Universiteit Utrecht

Department Clinical Sciences, Internal Medicine, Companion Animal Reproduction

Incidence of urinary incontinence after ovariectomy in Great Swiss Mountain dogs compared to similar sized dog breeds

MASTER THESIS

Name: Dieuwertje Heilig

Student number: 5837154

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Project tutor: Jeffrey de Gier

Abstract

Pet dogs have gained an important place in our households in the last century. While ovariectomy was previously considered the standard, more and more is known about the risk factors that come with this intervention. Advantages of ovariectomy include decreased chance on developing mammary tumours, ovarian diseases, uterine diseases, vaginal fold hyperplasia, as well as progestogen dependent diabetes mellitus, behavioural issues and pseudopregnancy. However, ovariectomy increase the risk on developing metabolic and endocrine disorders, behavioural concerns, coat changes and neoplastic disorders, but also orthopaedic diseases and immune disorders.

On the one hand, a literature study was done on these risk factors, with a main focus on Urethral Sphincter Mechanism Incompetence (USMI), the most prevalent cause of urinary incontinence (UI).

On the other hand, a questionnaire-based study was done to investigate the incidence of UI following ovariectomy (OVE) in Great Swiss Mountain dogs compared to a population of similar sized breeds, and risk factors such as the age at OVE and number of oestrous cycles prior to OVE related to the developing of UI. The questionnaire was distributed online to owners of Great Swiss Mountain dogs, and similar sized dog breeds.

A total of 489 questionnaires were analysed, with 60 responses pertaining to Great Swiss Mountain dogs and 429 to a reference population consisting of various large dog breeds. Among the Great Swiss Mountain dogs, 59.9% of ovariectomized dogs developed UI. This was significantly higher than the 21.3% incidence in the reference population and 11.8% incidence in the subpopulation Labrador Retrievers.

No significant relationship was found between age at OVE or the number of oestrous cycles and the development of UI.

Our findings accentuate the need for veterinarians to inform Great Swiss Mountain dog owners about the higher risk of UI after OVE, and to highlight the importance of weighing the advantages and disadvantages of ovariectomising their dog.

Abbreviations

ACVIM= American College of Veterinary Internal Medicine

AUS=artificial urethral sphincter

CI= confidence interval

EU=ectopic ureters

FOO=functional outflow obstruction

FSH=follicle stimulating hormone

GnRH=gonadotropin-releasing hormone

LH=luteinizing hormone

LUT=lower urinary tract

MOO=mechanical outflow obstruction

OVE=ovariectomy

OVH=ovariohysterectomy

PPA=phenylpropanolamine

UI=urinary incontinence

USMI=urethral sphincter mechanism incompetence

WSAVA=World Small Animal Veterinary Association

1. Introduction

Pet dogs have gained an important place in our households in the last century[1]. Especially in the developed countries, dogs are seen as a part of the family and dog owners want to receive the best care and advise on preventive health from the veterinarian. This has also led to increased attention to preventive care for animals, including vaccination and deworming. Elective surgeries such as ovariectomy are therefore often discussed during the first visits of a puppy and its owner to the veterinarian. Considering that, the decision to perform gonadectomy should be done in consideration of sex, breed, purpose and lifestyle of the dog. This is where the veterinarian plays an important advisory role. Gonadectomy is an elective surgical procedure that has been the subject of research for many years. From that research, more and more information on the advantages and disadvantages of gonadectomising pet dogs is known, but there is still a lot to be learned. The goal of this review is to fill in some more of the blank spots, focussing on urinary incontinence (UI) specifically in Great Swiss Mountain dogs, and to give the best possible advice to pet dog owners about gonadectomy.

Gonadectomy of female dogs, or ovariectomy (OVE), is the surgical, irreversible removal of the ovaries. When looking at responsible pet ownership, this method is commonly used to prevent pregnancy, as well as eliminating the risk of diseases of the reproductive tract such as mammary tumours, ovarian diseases, uterine diseases, vaginal fold hyperplasia, as well as progestogen dependent diabetes mellitus, behavioural issues and pseudopregnancy [1-3].

Mammary tumours are the most frequently diagnosed tumours in intact bitches. There is a large range of occurrence: between 8.4 and 52%[4,1,2,5].

In ovariectomised dogs, the incidence in one study is found to be 1.8%, although it is dependent on the age at OVE[6]. 50% of mammary tumours are malignant [4]. Breed predispositions have been found in Springer Spaniels, Cocker Spaniels, Boxers, Poodles and Dachshunds[1]. Additionally, epidemiological studies have suggested that there is a decreased incidence of mammary tumours in dogs that are ovariectomised before the first oestrus compared to dogs that are ovariectomised later in life[5]. It has been suggested progesterone and oestrogen have multifactorial effects on the mammary gland stem cells and epithelial cells during the first oestrus[1]. However, these studies are over 40 years old and the systematic review of Beauvais et al. (2012) suggested that the scientific level of these studies are too weak to draw a conclusion from [7].

Logically, OVE prevents ovarian diseases due to the ovaries no longer being present. For example, ovarian cysts cover 80% of all ovarian diseases, but ovarian tumours have a lower incidence (0.5 – 6.5%). However, these numbers might be underestimated because many dogs are ovariectomised[1].

Uterine diseases include tumours, pyometra and pathological pregnancies. A study in Sweden showed that the mean age of diagnosis of pyometra was 8 years. 19% of all intact bitches had been affected by the age of 10 years [2]. This study also found several breed predispositions in Rough Collies, Rottweilers, Cavalier King Charles Spaniels, Golden Retrievers, Bernese Mountain dogs and English Cocker Spaniels[2].

Progestogen dependent diabetes mellitus is comparable to human gestational diabetes. It is caused by an elevated plasma progesterone concentration during dioestrus. This can cause a temporary decrease in insulin sensitivity[1]. There has been found a breed predisposition in Norwegian and Swedish Elkhounds[1].

Pseudopregnancy, or pseudocyesis, is a behaviour syndrome that is observed in intact bitches and is caused by an increase of the pituitary hormone prolactin[8]. The intensity of the symptoms is very variable from almost no symptoms to clinically relevant symptoms that require treatment. The symptoms include swelling of the mammary glands and behavioural changes such as restlessness, anorexia, maternal aggression and maternal behaviours like nesting, digging and mothering over inanimate objects or other small animals[1,8]. Pseudocyesis is considered a physiological event but could nevertheless be a burden for the dog as well as the owner [1,8].

Despite the advantages of OVE, more and more evidence is found regarding the disadvantages of OVE as well. Mainly metabolic and endocrine disorders, such as UI, behavioural concerns, coat changes and neoplastic disorders, but also orthopaedic diseases and immune disorders[1].

Up to 68% of the gonadectomised dogs are suffering from obesity. This is caused via two mechanisms: increased appetite and decreased metabolic rate [9]. This is especially the case in small dog breeds or toy breeds (bodyweight < 10kg)[1].

Another concern of gonadectomy is the behavioural changes that can occur. For example: aggression or fear-based behaviour. There are signs that changes can occur, but there is insufficient knowledge to predict how gonadectomy affects the behaviour of an individual animal[1].

Certain breeds, including the Irish Setter, Cocker Spaniel, Longhaired Dachshund, Eurasier, Chow Chow, Golden Retriever, Newfoundland, and Landseer, are predisposed to coat changes following OVE. Affected dogs experience an increase in wool-like hair and a decrease in coat colour intensity. This altered coat is commonly referred to as a "puppy coat[10].

Especially large dog breeds are predisposed to develop neoplastic disorders as a result of OVE, such as osteosarcoma, lymphoma and hemangiosarcoma[1,11,12].

Firstly, osteosarcoma is a malignant tumour that originates in the transformed mesenchymal cells. Risk factors are breed, size, bodyweight and loss of sexual steroids. Ovariectomised Irish Wolfhounds, Leonbergers, Newfoundlanders and Labrador Retrievers seem to be affected frequently, where the incidence is significantly higher in the Irish Wolfhounds and Leonbergers compared to Newfoundlanders and Labrador Retrievers[12].

Secondly, lymphomas are tumours of the whole lymphatic system, including blood- and lymph tumours. There seem to be breed predispositions for ovariectomised Golden Retrievers, Australian Shepards and Vizslas[13,11,12].

At last, hemangiosarcomas originate from pluripotent bone marrow progenitor cells. This tumour can occur in all breeds, but studies found breed predisposition for German Shepherds, Golden Retrievers and Labrador Retrievers, especially ovariectomised dogs with an age >7 years[1].

The odds of developing orthopaedic diseases, such as hip dysplasia, elbow dysplasia, cranial cruciate ligament insufficiency, osteochondrosis dissecans, panosteitis and intervertebral disc disease, increase with gonadectomy. This seems to be the case especially in large and heavy breeds and when the gonadectomy is done before 6 months of age[1,6].

OVE also increases the risk of developing Urethral Sphincter Mechanism Incompetence (USMI). USMI is a type of urinary incontinence (UI). UI refers to the involuntary loss of urine, without the dog being consciously aware of it. This may involve the leakage of just a few drops of urine, or in some cases, a small puddle of urine may appear even though the dog was not actively urinating. USMI develops in 3% to 21% of ovariectomised bitches, in comparison with 0-1% in intact bitches[14]. It mainly occurs in large dog breeds with a bodyweight over >25kg and in known breed predispositions [3]. The persistence of USMI can cause irritation of the skin and lower urinary tract infections for the bitch. In addition, it causes hygiene and management problems for the owner [15]. This condition seems to be the consequence of hormonal changes caused by OVE[14].

Anecdotally, there was found an indication that the incidence of UI is higher in the Great Swiss Mountain dog compared to other large dog breeds. This has not yet been described in the available literature. Because there are already known breed predispositions, it is important to investigate this indication. The results can be used in the veterinary practice to inform dog-owners as good as possible.

The first part of this study consists of literature research on the pathophysiology of USMI, the diagnosis and the available treatment options. The second part of this study consists of the results of a questionnaire-based study on the incidence of UI in a population Great Swiss Mountain dogs compared to a reference population.

An existing questionnaire on UI was used for this study and questions related to OVE were added. Owners of Great Swiss Mountain dogs and other large dog breeds were invited to fill in the questionnaire. The questionnaire was distributed online through different Facebook groups.

Earlier this year, a world-wide consensus statement by the American College of Veterinary Internal Medicine (ACVIM) on the diagnosis and management of UI in dogs[3], and the World Small Animal Veterinary Association (WSAVA) guidelines for the control of reproduction in dogs and cats were released. This shows the importance of these topics and that the veterinary community was in need of up-to-date information on this subject. This review might be a refinement on these guidelines.

The goal of this study was to investigate the incidence of UI in ovariectomised Great Swiss Mountain dogs compared to a group similar sized ovariectomised bitches of other breeds to analyse if there is indeed a breed predisposition present in Great Swiss Mountain dogs. Furthermore, we analysed risk factors such as the age at OVE and number of oestrous cycles prior to OVE related to the developing of UI. The results of this review may help refine the advice for Great Swiss Mountain dog owners about the risks of OVE as good as possible.

2. Literature study

1.1 Urethral Sphincter Mechanism Incompetence

Urinary incontinence (UI) refers to the involuntary loss of urine, without the dog being consciously aware of it. This may involve the leakage of just a few drops of urine, or in some cases, a small puddle of urine may appear even though the dog was not actively urinating. Leaking urine can cause irritation of the skin, pain and discomfort. Another complication of UI is ascending lower urinary tract infections. Additionally, UI causes sanitary and management problems for the owner [15]. In addition, the dog will need medication for the rest of its life.

Disorders causing UI can be categorised in disorders of storage and disorders of voiding. Storage disorders include Urethral Sphincter Mechanism Incompetence (USMI), ectopic ureters (EU) and detrusor instability. Voiding disorders include functional and mechanical outflow obstruction (FOO and MOO) and atonic bladder [3].

USMI is the most frequent storage disorder seen in dogs [3] and is mostly associated with the change in sex hormones after gonadectomising male and female dogs. Another storage disorder is the presence of ectopic ureters which is a congenital disease. UI caused by FOO or MOO is the result of the bladder pressure exceeding the urethral pressure and causing overflow UI [3].

OVE is one of the main causes of USMI in bitches [9]. It is more prevalent in dog breeds with a bodyweight over 25kg, and certain breeds are predisposed[16,3].

There is still a lot of unclarity about what exactly causes USMI. Literature reveals that OVE causes changes in the reproduction tract in two ways: one, through hormonal changes and two, through physical changes to the urinary bladder. Before we go into the hormonal changes causing USMI, we explain the reproductive endocrinology.

1.2 Reproductive endocrinology

In an adult bitch, the reproduction, e.g. the oestrous cycle and pregnancy are regulated through the hypothalamus-pituitary-axis. Gonadotropin-releasing hormone (GnRH) is secreted by the hypothalamus. GnRH stimulates the anterior pituitary gland to release the luteinizing hormone (LH) and follicle stimulating hormone (FSH). LH and FSH are required for the complete oestrus cycle (folliculogenesis, ovulation and luteal phase, including regulation of the secretion of female gonadal hormones: oestrogen and progesterone). The gonadal hormones give negative feedback to the hypothalamus and anterior pituitary to decrease secretion of GnRH and LH and FSH, respectively.

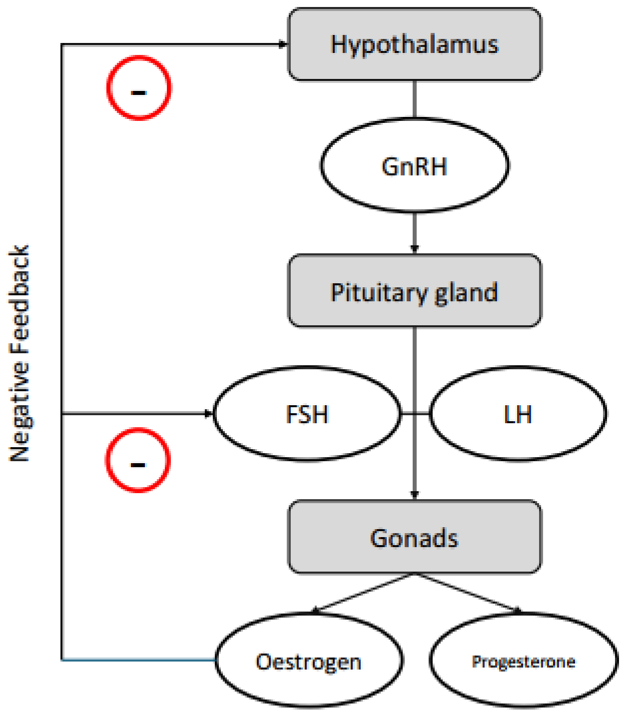

Figure 1 A simplified overview of the hypothalamic-pituitary-gonadal axis.
Note. Created by the author.

1.3 Proposed endocrine changes causing USMI

In the ovariectomised bitch, however, the gonads are removed so the plasma concentration of gonadal hormones decrease drastically. This results in a lack of negative gonadal feedback from gonadal hormones to the hypothalamus, resulting in elevated GnRH plasma concentrations. Consequently, circulating LH plasma concentrations increase to more than 30 times than plasma concentrations found in intact bitches[9], as well as increased FSH plasma concentrations[17].

Summarizing, OVE causes multiple alterations in hormone plasma concentrations. The removal of the gonads results in low plasma concentrations of gonadal hormones and consequently increased GnRH, LH and FSH concentrations, the so-called castration response.

It is thought a direct relationship exists between OVE and USMI[14]. Unfortunately, it is still poorly understood what exactly is the causal relationship between OVE and USMI. It is generally assumed that the decrease of the oestradiol plasma concentration is the cause because this leads to a decrease of urethral closing pressure. This idea is supported by the successful treatment with oestradiol. However, oestradiol treatment is only successful in 61-65% of the bitches[14]. This suggests that the decreased oestradiol concentration cannot be the only factor causing USMI. Additionally, the plasma oestradiol concentration in ovariectomised bitches is the same as the oestradiol concentration of intact bitches in anoestrus[14].

1.4 Proposed physical changes causing USMI

OVE is associated with structural modifications of the urinary bladder and urethra. The urinary bladder wall is less responsive to stimulation (through electrical stimulation and stimulation through a muscarine agonist) and a decrease in sensitivity to the muscarine agonist. This could lead to a lower bladder muscle strength and contractility and thus could be a cause of USMI[18,19]. Additionally, there is a decreased proportion of smooth muscle and an increase of the proportion of collagen in both the bladder and urethra. Functionally, this means a decreased bladder wall compliance. Furthermore, there is an inverse relationship between the degree of bladder contraction and bladder wall collagen content which means that the contractility is impaired as a result of a bigger proportion of collagen[19]. The study of Coit et al. (2008) showed that ovariectomy causes increased mRNA expression levels for LH receptors in the canine urinary bladder[18]. The treatment with GnRH implants can be successful in treating USMI. With this treatment, the plasma LH and FSH concentration decrease[16].

In conclusion, there seems to be an association between the lack of gonadal hormones and USMI[20].

1.5 Diagnosis of Urethral Sphincter Mechanism Incompetence

According to the ACVIM consensus statement (see figure 1), the first step when a dog with UI is presented in the first line veterinary practice, is to determine if the dog really has UI, or if it's consciously voiding [3]. To distinguish between this, questions need to be asked to the owner about when and where the UI occurs, what frequency and the timing. For bitches, recognition of the pattern illustrated from the history often leads presumptively to the diagnosis of USMI. To be able to distinguish between USMI and other storage disorders as previously mentioned, the activity associated with the UI must be understood. Female dogs with USMI usually leak urine while laying down or when they are resting. Because that is when the intravesicular pressure in the urine bladder overcomes the weak urethral sphincter mechanism[3].

In addition to obtaining information on the dog's urinary behaviour, it can be helpful to observe the dog while urinating. This can be done in real life or by watching a video[3].

Step two is a thorough physical examination, including urethral palpation through a rectal exam and bladder palpation as well as a neurological examination with focus on behaviour, gait, hindlimb postural reactions, spinal reflexes, tail tone and presence or absence of back pain. The vulva should be examined for evidence of dermatitis, saliva staining or degree of excessive perivulvar skin (ie, vulvar hooding)[3].

The third step is urinalysis and bacterial urine culture. The symptoms of lower urinary tract (LUT) infection can be similar to the symptoms of USMI, so it is important to exclude LUT infection before diagnosing USMI[3].

When no irregularities are found, a treatment with either phenylpropanolamine (PPA/Propalin®) or oestradiol can be started. According to the ACVIM statement, treatment is usually started with PPA. If there is no adequate response after 28 days, further diagnostics must be done. For example, urodynamic testing, diagnostic imaging and endourology[3].

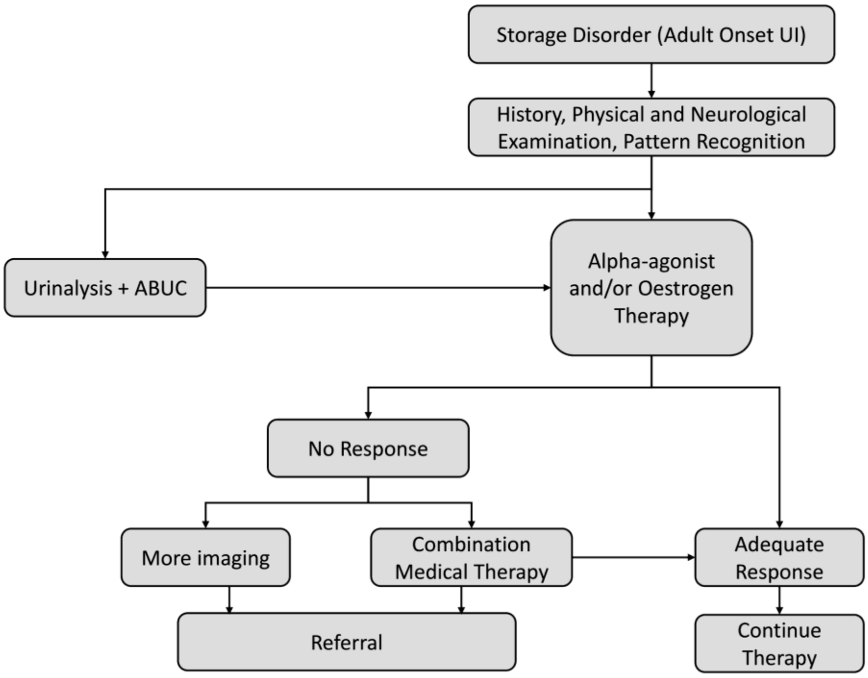

Figure 2 Flow-chart diagnosing USMI (modified and simplified from: ACVIM consensus statement on diagnosis and management of urinary incontinence in dogs[3]).

1.6 Current medical treatment options

The different medical interventions that are used in the veterinary practice are: Alpha- and beta-adrenoreceptor agonists, oestrogen compounds and a GnRH implant [3].

1.6.1 Alpha- and beta-adrenoreceptor agonists

The first choice of therapy is an alpha-adrenergic agonist, such as phenylpropanolamine (PPA/Propalin®/Tensurin®). 50% of the urethral closure pressure is maintained by sympathetic activation of alpha-adrenoreceptors in the smooth muscle of the urethra. Therefore, the initial treatment of USMI in female dogs is an alpha-agonist. This has the same effect as catecholamines by activating a1-adrenoreceptors. Hereby the urethral closure pressure is increased, and continence is restored. This results in continence in 75% of the incontinent bitches [21].

Another kind of medical therapy that is used often is ephedrine hydrochloride (Enurace®). Ephedrine stimulates the alpha- and beta-adrenoreceptors directly. This happens in the whole body, but the most important is that it causes contraction of internal urethral muscles and relaxation of the bladder muscles by a sympathomimetic effect as a result of stimulation of the adrenergic receptors.

1.6.2 Oestrogen compounds

An alternative medical treatment, is oestrogen compounds. This is successful in 65% of incontinent dogs. Only short working oestrogens are used nowadays [21].

Oestrogen compounds increase the expression of the alpha-receptors and sensitize the alpha-adrenoreceptors. This way, it makes the alpha-agonists more potent. Oestrogen compounds also increase the urethral sphincter mechanism. If treatment with alpha- and/or beta adrenoreceptor agonists is not enough, oestrogen compounds can be added to the treatment [3].

Adverse effects of oestrogen treatment are: mammary and vulvar swelling, uterine stump enlargement and attractiveness to male dogs. These effects are dose-dependent. It is important to manage the dose per individual. Oestrogen treatment in prepubertal intact female dogs is controversial [3].

1.6.3 GnRH agonist implant

A slow-releasing GnRH implant (Suprelorin®) can be used if alpha-adrenoreceptor agonists induce too many side effects, if they are contraindicated or if the treatment is not adequate. The implant is applicated subcutaneously. A single therapy is successful in 50% of bitches with USMI [22]. GnRH depots release GnRH continuously, and it eventually results via downregulation of the GnRH-receptor in the anterior pituitary in decreased plasma LH and FSH concentrations lasting for months.

Because of the pathophysiology of USMI, it was thought that the effect of GnRH-implants on USMI was caused by normalization of the urethral pressure. However, this was disproved by a study that showed that the urethral pressure was the same before and after GnRH treatment. Other studies assume that GnRH-implants alter the bladder compliance. The results of this study show that the bladder filling volume is doubled after treatment with GnRH [21].

1.7 Current surgical option

1.7.1 Artificial Urethral Sphincter implant (AUS)

When medical treatment of USMI is not sufficient, surgical treatment can be considered. There are different surgical interventions that can be done, but in the Netherlands surgical treatment consists of placement of a permanent artificial urethral sphincter (AUS) [23]. It is a silicone cuff that is placed around the urethra so the sphincter muscle needs to work less hard. The cuff can be inflated through a device that is placed subcutaneously. The study of Gomes et al. (2018) showed that this therapy is successful in 90% of the cases [24].

2. Materials & methods

2.1 Search strategy literature

For this literature study Pubmed was used. The following searching terms were used:

Table 1 MeSH terms for the literature study.

Urinary incontinence	"Urinary Incontinence"[Mesh]
Dogs	"Dogs"[Mesh]
Ovariectomy	"Ovariectomy"[Mesh]
Gonadectomy	"Castration"[Mesh]

From these terms, search blocks were made.

Search blocks

"Dogs"[Mesh] OR "female dog*"[tiab] OR canis*[tiab] OR bitch*[tiab]

"male dog*"[tiab] OR male*[tiab]

"Urinary incontinence" [Mesh] OR urin*[tiab] OR incontinence*[tiab] OR "sphincter incompetence*"[tiab]

"Ovariectomy"[Mesh] OR ovariec*[tiab] OR gonadect*[tiab] OR castrat*[tiab]

Search strategy:

("Dogs"[MeSH Terms] OR "female dog*"[Title/Abstract] OR "canis*"[Title/Abstract] OR "bitch*"[Title/Abstract]) AND ("Urinary incontinence"[MeSH Terms] OR "urin*"[Title/Abstract] OR "incontinence*"[Title/Abstract] OR "sphincter incompetence*"[Title/Abstract]) AND ("Ovariectomy"[MeSH Terms] OR "ovariec*"[Title/Abstract] OR "gonadect*"[Title/Abstract] OR "castrat*"[Title/Abstract])

78 results

I was only interested in articles about female dogs, so I used a new searching strategy:

((("Dogs"[MeSH Terms] OR "female dog*"[Title/Abstract] OR "canis*"[Title/Abstract] OR "bitch*"[Title/Abstract]) AND ("Urinary incontinence"[MeSH Terms] OR "urin*"[Title/Abstract] OR "incontinence*"[Title/Abstract] OR "sphincter incompetence*"[Title/Abstract]) AND ("Ovariectomy"[MeSH Terms] OR "ovariec*"[Title/Abstract] OR "gonadect*"[Title/Abstract] OR "castrat*"[Title/Abstract])) NOT "male"[All Fields]) AND (y_10[Filter])

26 results

Lastly, I used the following selection criteria:

Language: English or German

Species: dogs

Gender: female

The rest of the articles were found through the references of the articles found with the searching strategy above.

2.2 Questionnaire

To investigate the incidence of UI in Great Swiss Mountain dogs compared to other large dog breeds, an existing questionnaire on UI was used for this study and adapted to the specific needs of this subject. The questionnaire was tested by a group of 10 friends, 4 of them were veterinary educated and 6 of them not at all. It was stated that the maximum completion time of the questionnaire was five minutes.

Owners of Great Swiss Mountain dogs and other large dog breeds were invited to fill in the questionnaire. The questionnaire was distributed online through different Facebook groups, only in Dutch.

The questionnaire consisted of four parts, with 26 questions in total (see appendix 1 and 2).

1. General information of the dog, consisting of 4 single closed questions, 1 single open question, and 1 closed question followed by 2 open questions that were dependant on the answer.
2. The living conditions of the dog, consisting of 3 single closed questions and 1 closed question followed by another closed question dependant on the answer.
3. General health of the dog, consisting of 3 single closed questions.
4. Miction behaviour of the dog, consisting of 4 single closed questions, 1 single open question, 1 closed question followed by 1 closed and 1 open question dependant on the answer and 2 closed questions followed by another closed question dependant on the answer.

Because the questionnaire was going to be distributed online only, the goal was to make it as short as possible while still obtaining enough information to allow for reliable conclusions.

2.3 Data collection

The questionnaire was only available in Dutch, and was distributed through different Facebook groups. During the distribution, it seemed that the breed-specific groups were more invested than the non-breed specific (control) group. This resulted in a very small control group. It was then decided to distribute the questionnaire breed-specific groups of large dog breeds as well. For this, the most popular large dog breeds of the Netherlands were selected (Labrador retriever, Bernese Mountain dog, Golden retriever, Rhodesian Ridgeback, Rottweiler and the Swiss White shepherd). Within three days, the reactions went from 19 to 300.

The questionnaire in the Great Swiss Mountain dog Facebook-group was open from 8-7-2024 to 1-9-2024.

The questionnaire in the non-breed specific Facebook-group was open from 8-7 to 1-9-2024.

The questionnaire in the large breed-specific Facebook-groups were open from 22-8-2024 to 1-9-2024.

After closing the questionnaire a total of 688 entries were recorded. The questionnaire was filled in by 111 owners of male dogs and 88 entries were not completed. Because this study focuses on female dogs, both of these categories were deleted. This means a total of 489 completed questionnaires on female dogs were left. Questionnaires that had been completed up to and including whether the dog was incontinent were included.

For some of the conclusions, Pet-scan data were used as well. Pet-Scan is a national database managed by the Expertise Centre for Veterinary Genetics at Utrecht University. This database consolidates diagnoses made by veterinarians across the Netherlands. This dataset consists of 1965 female dogs with a bodyweight of more than 25kg.

The Labrador Retrievers represented the largest group in the reference population. Therefore, they were used as a subpopulation.

2.4 Data analysis

There were two datasets: one with the data of the Great Swiss Mountain dogs and the other with the data from the reference population. At first, the population descriptives (Neuter status, age at ovariectomy, reason of ovariectomy and number of oestrus cycles) were calculated for both of the datasets in RStudio.

To test if the data were normally distributed, we used the Shapiro-Wilk test. A p-value<0.05 means that the data is not normally distributed.

Because none of the data were normally distributed, the non-parametric Wilcoxon rank sum test was used to test the significance of the variables. A p-value>0.05 means that the null-hypothesis can be assumed, and a p-value<0.05 means that the null-hypothesis can be rejected.

Then, multivariable logistic regression was performed to test the influence of the age at OVE and the number of oestrous cycles prior to OVE on the development of UI in the different populations.

The significant difference of incidence of UI after OVE in different population was tested with a Chi-squared test.

The Fisher's Exact test was performed to test the significant difference between populations, per timing category of development of the symptoms of UI (Prior to OVE, 0-6 months post OVE, 6-12 months post OVE, 12-24 months post OVE, >24 months post OVE). Because the numbers per category were <5, a different test than Chi-squared test was chosen. A p-value>0.05 means that the null-hypothesis can be assumed, and a p-value<0.05 means that the null-hypothesis can be rejected.

3. Results

3.1 Questionnaire response rate

The questionnaire was distributed in two rounds. In the population Great Swiss Mountain dogs the first round was send on the 8th of July 2024 and the second round the 5th of August 2024 (figure 3). In the reference population the first round was on the 18th of July in a general Facebook group. On the 22nd of August, the questionnaire was send in breed-specific Facebook groups and on the 26th of August, a reminder was send (figure 4). Figures 3 and 4 show that there is a peak on the day the questionnaire was sent. This is in line with the study of Reynolds et al. (2009) where they found that 40% of the total responses are collected on the first day, 50% within 24 hours and 60% within 48 hours[25].

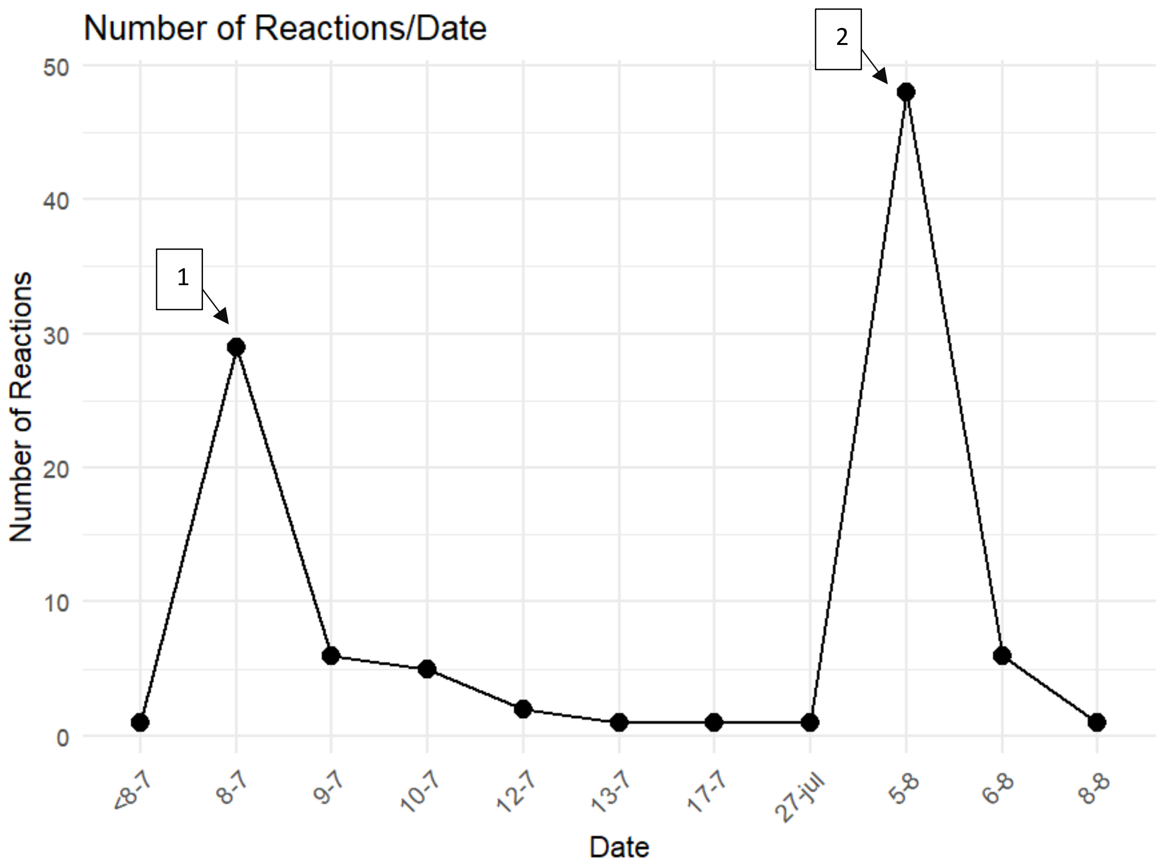

Figure 3 Response curve from the reactions on the questionnaire send in the population Great Swiss Mountain dogs (1=first round of distribution, 2=second round of distribution).

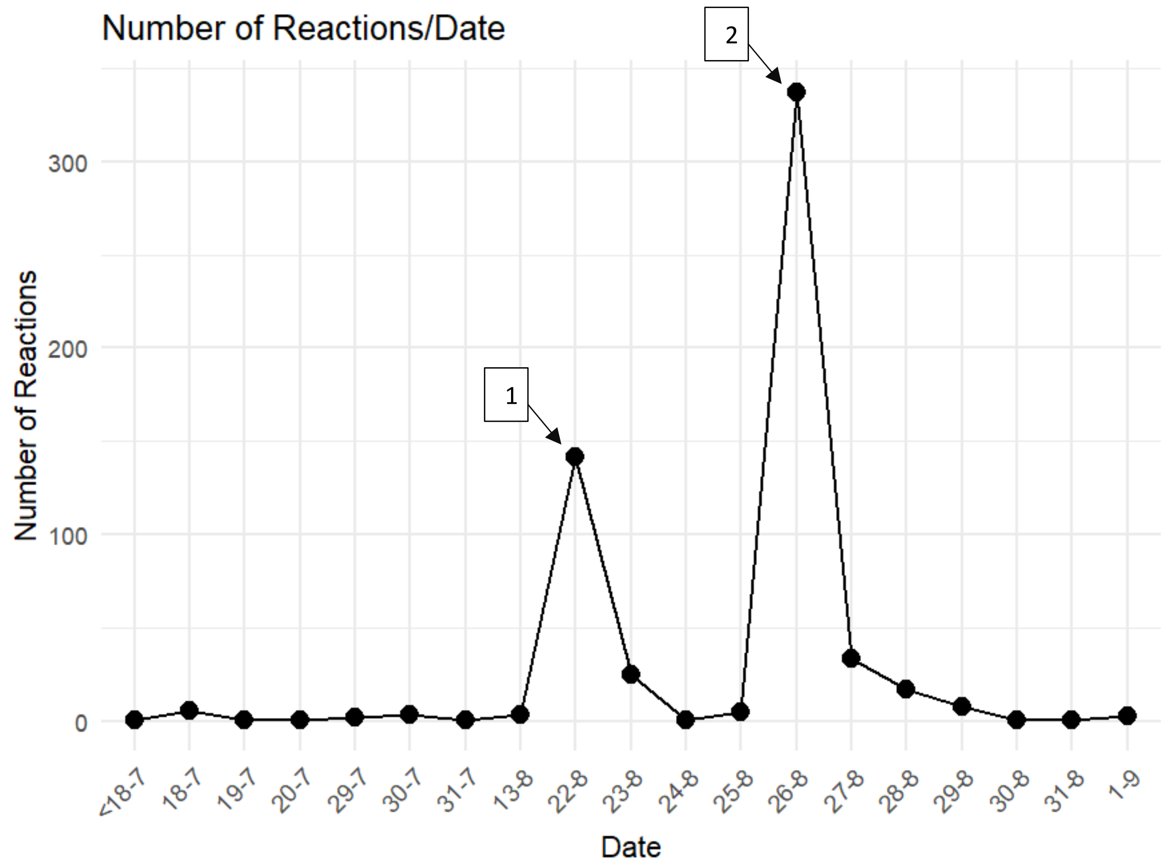

Figure 4 Response curve from the reactions on the questionnaire send in the reference population (1=first round of distribution, 2=second round of distribution).

3.2 Breed distribution

From the remaining group of 489 dogs, a total of 66 owners of the Great Swiss Mountain dog filled in the questionnaire. 3 of these dogs were Great Swiss Mountain dog mix breeds, 2 were neither a breed nor a mixed breed and 1 was a Labrador Retriever. These data were then copied to the control group, because the research group consists of only Great Swiss Mountain dogs. So in total, there are 60 owners of Great Swiss Mountain dogs that filled in the questionnaire.

The reference population consists of 429 dogs, of which 145 Labrador retriever, 23 Bernese Mountain dogs, 2 Golden retriever, 67 Rhodesian Ridgeback, 74 Rottweiler, 57 Swiss White shepherd, 1 American Stafford, 1 Border collie, 1 Bouvier, 1 Boxer, 3 German Shepherd, 1 Dutch Shepherd, 1 Malinois Shepherd, 3 Old German Shepherd, 2 St. Bernard, 2 Vizsla, 1 Wetter Houn, and 47 mixed breeds.

3.3 Descriptives of populations

3.3.1 Neuter status

In the group of Great Swiss Mountain dogs, 42 (70%) were ovariectomised and 18 (30%) were intact. In the reference population, 355 (83%) dogs were ovariectomised and 74 (17%) were intact and in the subpopulation Labrador Retrievers 128 (88%) were ovariectomised and 17 (12%) were intact (table 2).

Pet-scan data were used to compare the proportion ovariectomised bitches in our study, with the proportion ovariectomised bitches in Pet-scan. This data only include bitches with a bodyweight of >25kg (table 2).

A Chi-squared test was performed to test the null-hypothesis that there is no significant difference between the ovariectomised/intact proportions of our complete study population (including the population Great Swiss Mountain dogs as well as the reference population) compared to the Pet-scan population. The p-value was 3.05e-06, concluding that the proportion ovariectomised dogs in our study population differed significantly from the Pet-scan population. Therefore it could be assumed the proportion ovariectomised dogs in our dog population was not representative for the real dog population in the Netherlands and that the real proportion is lower.

But, when performing a Chi-squared test to test on the population Great Swiss Mountain dogs as well as the reference population compared to the Pet-scan population, the p-values were 0.77 and 3.56e-07, respectively. In conclusion: the population Great Swiss Mountain dogs did not and the reference population did differ significantly from the Pet-scan population.

Table 2 Number and proportion of ovariectomised dogs in the population Great Swiss Mountain dogs, the reference population, the population Labrador Retrievers and the Pet-scan population.

	Number of dogs	Ovariectomised	Intact
Great Swiss Mountain dogs	60	42 (70%)	18 (30%)
Reference population	429	355 (83%)	74 (17%)
Labrador Retrievers	145	127 (88%)	18 (12%)
Pet-scan population	1963	1407 (72%)	556 (28%)

3.3.2 Age at ovariectomy and reason for ovariectomy

The age at OVE is not normally distributed in the population Great Swiss Mountain dogs, the reference population and subpopulation Labrador Retrievers, tested with the Shapiro test.

The median age at OVE of Great Swiss Mountain dogs was 18 months (6.5 – 84), the median age at OVE in the reference group was 16 months (4 – 145) and the median age at OVE in the subpopulation Labrador Retrievers was 15 months (5 – 84), shown in table 3 and figure 5.

The non-parametric Wilcoxon rank sum test was performed to test if the populations were significantly different or not. The population Great Swiss Mountain dogs was compared to the reference population and the subpopulation Labrador Retrievers. The p-values were 0.21 and 0.08 (95% confidence interval (CI) -0.99 – 4.00 and -2.23 – 4.99), respectively (table 3). So no significant difference was found between the median age of the different study populations.

Table 3 Median age and range in months at OVE in the population Great Swiss Mountain dogs, the reference population and the subpopulation Labrador Retrievers, as well as the p-values that were calculated with the Wilcoxon rank sum test to compare the population Great Swiss Mountain dogs with the reference population and the subpopulation Labrador Retrievers.

	Median age at OVE (months)	Range (months)	p-value (95% CI)
Great Swiss Mountain dogs	18 (n=42)	6.5 – 84	-
Reference population	16 (n=351)	4 – 145	0.21 (-0.99 – 4.00)
Labrador Retrievers	15 (n=125)	5 – 84	0.08 (-2.23 – 4.99)

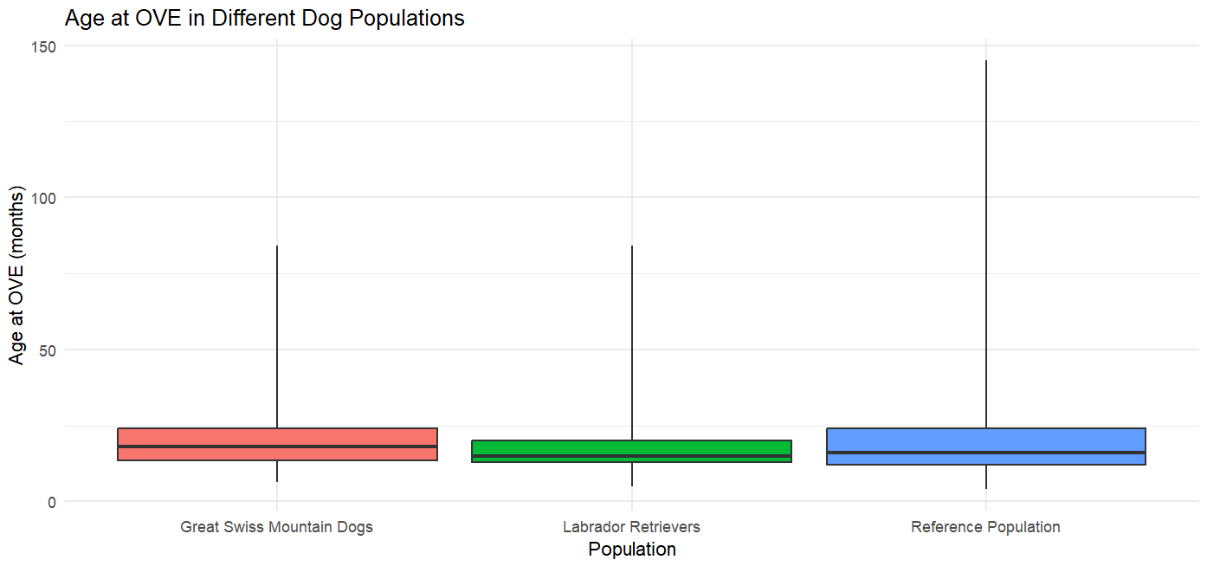

Figure 5 Boxplots of the distribution of the age at OVE in the populations Great Swiss Mountain dogs, Labrador Retrievers and the reference population.

Table 4 shows that the proportion dogs that are ovariectomised to prevent pregnancy is 40% in the population Great Swiss Mountain dogs, 55% in the reference population and 64% in the subpopulation Labrador Retrievers. In the population Great Swiss Mountain dogs, 60% was ovariectomised for other (medical) reasons. In the reference population this was 45% and the subpopulation Labrador Retrievers it was 36% (table 4).

The Chi-squared test was performed to test if the reason for OVE in different populations were significantly different or not. The population Great Swiss Mountain dogs was compared to the reference population and the subpopulation Labrador Retrievers. The p-values were 0.07 and 0.001, respectively (table 4). So no significant difference was found between the reason for OVE between the Great Swiss Mountain dogs and the reference population. However, the populations Great Swiss Mountain dogs and subpopulation Labrador Retrievers were indeed significantly different (table 4).

Table 4 Proportion of dogs that were ovariectomised to prevent pregnancy and ovariectomised for other (medical) reasons in the population Great Swiss Mountain dogs, the reference population and the population Labrador Retrievers, as well as the p-values that were calculated with the Chi-squared test to compare the population Great Swiss Mountain dogs with the reference population and the subpopulation Labrador Retrievers.

	To prevent pregnancy	Other (medical) reason	p-value
Great Swiss Mountain dogs	17 (40%)	25 (60%)	-
Reference population	194 (55%)	161 (45%)	0.07
Labrador Retrievers	82 (64%)	46 (36%)	0.001

3.3.3 Number of oestrous cycles prior to OVE

The number of oestrous cycles prior to OVE is not normally distributed in the population Great Swiss Mountain dogs, the reference population and the subpopulation Labrador Retrievers, tested with the Shapiro test.

The median number of oestrous cycles prior to OVE is 1 in both the population of Great Swiss Mountain dogs, the reference population and the subpopulation Labrador Retrievers (table 5).

The non-parametric Wilcoxon rank sum test was performed to test if the populations were significantly different or not. The population Great Swiss Mountain dogs was compared to the reference population and the subpopulation Labrador Retrievers. The p-values were 0.28 and 0.05 (95%CI -1.43e-06 – 6.52e-05 and -6.55e-05 – 9.99e-01), respectively (table 5). So no significant difference was found between the median age of the different study populations, although it seems that the median number of oestrous cycles of the population Great Swiss Mountain dogs and Labrador Retrievers are almost significantly differently.

Table 5 Median frequency and range of oestrus cycles prior to OVE in the population Great Swiss Mountain dogs, the reference population and the subpopulation Labrador Retrievers, as well as the p-values that were calculated with the Wilcoxon rank sum test to compare the population Great Swiss Mountain dogs with the reference population and the subpopulation Labrador Retrievers.

	Median number of oestrous cycles	Range	p-value (95% CI)
Great Swiss Mountain dogs	1 (n=41)	0 – 14	-
Reference population	1 (n=341)	0 – 21	0.28 (-1.43e-06 – 6.52e-05)
Labrador Retrievers	1 (n=122)	0 – 15	0.05 (-6.55e-05 – 9.99e-01)

The distribution of the number of oestrus cycles prior to OVE is visualised in the boxplots in figure 6.

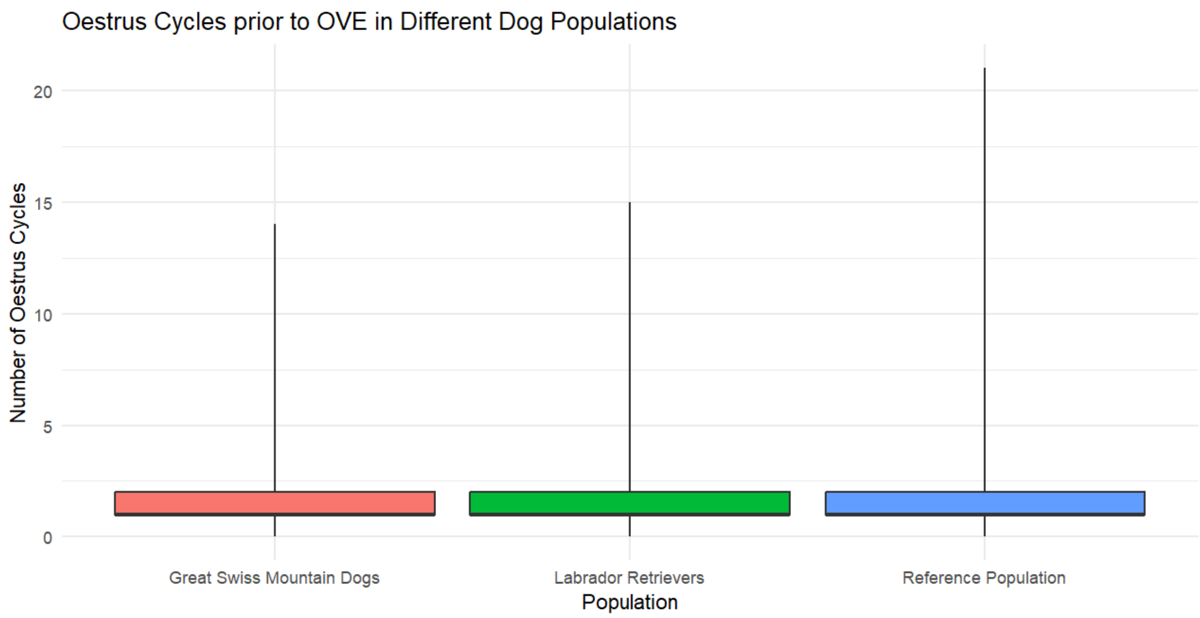

Figure 6 Boxplots of the distribution of number of oestrus cycles prior to OVE in the populations Great Swiss Mountain dogs, Labrador Retrievers and the reference population.

3.4 Incidence of urinary incontinence

Proportions were calculated for the presence of UI in the population Great Swiss Mountain dogs, the reference population and the subpopulation Labrador Retrievers. The percentages suffering from UI were 48.3% (n=29), 18.9% (n=84) and 10.3% (n=15), respectively.

For the population Great Swiss Mountain dogs, the reference population and subpopulation Labrador Retrievers, it was calculated what the proportions were of ovariectomised dogs suffering from UI. 59.5% (n=25), 21.3% (78) and 11.8% (n=15), respectively (table 6).

Table 6 Incidence of USMI in the population Great Swiss Mountain dogs, the reference population and the subpopulation Labrador Retrievers in the groups ovariectomised and intact dogs.

Population	Variable	Ovariectomised	Intact
Great Swiss Mountain dogs	Suffering from UI	25 (59.5%)	4 (22.2%)
	Not suffering from UI	17 (40.5%)	14 (77.8%)
	Total	**42**	**18**
Reference population	Suffering from UI	78 (21.3%)	6 (7.7%)
	Not suffering from UI	289 (78.8%)	72 (92.3%)
	Total	**367**	**78**
Labrador Retrievers	Suffering from UI	15 (11.8%)	0 (0%)
	Not suffering from UI	112 (88.2%)	18 (100%)
	Total	**127**	**18**

3.4.1 Chi-squared test on incidence UI

In the reference population, 21.3% of the ovariectomised dogs were suffering from UI. In the population Great Swiss Mountain dogs, 59.5% of the ovariectomised dogs were suffering from UI (table 6).

The Chi-squared test resulted in a p-value of 1.34e-09. The p-value is smaller than 0.05. Therefore, the null-hypothesis that there is no difference between the incidence of UI in Great Swiss Mountain dogs compared to the reference population, can be rejected. The incidence of UI in Great Swiss Mountain dogs is significantly higher compared to the reference population.

In the subpopulation Labrador Retrievers, 11.8% of the ovariectomised dogs were suffering from UI. In the population Great Swiss Mountain dogs, 59.5% of the ovariectomised dogs were suffering from UI (table 6).

A Chi-squared test resulted in a p-value of 2.2e-16. The p-value is smaller than 0.05. Therefore, the null-hypothesis that there is no difference between the incidence of UI in Great Swiss Mountain dogs compared to the subpopulation Labrador Retrievers, can be rejected. The incidence of UI in Great Swiss Mountain dogs is significantly higher compared to the population Great Swiss Mountain dogs.

3.5 Statistical tests on different risk factors for UI

3.5.1 Median age at OVE in three populations

The non-parametric Wilcoxon rank sum test was used to test the null-hypothesis that there is no significant difference for the median age at OVE in the group with UI versus the group without UI. In the population Great Swiss Mountain dogs, the reference population and the subpopulation Labrador Retrievers the p-values were 0.42, 0.99 and 0.15 (95% CI -6.99 – 3.99; -1.99 – 1.99; -5.00 – 0.99), respectively (table 7). Therefore, the null-hypothesis that there is no significant difference for the median age at OVE in the group with UI versus the group without UI could be assumed.

Table 7 p-values of age at OVE comparing the group developing UI and not developing UI and their 95% confidence intervals in the population Great Swiss Mountain dogs, the reference population and the subpopulation Labrador Retrievers.

	p-value	95% CI
Great Swiss Mountain dogs	0.42	-6.99 – 3.99
Reference population	0.99	-1.99 – 1.99
Labrador Retrievers	0.15	-5.00 – 0.99

3.5.2 Median number of oestrous cycles prior to OVE in three populations

The non-parametric Wilcoxon rank sum test was used to test the null-hypothesis that there is no significant difference for the median number of oestrous cycles in the group with UI versus the group without UI. In the population Great Swiss Mountain dogs, the reference population and the subpopulation Labrador Retrievers the p-values were 0.71, 0.28 and 0.69 (95% CI -0.99 – 0.99; -2.09e-05 – 1.49e-05; -5.70e-06 – 3.96e-05), respectively (table 8). Therefore, the null-hypothesis that there is no significant difference for the median number of oestrous cycles in the group with UI versus the group without UI could be assumed.

Table 8 p-values of number of oestrous cycles prior to OVE comparing the group developing UI and not developing UI and their 95% confidence intervals in the population Great Swiss Mountain dogs, the reference population and the subpopulation Labrador Retrievers.

	p-value	95% CI
Great Swiss Mountain dogs	0.71	-0.99 – 0.99
Reference population	0.28	-2.09e-05 – 1.49e-05
Labrador Retrievers	0.69	-5.70e-06 – 3.96e-05

3.5.3 Influence of age at OVE and number of oestrous cycles on development UI

Multivariable logistic regression was performed to test the influence of the age at OVE and the number of oestrous cycles prior to OVE on the development of UI in the population of Great Swiss Mountain dogs, reference population and the subpopulation Labrador Retrievers.

The p-values for the influence of age at OVE on development of UI are 0.73, 0.70 and 0.32, respectively (table 9). The p-values for the influence of number of oestrous cycles prior to OVE on the development on UI were 0.74, 0.70 and 0.60, respectively (table 9). Additionally, the odds ratios for both variables were approximately 1 across all populations, suggesting that these variables exerted minimal influence on the development of UI.

From these results could be concluded that both the age at OVE and the number of oestrous cycles prior to OVE did not have influence on developing UI.

Table 9 P-values and odds ratios of multivariable logistic regression in the population Great Swiss Mountain dogs, reference population and subpopulation Labrador Retrievers.

	Variable	p-value multivariable logistic regression	Odds ratio
Great Swiss Mountain dogs	Age at OVE	0.73	1.02
	Number of oestrus cycles prior to OVE	0.74	0.90
Reference population	Age at OVE	0.70	0.99
	Number of oestrus cycles prior to OVE	0.45	1.10
Labrador Retrievers	Age at OVE	0.32	0.98
	Number of oestrus cycles prior to OVE	0.60	1.12

3.6 Age developing signs of UI

The proportions on the age of developing signs of UI are summarized in table 10 and figure 7 for the population Great Swiss Mountain dogs, the reference population and the subpopulation Labrador Retrievers.

Table 10 Development of UI in the population ovariectomised Great Swiss Mountain dogs, reference population and subpopulation Labrador Retrievers.

	Great Swiss Mountain dog	Reference population	Labrador Retrievers
Prior to OVE	3 (12%)	3 (4%)	1 (8%)
0-6 months post OVE	9 (36%)	21 (28%)	3 (23%)
6-12 months post OVE	8 (32%)	17 (23%)	4 (31%)
12-24 months post OVE	3(12%)	16 (22%)	2 (15%)
>24 months post OVE	2 (8%)	17 (23%)	3 (23%)
Total	25 (100%)	74 (100%)	13 (100%)

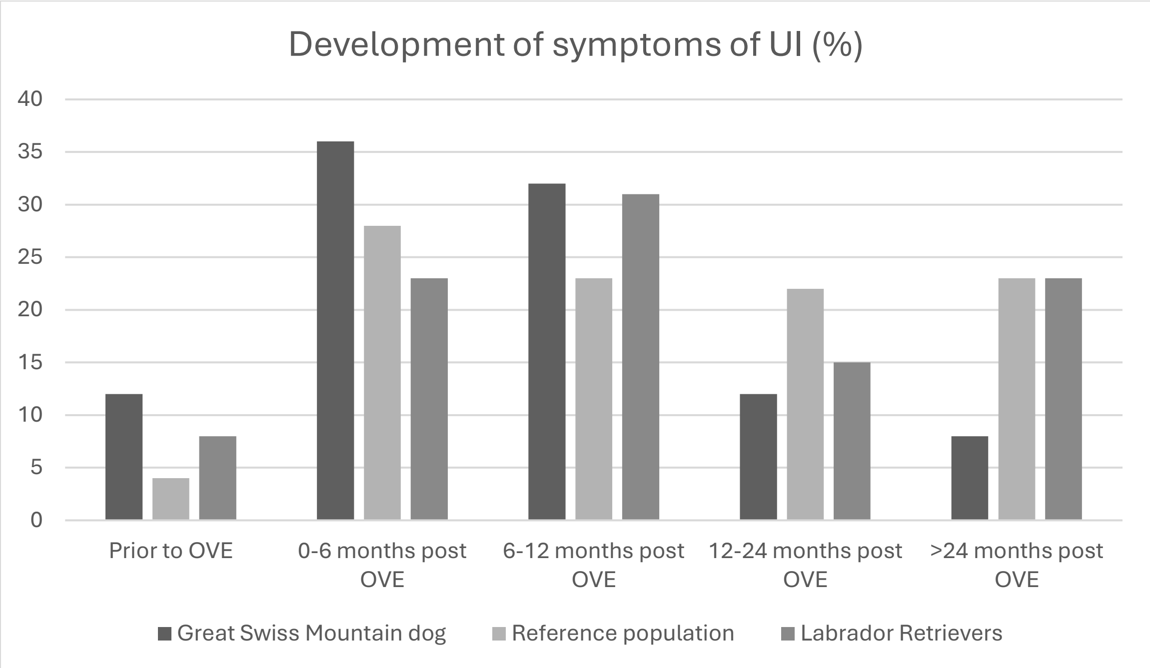

Figure 7 Bar chart of development of symptoms of UI in the population Great Swiss Mountain dogs versus the reference population and the subpopulation Labrador Retrievers.

3.6.1 Comparison of UI incidence across different populations and time intervals

A Fisher's Exact test was used to test the null-hypothesis that there is no significant difference in the age of developing symptoms of UI in the Great Swiss Mountain dogs, compared to the reference population and the subpopulation Labrador Retrievers (table 11).

There was no significant difference found between the Great Swiss Mountain dogs compared to the reference population and subpopulation Labrador Retrievers in any of the time intervals.

In the earlier intervals (0-12 months post OVE) there could be a slight higher risk of developing symptoms in the Great Swiss Mountain dogs according to the odds ratio, but this was not significant. In the later intervals (12-24 and >24 months post OVE) this seems to be the other way around, but this was not significant either (table 11).

Table 11 Comparison of UI incidence across different populations and time intervals.

Time interval		p-value	Odds ratio
Prior to OVE	Great Swiss Mountain dogs and reference population	0.17	3.18
	Great Swiss Mountain dogs and Labrador Retriever	1	1.62
0-6 months post OVE	Great Swiss Mountain dogs and reference population	0.46	1.41
	Great Swiss Mountain dogs and Labrador Retriever	0.48	1.85
6-12 months post OVE	Great Swiss Mountain dogs and reference population	0.42	1.57
	Great Swiss Mountain dogs and Labrador Retriever	1	1.06
12-24 months post OVE	Great Swiss Mountain dogs and reference population	0.39	0.50
	Great Swiss Mountain dogs and Labrador Retriever	1	0.76
>24 months post OVE	Great Swiss Mountain dogs and reference population	0.14	0.30
	Great Swiss Mountain dogs and Labrador Retriever	0.32	0.30

3.7 Distribution of treatment UI

In the group of Great Swiss Mountain dogs, the reference population and the subpopulation Labrador Retrievers 19 (76%), 40 (54%) and 6 (46%) received treatment for UI on the moment of completing the questionnaire (table 12).

Table 12 Proportions of three populations that receive treatment and that do not receive treatment for UI.

	Treatment for UI	No treatment for UI
Great Swiss Mountain dog	19 (76%)	6 (24%)
Reference population	40 (54%)	34 (46%)
Population Labrador Retrievers	6 (46%)	7 (54%)

The number of dogs in the population of Great Swiss Mountain dogs, the reference population and the subpopulation Labrador Retrievers that received different combinations of medical treatment are visualised in the Up Set plots in figure 8, 9 and 10.

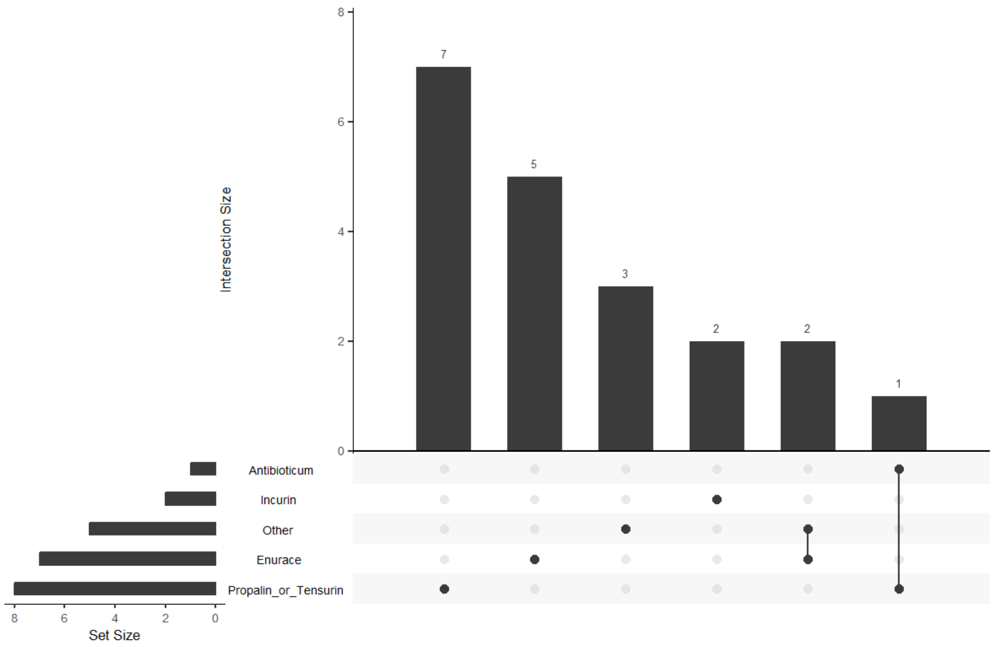

Figure 8 Up Set plot of combinations and frequency of treatment options for UI in Great Swiss Mountain dogs.

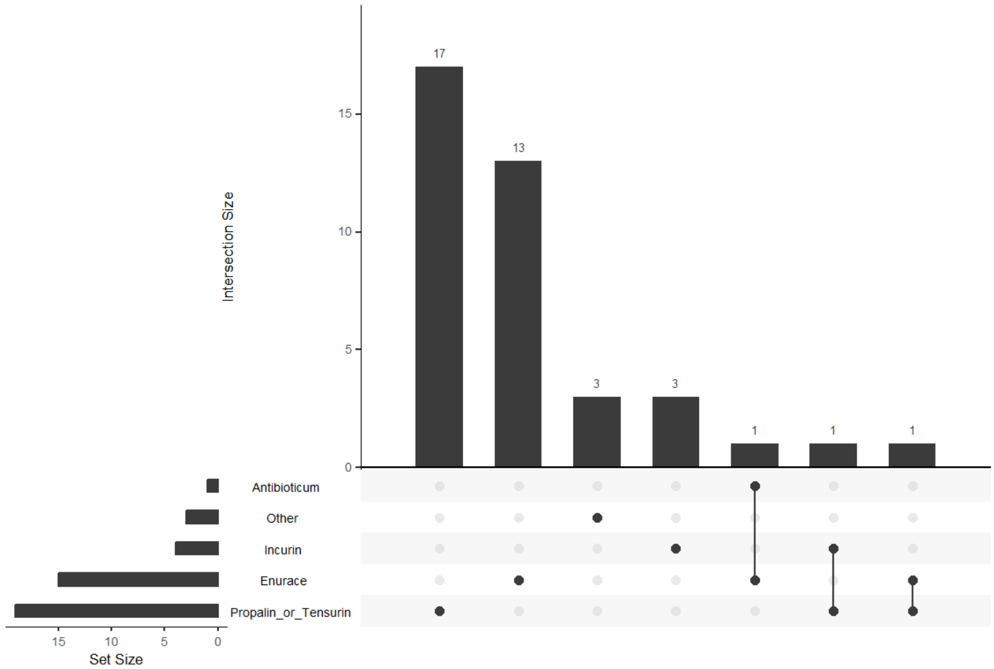

Figure 9 Up Set plot of combinations and frequency of treatment options for UI in the reference population.

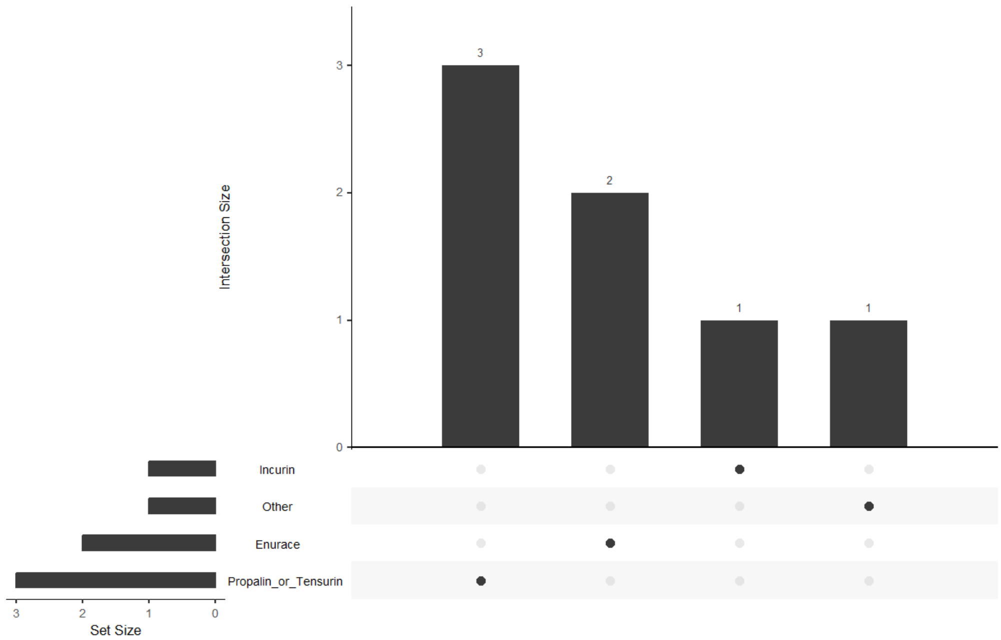

Figure 10 Up Set plot of combinations and frequency of treatment options for UI in the subpopulation Labrador Retrievers.

4. Discussion

4.1 The questionnaire

When doing a questionnaire-based study, a lot of accurate, quantitative and reliable information can be obtained if the right questions are asked. In the case of our study, the owner knows the most about their dogs and the dog's incontinence. Adding to that, incontinence is a digital observation: a dog is incontinent or is not incontinent with little risk of subjectivity. This makes the opinion of the owner even more reliable and therefore makes a questionnaire-based study for our research question a suitable option. However, there is a risk of subjectivity of the owner, and a risk of a recall bias.

During the first round of distribution of the questionnaire, it was distributed with a message that focused on dogs with UI. This may have created a selection bias of the first group of participants . The message of the second round of distribution specified that the questionnaire was intended for all owners of dogs with a bodyweight over 25kg, regardless of being incontinent or not (figure 3 and 4). As seen in figure 3 and 4, the risk of this selection bias occurred in ±50% of the Great Swiss Mountain dogs and in ±30% of the reference population. So ±50% of the Great Swiss Mountain dogs and ±70% of the reference population did not have this selection bias.

The questionnaire could also be filled in by owners of deceased dogs, which could cause a recall bias and this has to be taken into account. During the preparation of the questionnaire, it was not considered to ask for the age of death. As a result, nothing can be concluded from the data regarding the age of the dogs. Additionally, it was not thought to make all of the questions mandatory, which led to owners not filling in all of the questions. Consequently, the number of dogs can differ throughout the results of this study.

As mentioned before, it was decided to distribute the questionnaire in 'large breed-specific' Facebook-groups because the responses in the 'general large breeds' Facebook-group was not adequate. This was decided a few weeks after the first distribution round of the questionnaire, meaning that this 'breed-specific'-questionnaire had a shorter collection period than the 'general large breeds'-questionnaire. When looking at the reaction curves, most of the responses were collected during the first day. This is in line with the study of Reynolds et al. (2009) where they found that 40% of the total responses are collected on the first day, 50% within 24 hours and 60% within 48 hours[25]. Therefore, it was concluded that it is not likely that the shorter collection time influenced the outcomes of this study.

4.2 Breed distribution

The reference population consists of a mixture the most common large dog breeds of the Netherlands: Labrador retriever, Bernese Mountain dog, Golden retriever, Rhodesian Ridgeback, Rottweiler and the Swiss White shepherd, with the first 20 responses of 'general large dog breeds'. These specific breeds were chosen because they are common in the Netherlands and because there was a breed-specific Facebook-group available (in which I was accepted to distribute the questionnaire).

It was decided to include large mixed-breeds in the reference group as well. The reason is that this study is about one breed in specific: the Great Swiss Mountain dog and to compare it to a reference group of dogs with a bodyweight of >25kg regardless of being a thoroughbred or not. Therefore, there is no reason to exclude mixed breeds from the data in the reference group.

However, the Labrador Retrievers represented the largest group in the reference population. According to the board of canine management in the Netherlands (Raad van Beheer op Kynologisch gebied), they are also the largest group of the population pet dogs and therefore we also compared the population Great Swiss Mountain dogs to the subpopulation Labrador Retrievers.

4.3 Descriptives of populations

4.3.1 Neuter status

In our study, in the group of Great Swiss Mountain dogs, 42 (70%) were ovariectomised and 18 (30%) were intact. In the reference population, 355 (83%) dogs were ovariectomised and 74 (17%) were intact. A review of Urfer et al. (2019) concluded that the prevalence of gonadectomised dogs (of all sizes) is around 50% in Western Europe[2], although it was not clear which countries were included in Western Europe. It is possible that the general percentage ovariectomised dogs in the Netherlands is higher, or that large dogs are ovariectomised more often than smaller dogs.

Another possibility is that a selection bias occurred. In the message that was send with the questionnaire, the goal of the questionnaire was stated: researching the incidence of UI after OVE. It was highlighted that the target audience was 'owners of dogs with a bodyweight >25kg'. It is possible that owners did not read the message carefully, and that the questionnaire was more often filled in by owners of ovariectomised dogs than intact dogs.

To draw more reliable conclusions, Pet-scan data were used. Like mentioned before, these data consisted only of bitches with a bodyweight of >25kg. We found that 1407 (72%) of the bitches in the Pet-scan population were ovariectomised and this was significantly different from the percentage that we found in our study population (table 2). Hence, it is very possible that a selection bias indeed occurred.

Calculated independently, the reference population also differed significantly from the Pet-scan population. The population Great Swiss Mountain dogs however, did not differ significantly from the Pet-scan population.

4.3.2 Age at OVE and reason of OVE

In the Netherlands it is generally advised to ovariectomise after the first oestrus (which occurs between 6 and 18 months of age), especially in larger breeds and crossbreds. This consensus advise can be seen in our results as well, whereas the median age at OVE for Great Swiss Mountain dogs, the reference population and the subpopulation Labrador Retrievers was 18, 16 and 15 months, respectively (table 3). No significant difference was found between the median age of the different study populations.

No significant difference was found between the reason for OVE between the Great Swiss Mountain dogs and the reference population. However, the populations Great Swiss Mountain dogs and subpopulation Labrador Retrievers were indeed significantly different (table 4).

4.3.3 Number of oestrous cycles prior to OVE

The median number of oestrous cycles in our study populations is 1 (table 5). This is in line with the advice towards OVE in the Netherlands, which is to do OVE after the first oestrus cycle.

No significant difference was found between the median age of the different study populations, however it seems that the median number of oestrous cycles of the population Great Swiss Mountain dogs and Labrador Retrievers are almost significantly differently. It sounds odd, because the median is 1 in both populations and the range is almost the same. The Wilcoxon rank sum test compares distributions, and not only medians. Even if the median is the same in both populations, there can be differences in the way the data is distributed within the populations. This can result in a significant difference.

4.6 Incidence UI

Previously reported breed predispositions for UI development following OVE are the German Shepherd, Dalmatian, Bearded Collie, Rough Collie, Boxer, Rottweiler, Doberman, Old English Sheepdog, Springer Spaniel, Weimaraner, and Irish Setter.[1,28].

The study of Pegram et al. (2019) found breed predispositions for UI that concurred in previous studies: Dobermann, Weimaraner and Boxer. However, the Irish Setter has been previously identified as a high-risk breed[30] but in the study of Pegram et al. (2019) only a very small group of this breed was included so this breed was not retained as an individual breed.

Similarly, as far as we know, we are the first to report a new breed predisposition. Our study shows that there is a significant higher incidence of UI in the population of Great Swiss Mountain dogs (59.5%) compared to the reference population (21.3%), even if we compare the Great Swiss Mountain dogs to the subpopulation Labrador Retrievers (11.8%). This highly significant finding suggests new information on a breed predisposition for developing UI after OVE, and more research should be done.

4.6 Statistical tests on risk factors

4.6.1 Influence of age at OVE and number of oestrous cycles on development UI

In our study, no significant influence was found between the age at ovariectomy and developing UI. This finding is supported by the studies of Byron et al. (2017) and Pegram et al. (2019) In the study of Byron et al. (2018), it was found that there was no significant difference between the median age at OVH between UI dogs and intact dogs[27]. In the study of Pegram et al. (2019) it was also concluded through logistic regression that age at OVE is not a risk factor for the development of UI [28].

However, in the study of Viktor Spain et al. (2004) it was found that there is a higher risk for UI when dogs are ovariectomised before the age of 3 months[29]. In our study, there were no dogs ovariectomised before the age of 3 months, so logically this risk did not arise in our study.

As far as we know, there has not yet been published studies on the influence of the number of oestrous cycles prior to OVE on developing UI. In our study, it is found that there is no significant influence of the number of oestrous cycles prior to OVE, on the development of UI. However, because of the consensus advice to ovariectomise after the first oestrous cycle, our dataset may not be fitting to draw reliable conclusions on the influence of oestrous cycles on the development of UI.

4.7 Age developing symptoms of UI

According to figure 7, it seems that symptoms of UI develop earlier after OVE in Great Swiss Mountain dogs compared to the reference population and the population Labrador Retrievers. We found indeed that in the earlier intervals there could be a slight higher risk of developing symptoms in the Great Swiss Mountain dogs and the other way around in the later intervals, but neither was significant (table 11).

From figure 7, it stands out that there are some dogs with UI symptoms prior to OVE. In our study it was not clear what the diagnosis of these dogs was, because this question was not answered. It is possible that these dogs had a condition other that UI, for example ectopic ureters (EU). Ureteral ectopia is a congenital disease and is usually diagnosed at an early age. Symptoms of ureteral ectopia are very similar to the symptoms of UI. In future research, it is important to take other abnormalities such as EU into account.

4.8 Treatment

Our study shows that most of the dogs are treated with phenylpropanolamine (PPA, Propalin® or Tensurin®). This is in line with the study of Byron et al. (2017)[27], where they found that 75% of the 163 dogs were treated with PPA, and with the ACVIM consensus statement (2024) where it is recommended as the initial treatment for USMI[3].

It was also found in our study that a large number of Great Swiss Mountain dogs and dogs from the reference population did not receive treatment at the moment of completing the questionnaire. Unfortunately, it remains unclear whether these dogs had never received treatment or if they were simply not under treatment at the specific moment of completing the questionnaire.

Conclusion and recommendations

With the obtained data of 489 dogs from the questionnaire, a general inventory could be made about the development of urinary incontinence in Great Swiss Mountain dogs, compared to other large dog breeds. The results of the current study show that there is indeed a higher incidence of UI after OVE in the population Great Swiss Mountain dogs. There is no relation found between the age at OVE and the occurrence of UI, or between the number of oestrus cycles prior to the OVE.

In conclusion, more and more disadvantages are known about OVE. Besides preventing certain diseases, OVE may underlie other, such as urinary incontinence. Our study shows that the Great Swiss Mountain dog may be at an elevated risk for developing this condition. Consequently, it is essential for veterinarians to communicate these potential risks to dog owners, thereby enabling informed decision-making.

Acknowledgements

I am grateful to Jeffrey de Gier from the reproduction department for being my supervisor, for Else den Boer for supporting the development of the questionnaire and Hans Vernooij and Ivo Borkus for helping with writing codes for RStudio and interpreting the results.

Appendix 1

1. Wat is de geboortedatum van uw hond?
2. Heeft u een rashond?
    a. Nee
    b. Ja, namelijk:
3. Is uw hond een kruising?
    a. Nee
    b. Ja, namelijk:
4. Wat is het geslacht van uw hond?
    a. Teef
    b. Reu
5. Is er bij uw hond een neutralisatie-operatie uitgevoerd waarbij de eierstokken zijn verwijderd (ook wel bekend als 'sterilisatie')?
    a. Ja
    b. Nee
6. Waarom is uw hond gesteriliseerd?
    a. Om drachtigheid te voorkomen
    b. Vanwege een medische reden, namelijk:
    c. Anders, namelijk:
7. Op welke leeftijd is uw hond gesteriliseerd?
8. Hoe vaak is uw hond loops geweest voorafgaand aan de sterilisatie?
9. Kunt u inschatten hoeveel uw hond drinkt per dag?
    a. >50ml/kg
    b. 50ml/kg
    c. <50ml/kg
    d. Weet ik niet
10. Waar leeft uw hond?
    a. Overwegend binnenshuis
    b. Overwegend buitenshuis (bijvoorbeeld op het erf, in de tuin of in een schuur)
11. Wordt uw hond uitgelaten?
    a. Ja
    b. Nee
12. Hoe vaak wordt uw hond uitgelaten?
    a. 1-2 keer per dag
    b. 3-4 per keer per dag
    c. 5-6 keer per dag
13. Heeft u de indruk dat uw hond gezond is?
    a. Ja
    b. Nee
14. Wordt uw hond behandeld met medicatie?
    a. Nee
    b. Ja, namelijk:
15. Ziet u weleens vaginale uitvloeiing? Denk aan: rode uitvloeiing of pus.
    a. Nee
    b. Ja, namelijk:
16. Heeft uw hond ooit last gehad van urine incontinentie?

    Urine incontinentie is het passief verliezen van urine, zonder dat de hond het zelf doorheeft. Hierbij kunnen enkele druppels urine verloren gaan. Er kan ook opeens een plasje urine liggen, zonder dat u de hond actief heeft zien plassen op die plek.
    a. Ja
    b. Nee
17. Wanneer had uw hond voor het eerst last van urine incontinentie?
    a. Voor de sterilisatie
    b. 0-6 maanden na de sterilisatie
    c. 6-12 maanden na de sterilisatie

    d. >12 maanden na de sterilisatie
18. Hoe ernstig schat u het gemiddelde urineverlies van uw hond toen het voor het eerst gebeurde?
    a. 0, geen urineverlies
    b. 1, een paar druppels na lang (4 uur of langer) niet uit te zijn geweest
    c. 2, een paar druppels na kort (minder dan 4 uur) niet uit te zijn geweest
    d. 3, een plas urine na lang (4 uur of langer) niet uit te zijn geweest
    e. 4, een plas na kort (minder dan 4 uur) niet uit te zijn geweest
19. Is het plasgedrag van uw hond veranderd rondom het optreden van de incontinentie? Denk aan: de houding tijdens het plassen, de kleur van de urine, persen, etc.
    a. Nee
    b. Ja, namelijk:
20. Bent u met uw hond naar de dierenarts geweest om de urine incontinentie te laten onderzoeken?
    a. Ja
    b. Nee
21. Kunt u aanvinken welke onderzoeken uw dierenarts heeft gedaan? *(U kunt meerdere antwoorden invullen)*
    a. Algemeen onderzoek
    b. Urine onderzoek
    c. Echo
    d. Röntgenfoto
    e. Ben ik vergeten/weet ik niet
22. Welke diagnose werd er gesteld?
23. Heeft uw hond op dit moment last van urine incontinentie?
    a. Ja
    b. Nee
24. Welke behandeling krijgt uw hond? (U kunt meerdere antwoorden invullen)
    a. Propalin of Tensurin
    b. Enurace
    c. Incurin
    d. Suprelorin implantaat
    e. AUS implantaat
    f. Antibioticum
    g. Anders, namelijk:
    h. Onbekend
25. Hoe ernstig schat u het gemiddelde urineverlies van uw hond op dit moment?
    a. 0, geen urineverlies
    b. 1, een paar druppels na lang (4 uur of langer) niet uit te zijn geweest
    c. 2, een paar druppels na kort (minder dan 4 uur) niet uit te zijn geweest
    d. 3, een plas urine na lang (4 uur of langer) niet uit te zijn geweest
    e. 4, een plas na kort (minder dan 4 uur) niet uit te zijn geweest
26. Heeft u tot slot nog op- of aanmerking over de enquête? Of wilt u nog iets kwijt?

Appendix 2

Note: this version was not distributed.

1. What is your dog's date of birth?
2. Is your dog a purebred?
    a. No
    b. Yes, specifically:
3. Is your dog a mixed breed?
    a. No
    b. Yes, specifically:
4. What is your dog’s gender?
    a. Female
    b. Male

5. Has your dog undergone a neutering surgery in which the ovaries were removed (also known as 'spaying')?
    a. Yes
    b. No
6. Why was your dog spayed?
    a. To prevent pregnancy
    b. Due to a medical reason, specifically:
    c. Other, specifically:
7. At what age was your dog spayed?
8. How many times did your dog go into oestrus before the spaying?
9. Can you estimate how much your dog drinks per day?
    a. >50ml/kg
    b. 50ml/kg
    c. <50ml/kg
    d. I don't know
10. Where does your dog live?
    a. Mostly indoors
    b. Mostly outdoors (for example, in the yard, garden, or a shed)
11. Does your dog go for walks?
    a. Yes
    b. No
12. How often is your dog taken for a walk?
    a. 1-2 times per day
    b. 3-4 times per day
    c. 5-6 times per day
13. Do you think your dog is healthy?
    a. Yes
    b. No
14. Is your dog being treated with medication?
    a. No
    b. Yes, specifically:
15. Do you ever notice vaginal discharge? Think of: red discharge or pus.
    a. No
    b. Yes, specifically:
16. Has your dog ever suffered from urinary incontinence?
    Urinary incontinence is the involuntary loss of urine, without the dog being aware of it. This can involve a few drops of urine being lost or a puddle of urine suddenly appearing without you seeing the dog actively urinate in that spot.
    a. Yes
    b. No
17. When did your dog first experience urinary incontinence?
    a. Before the spaying
    b. 0-6 months after the spaying
    c. 6-12 months after the spaying
    d. >12 months after the spaying
18. How severe was your dog's average urine loss when it first occurred?
    a. 0, no urine loss
    b. 1, a few drops after a long time (4 hours or more) without being let out
    c. 2, a few drops after a short time (less than 4 hours) without being let out
    d. 3, a puddle of urine after a long time (4 hours or more) without being let out
    e. 4, a puddle of urine after a short time (less than 4 hours) without being let out
19. Has your dog's urination behavior changed around the time the incontinence started? Think of: the posture during urination, the color of the urine, straining, etc.
    a. No
    b. Yes, specifically:
20. Have you taken your dog to the vet to have the urinary incontinence examined?
    a. Yes

    b. No
21. Can you indicate which tests your vet performed? (You can select multiple answers)
    a. General examination
    b. Urine test
    c. Ultrasound
    d. X-ray
    e. I forgot/I don't know
22. What diagnosis was made?
23. Does your dog currently suffer from urinary incontinence?
    a. Yes
    b. No
24. What treatment is your dog receiving? (You can select multiple answers)
    a. Propalin or Tensurin
    b. Enurace
    c. Incurin
    d. Suprelorin implant
    e. AUS implant
    f. Antibiotics
    g. Other, specifically:
    h. Unknown
25. How severe do you estimate your dog's average urine loss is at this moment?
    a. 0, no urine loss
    b. 1, a few drops after a long time (4 hours or more) without being let out
    c. 2, a few drops after a short time (less than 4 hours) without being let out
    d. 3, a puddle of urine after a long time (4 hours or more) without being let out
    e. 4, a puddle of urine after a short time (less than 4 hours) without being let out
26. Do you have any comments or suggestions about the questionnaire? Or is there anything else you would like to add?

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