs had significantly higher odds of several immune-mediated diseases, including hypothyroidism.

Sundburg CR, Belanger JM, Bannasch DL, Famula TR, Oberbauer AM. Gonadectomy effects on the risk of immune disorders in the dog: a retrospective study. BMC Vet Res. 2016;12:278.

Chronic post-gonadectomy luteinizing hormone elevations were proposed as a mechanistic contributor to non-reproductive endocrine disorders.

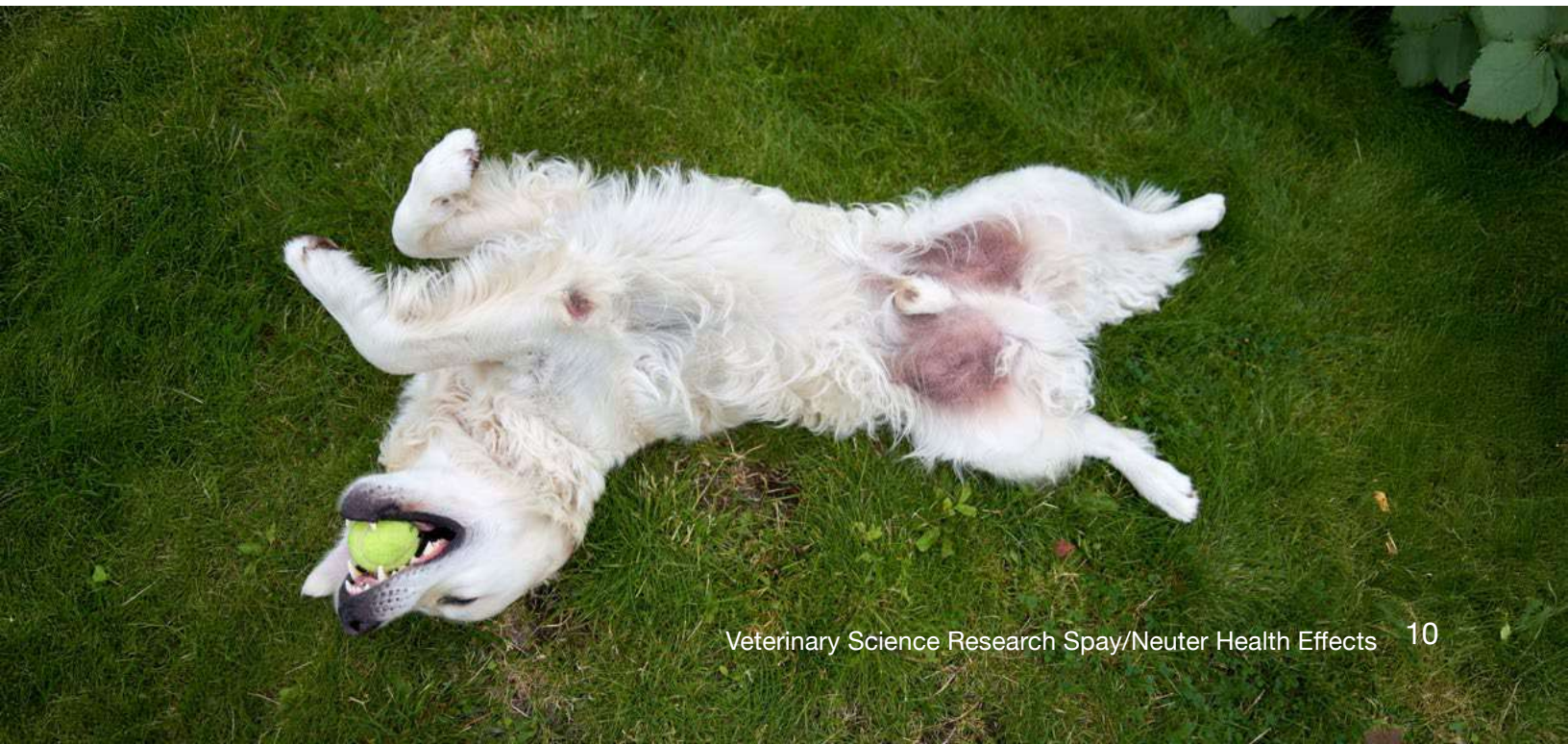
Zwida K, Kutzler MA. Non-reproductive long-term health complications of gonad removal in dogs and cats. Presented via Parsemus Foundation, 2016.

Neutered dogs had a higher risk of developing diabetes mellitus compared with intact dogs under primary veterinary care.

Mattin MJ, O'Neill DG, Church DB, McGreevy PD, Thomson PC, Brodbelt DC. An epidemiological study of diabetes mellitus in dogs attending first opinion practice in the UK. Vet Rec. 2014;174(14):349.

Neutered dogs were overrepresented among hypothyroid dogs, suggesting that gonadectomy may be a risk factor for thyroid hormone deficiency.

Panciera DL. Hypothyroidism in dogs: 66 cases (1987–1992). J Am Vet Med Assoc. 1994;204(5):761–767.



Immune-Mediated, Allergic, and Gastrointestinal Effects

Neuter status was associated with higher risk for inflammatory bowel disease, suggesting that removal of sex steroids may impair gut immune regulation.

[Díaz-Regañón D, Sainz Á, Rodríguez-Franco F, et al. Risk factors for canine chronic enteropathies. Vet Sci. 2023;10\(7\):405.](#)

Neutered dogs showed increased risk of several immune-mediated diseases, including lupus-like disease, autoimmune hemolytic anemia, and immune-mediated thrombocytopenia.

[Sundburg CR, Belanger JM, Bannasch DL, Famula TR, Oberbauer AM. Gonadectomy effects on the risk of immune disorders in the dog: a retrospective study. BMC Vet Res. 2016;12:278.](#)

Spayed and neutered dogs had an increased risk of atopic dermatitis compared with intact dogs.

[Nødtvedt A, Egenvall A, Bergvall K, Hedhammar A. Incidence of and risk factors for atopic dermatitis in a Swedish population of insured dogs. Vet Dermatol. 2006;17\(1\):7–18.](#)



Behavioral and Cognitive Effects



Determining the earliest age for neutering and spaying specific companion dogs

[Krishna Prasad Acharya, Sarita Phuyal, Lynette Arnason Hart, and Benjamin L. Hart. Determining the earliest age for neutering and spaying specific companion dogs. Open Veterinary Journal, 2025, Vol.15, 2284-2285](#)

Exploring behavioral outcomes of gonadectomy in pets: a need for personalized approaches

[Guimarães FB, Barreto RO, Apparício M. Exploring behavioral outcomes of gonadectomy in pets: a need for personalized approaches. Anim Reprod. 2026;23\(3\):e20250125](#)

Spay/neuter was associated with increased fearfulness, anxiety, and noise sensitivity in many dogs.

[Farhooody P, Mallawaarachchi I, Tarwater PM, Serpell JA, Duffy DL, Zink CM. Behavioral and physical effects of spaying and neutering domestic dogs \(Canis familiaris\). Front Vet Sci. 2018;5:18.](#)

Dogs neutered before puberty showed significantly more fear-based aggression, resource guarding, and reactivity.

[Balogh O, Borruat N, Meier A, Hartnack S, Reichler IM. The influence of spaying and neutering on behavioral problems in dogs. Reprod Domest Anim. 2018;53\(5\):1184–1190.](#)

Ovariohysterectomy increased reactivity in German Shepherd Dogs, indicating a behavioral impact of gonad removal.

[Kim HH, Yeon SC, Houpt KA, Lee HC, Chang HH, Lee HJ. Effects of ovariohysterectomy on reactivity in German Shepherd Dogs. Vet J. 2006;172\(1\):154–159.](#)

Early-age gonadectomy was associated with increased noise phobia, separation anxiety, and other undesirable behaviors.

[Spain CV, Scarlett JM, Houpt KA. Long-term risks and benefits of early-age gonadectomy in dogs. J Am Vet Med Assoc. 2004;224\(3\):380–387.](#)

Gonadectomy appeared to increase the risk of age-related cognitive impairment in dogs.

[Hart BL. Effect of gonadectomy on subsequent development of age-related cognitive impairment in dogs. J Am Vet Med Assoc. 2001;219\(1\):51–56.](#)

Urinary Tract Effects

Urinary incontinence and inappropriate urination were more common in neutered bitches than in intact females under primary care.

O'Neill DG, Riddell A, Church DB, Owen L, Brodbelt DC, Hall JL. Urinary incontinence in bitches under primary veterinary care in England. J Small Anim Pract. 2017;58(12):685–693.

Spayed female dogs had a substantially higher prevalence of urinary incontinence (urethral sphincter mechanism incompetence) than intact females.

Forsee KM, Davis GJ, Mouat EE, Salmeri KR, Bastian RP. Evaluation of the prevalence of urinary incontinence in spayed female dogs: 566 cases (2003–2008). J Am Vet Med Assoc. 2013;242(7):959–962.

Early-age spaying markedly increased the risk of acquired urethral sphincter mechanism incompetence.

de Bleser B, Brodbelt DC, Gregory NG, Martinez TA. The association between acquired urinary incontinence and early neutering in bitches. Vet J. 2011;187(1):42–47.

Spaying at an early age significantly increased the lifetime risk of urethral sphincter mechanism incompetence in bitches.

Thrusfield MV, Holt PE, Muirhead RH. Acquired urinary incontinence in bitches: its incidence and relationship to neutering. Vet Rec. 1998;143(19):539–542.

Male dogs developed urethral sphincter mechanism incompetence, often in association with neuter status.

Aaron A, Eggleton K, Power C, Holt PE. Urethral sphincter mechanism incompetence in male dogs: a retrospective analysis of 54 cases. Vet Rec. 1996;139(24):592–597.

Neoplastic (Cancer) Risks



Systematic Review: Does Pre-Pubertal Spaying Reduce the Risk of Canine Mammary Tumours?

[Guirguis P, Beggs DS. Systematic Review: Does Pre-Pubertal Spaying Reduce the Risk of Canine Mammary Tumours? Animals. 2025; 15\(3\):436.](#)

Assisting decision-making on age of neutering for German Short/Wirehaired Pointer, Mastiff, Newfoundland, Rhodesian Ridgeback, Siberian Husky: associated joint disorders, cancers, and urinary incontinence

[Hart LA, Thigpen AP, Hart BL, Willits NH, Lee M, Babchuk MM, Lee J, Ho M, Clarkson ST and Chou JW \(2024\) Assisting decision-making on age of neutering for German Short/Wirehaired Pointer, Mastiff, Newfoundland, Rhodesian Ridgeback, Siberian Husky: associated joint disorders, cancers, and urinary incontinence. Front. Vet. Sci. 11:1322276.](#)

German Shepherd Dogs neutered early had higher rates of various cancers than intact counterparts.

[Hart BL, Hart LA, Thigpen AP, Willits NH. Neutering of German Shepherd Dogs: associated joint disorders, cancers and urinary incontinence. Vet Med Sci. 2016;2\(3\):191–199.](#)

[Beauvais W, et al. The effect of neutering on the risk of mammary tumours in dogs – a systematic review. J Small Anim Pract. 2012.](#)

Spaying after the first estrus increased the risk of aggressive mammary tumors compared with earlier spaying.

[Salas Y, Márquez A, Díaz D, Romero L. Epidemiological study of canine mammary tumors: age, breed, size and malignancy. PLoS One. 2015;10\(5\):e0127381.](#)

Vizslas that were neutered had increased lifetime cancer risk and earlier onset of malignant disease compared with intact Vizslas.

Zink MC, Farhoody P, Elser SE, Ruffini LD, Gibbons TA, Rieger RH. Evaluation of the risk and age of onset of cancer and behavioral disorders in gonadectomized Vizslas. J Am Vet Med Assoc. 2014;244(3):309–319.

Early or conventional neutering was associated with increased risk of several malignancies, including lymphoma, osteosarcoma, and hemangiosarcoma, in certain breeds.

Torres de la Riva G, Hart BL, Farver TB, et al. Neutering dogs: effects on joint disorders and cancers in Golden Retrievers. PLoS One. 2013;8(2):e55937.

Neutered dogs had a significantly higher odds ratio for developing lymphoma compared with intact animals.

Villamil JA, Henry CJ, Bryan JN, Ellersieck M, Schultz L, Tyler JW. Identification of the most common cutaneous neoplasms in dogs and evaluation of breed and age distributions for selected neoplasms. J Vet Intern Med. 2009;23(3):633–639.

Neutered dogs had an increased risk of transitional cell carcinoma of the urinary bladder compared with intact dogs.

Bryan JN, Keeler MR, Henry CJ, Bryan ME, Hahn AW, Caldwell CW. Urinary bladder transitional cell carcinoma in dogs: a study of neuter status and other risk factors. Vet Comp Oncol. 2007;5(2):63–72.

Neutered male dogs had a significantly higher risk of developing prostate carcinoma than intact males.

Bryan JM, Keeler MR, Henry CJ, Bryan ME, Hahn AW, Caldwell CW. A population study of neutering status as a risk factor for canine prostate cancer. Prostate. 2007;67(11):1174–1181.



Mammary Cancer Information



Evidence does not support the idea that neutering reliably reduces mammary cancer risk; data are weak and inconsistent.

[Beauvais W, Cardwell JM, Brodbelt DC. The effect of neutering on the risk of mammary tumours in dogs—a systematic review. J Small Anim Pract. 2012.](#)

Systematic review found that many studies supporting mammary tumor prevention were biased or methodologically weak.

[Burke W, et al. Mammary Neoplasia Review. Animals \(Basel\). 2024;15\(3\):436.](#)

Additional Resources:

Hormone-Sparing Sterilization & Education



Parsemus Foundation

The Parsemus Foundation provides a comprehensive directory of veterinarians offering hormone-sparing sterilization options—including vasectomy, ovary-sparing spay (OSS), and partial hysterectomy—as well as veterinarians who provide hormone replacement therapy (HRT) for spayed and neutered dogs.

[Visit Parsemus Foundation](#)



To learn more about hormone health, pet parents can watch the free educational video series created by Dr. Karen Becker and Dr. Peter Dobias at:

<https://www.hormonehealthfordogs.org>



Click [here](#) to sign Dr. Becker's petition to vet schools around the world to teach hormone-sparing surgical techniques.

