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Intervention Types and Frequency in Animal Prosthetics and Orthotics

Ray Jeffrey Lee
Iowa State University, ray.lee.ms.cf@gmail.com

Ray Jeffrey Lee
Concordia St. Paul, ray.lee.ms.cf@gmail.com

CONCORDIA UNIVERSITY, ST. PAUL

ST. PAUL, MINNESOTA

DEPARTMENT OF KINESIOLOGY AND HEALTH SCIENCES

Intervention Types and Frequency in Animal Prosthetics and Orthotics

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Ray Jeffrey Lee

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Dedications

To Peg, the one-legged chicken who could; Sunka, the three-legged dog who can outrun most four-legged ones; and my wife Molly, who has a normal number of legs but is a great source of support and inspiration nonetheless.

I remember the day she was hatched out
The vet came to see her and said
"She has only one leg, she'll never grow up"
He said that chick would be better off dead
I said, "No, let's just let her keep growing
We'll just wait and see how she gets"
Before very long she was hopping
And pecking and chasing the bugs with the rest
And now she is a beautiful chicken
Though she has only one leg
When I go to see her each morning
She hops from the nest and she leaves me an egg

-Tom T. Hall

From *The song of the one-legged chicken*

Songs of Fox Hollow (1974)

Abstract

Orthotic and prosthetic interventions in veterinary medicine have been performed on a wide range of animal species, aiding in rehabilitation and healing for various pathologies. Contrary to popular belief, veterinary orthotics and prosthetics are not a recent development but have a long history. This study aimed to assess the frequency, cause, and nature of veterinary interventions that could have benefited from orthotic and prosthetic interventions across different species. Data were collected through a survey administered to veterinarians and veterinary orthotic and prosthetic professionals. The outcomes of the investigation contribute to enhancing the knowledge surrounding veterinary amputations, arthrodesis, and the use of orthotic and prosthetic interventions. The survey findings reveal valuable insights into the world of veterinary orthotics and prosthetics, highlighting the growing recognition of their potential benefits among veterinarians. The diverse range of interventions reported and the inclusion of various species underscore the versatility and applicability of orthotics and prosthetics in veterinary medicine. By addressing the recommendations from this study, future research can further advance the field of veterinary orthotics and prosthetics, expanding our understanding of their applications, improving treatment options, and ultimately enhancing the quality of life and mobility of animals in need.

Keywords: *Veterinary Orthotics, Veterinary Prosthetics*

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Chapter 1: Introduction

Orthotic and prosthetic interventions or amputations are performed on a wide variety of animal species. Many animals adapt well to a complete disarticulation, such as a pelvic limb disarticulation from a canine or amputation of a bovine digit. There are numerous examples of animals of various species that have been fit with a variety of prostheses or orthotic devices, such as orthotics for canines with torn cranial cruciate ligaments. The primary function of a canine stifle orthosis is to limit excessive movement of the knee joint, preventing further damage and promoting healing (Bertocci et al., 2017). This sort of device has also been used with small ruminants (Sama, 2018) and in birds (Kleinschmidt, 2019). In animal models of different species, the level of this intervention may determine different device designs based around the biomechanics of the digit; for instance, the equine digit functions differently biomechanically at the level of the fetlock than at the level of the carpus. To our knowledge, the current body of literature does not describe the frequency of the level of the amputation or intervention based on species.

This information is useful because it may help future researchers focus their efforts on interventions that more commonly occur; further research would need to be performed to determine what design of the prostheses or orthosis would be most effective to produce the most natural biomechanics for the animal. Having this information would allow the interested researchers to prioritize what interventions would be most beneficial to further research.

Such devices may be beneficial to correct problems that limit the comfort and longevity of an animal. Examples of these problems include osteoarthritis in the canine elbow producing lameness resulting in compensatory load redistribution onto the unaffected limbs (Bockstahler, 2009), or an amputation at a higher level of the digit or limb, altering the gait pattern and

creating more stress on other structures to compensate for this pathomechanical gait pattern (Borghese, 2013). Compensatory load redistributions and gait alterations such as these may lead to premature breakdown of the contralateral limb or spinal structures. Transferring this load to a prosthesis or supporting the structures with an orthosis allows the animal to have a more normal gait that reduces the load on these structures. Knowing which orthotic or prosthetic interventions are most common, and/or details on biomechanical issues in animals that could be corrected with an orthotic or prosthetic (such as level of limb amputation) may be used in prioritizing future research on devices that may be used to promote the most biomechanical gait possible. A review of existing literature suggests that a comprehensive study of the frequency and level of veterinary orthotic and prosthetic interventions is a practicable topic. There is interest from others published on the topic and there is a wide variety of published articles regarding veterinary orthotic and prosthetic devices and veterinary amputation. Developing the base of knowledge on the frequency and type of intervention into one study would be beneficial to future researchers to determine what would be the most effective to develop further versions of orthotic and/or prosthetic interventions.

Veterinary Orthotics and Prosthetics History and Advancements

Many assume that veterinary orthotics and prosthetics is a new field; however, the opposite is true. There have been numerous veterinary orthotic and prosthetic interventions described in the literature for decades (Hall, 1974; Koger, 1963; Koger, 1970; Orsini, 1985; Zehr, 1977). Beyond this literature, one may consider therapeutic farriery (the practice of managing the hoof health and supporting devices applied to the hooves of an equine) as veterinary orthotic intervention (Butler, 2004), thus demonstrating that such interventions have been in use for over a hundred or possibly thousands of years as there is evidence that farriery

existed and was frequently practiced well before the common era (Butler, 2004, Churchill, 1926; War Department, 1941).

The development of modern materials and methods have improved the feasibility of constructing Veterinary Orthotic and Prosthetic devices. Methods such as additive manufacturing, commonly referred to as 3-D printing, is an effective and useful method (Wojnarowska, 2021). One advantage to using additive manufacturing is that it is an efficient way to construct a device with a reasonable high-level of detail, especially if the device needs to be of small size. One example of this is the case of a chicken with a sprained ankle joint and use this process to construct an ankle-foot orthosis for the chicken (Wojnarowska, 2021). Another advantage of additive manufacturing is the ability to use software to create an electronic model of the device thus allowing the device to be created quickly (Wojnarowska, 2021).

Veterinary Orthotics and Prosthetics Need

According to survey data, pet owners are willing to invest in the health and mobility of their animals so that they may be more comfortable and have a better quality of life especially towards their end of life (Heuberger, 2016). Moreover, these pet owners are interested in investing both time and financial commitments to provide their animals with devices so that they may have more comfort and better mobility (Heuberger, 2016). Livestock, such as bovines or equines, may be high-value animals and thus may also be worth providing orthotic or prosthetic devices to prolong and improve their quality of life. In a study by Beisser, traumatic musculoskeletal injuries were observed to be common in midwestern racehorses (2011). These horses often have high value and the owners of such animals may be willing to invest in these animals so that the lifespan at a reasonable quality of life may be increased after these injuries.

The Veterinary Orthotics and Prosthetics field is a viable field because there is a need to construct and provide animals with the devices for the orthotic or prosthetic interventions in order to most successfully treat a variety of pathologies. It is possible to harm the animal with such devices, so proper understanding of veterinary anatomy and orthotic or prosthetic design and material properties is imperative.

Veterinary Orthoses

Veterinary orthoses may be used as a pain mitigation strategy for a variety of musculoskeletal pathologies that arise from contractures, joint instability, or ligament insufficiency such as Cranial Cruciate Ligament insufficiency (Kaufmann, 2014). For instance, veterinary orthoses have been constructed and have been useful for canine hock instability (Marcellin-Little, 2015). Stifle orthoses are often used as an intervention for Cranial Cruciate Ligament insufficiency; the most common cause of canine hind limb lameness (Carr, 2016; Borghese, 2013). A stifle orthosis gives the injured canine tibiofemoral joint more stability by supporting the soft tissue structures that allow this joint to articulate (Kaufmann, 2014). Other examples of veterinary orthoses that can be found described in the literature are orthoses designed to help promote healing of a canine gastrocnemius strain (Case, 2013), canine paw pad wounds and other distal extremity wounds (Hardie, 2013), and traumatic sciatic neuropathy in a canine using an ankle-foot orthosis (Levine, 2003).

Other forms of veterinary orthotic interventions or assistive devices include orthoses constructed to treat tendon contractures, orthoses that provide carpal supports, harness or slings to provide support for rehabilitation after amputation and fitting a prosthetic device, hobbles to restrict motion so that range of motion is limited to facilitate healing, or carts (Borghese, 2013;

Adamson, 2005). Additional examples discussed in the literature include goats with green stick fractures being treated successfully with orthoses (Sama, 2018) or the additive manufacturing used to construct an ankle-foot orthosis for a chicken with a sprained ankle joint mentioned previously (Wojnarowska, 2021). Veterinary orthoses can be used to facilitate an animal's rehabilitation and improve the animal's quality of life and promote healing of a variety of injuries. After providing the orthotic device to the animal, rehabilitation therapy is critical to recovery (Marcellin-Little, 2007).

Another form of Veterinary Orthotics is therapeutic farriery; or the practice of managing the hoof health and supporting devices applied to the hooves of an equine. Farriery is an ancient craft that has existed for thousands of years; iron hipposandals, or an iron horseshoe held on with leather straps, can be dated to 400 BCE (Butler, 2004). Lameness in horses has been studied widely; the ground reaction forces of the horse during locomotion (Weishaupt, 2002) and kinematics and kinetics of the limb when lame and sound have been examined (Kai, 2000; Oosterlinck, 2013; Weishaupt, 2010). The effects of lameness of the thoracic (Buchner, 1996) or pelvic limb (Bell, 2016; Buchner, 1996) have been considered.

One example of a pathology that is frequently stabilized with an orthotic intervention is laminitis. Laminitis occurs when there is inflammation and damage to the sensitive laminae, which are the soft tissues that connect the hoof wall to the distal phalanx inside the hoof (Lee, 2018). This can cause the coffin bone to shift or rotate within the hoof, leading to severe pain and potential permanent damage to the foot (Butler, 2004). Laminitis affects many horses annually regardless of breed, use, or location (Slater, 1995). In the acute stage, pads made of closed cell polystyrene foam can be used to distribute the load of the equine across the palmar surface of the hoof (Cerfogli, 2009). A second example of an intervention that may be used to treat equine

laminitis is the heart bar shoe (therapeutic horseshoe constructed with a frog plate) (Butler, 2005; Reilly, 2010). Yet a third example of a device used during an intervention of acute laminitis is clogs (Butler, 2005; Reilly, 2010); these devices are typically fashioned of wood and rubber and are designed with a rocker sole so that the horse can adjust the amount of force being transferred through the soft structures of its hoof and suspensory structures by shifting its weight. All of these devices work to redistribute the forces that are transferred through the hoof. Beyond laminitis, additional issues can be successfully managed in horses using orthotic interventions. For instance; limb length discrepancies occur in horses, subsequently causing discrepancies in loading of the horse's limb(s), and providing a horse with a shoe with an orthotic lift may improve the gait of the animal (Butler, 2004, pp.97-98; Vertz, 2018). There are many other devices that fall under the scope of therapeutic farriery which are typically custom constructed and fit to the digit of the equine based upon the animal's specific pathology.

Veterinary Prosthetics

Using veterinary prosthetics in research offers many advantages. For instance, commonly used animals to research osseointegration are rats (Farrell, 2013) and micropigs (Saunders, 2012). Osseointegration is the practice of creating a direct connection to the skeletal anatomy. Osseointegration is described in the literature for a variety of species (in some cases for research prior to human application) and has been used as an effective method of suspending veterinary prosthetics in rats (Pitkin, 2006; Shelton, 2011), cats (Jarrell, 2018) and in horses (Hansen, 2016). There are a number of advantages to this type of suspension; the load being transferred directly into the animal's limb or digit and removing the soft tissue interface between the prosthesis and the bony structures is a significant advantage, the most significant disadvantage is the likelihood of infection. (Pitkin, 2006; Shelton, 2011; Hansen, 2016). Amputation and

osseointegration has also been practiced on a variety of avian species; such as on a white-naped crane (Rush, 2012).

There are also numerous advantages that may be realized by using veterinary prostheses in companion animals and livestock. During their education, veterinarians are often taught that "animals do 'great' on 3 legs" (Mich, 2014). Small animals (e.g., dogs, cats) often experience complete limb disarticulation even if the unsalvageable part of the limb is distal (Mich, 2014). This practice means that the remaining limbs must bear the stresses that were originally distributed amongst four limbs. The effect of the amputation of a pelvic limb and thoracic limb has been studied (Hogy, 2013, Jarvis, 2013). Not surprisingly, the load is transferred to the remaining limbs and the missing limb creates abnormalities during locomotion. Canines standing on three limbs rather than four have to bear significantly more weight on the remaining limbs (Millis, 2017). The ability to salvage more of the limb and allow that limb to bear some load would alleviate the load distribution (Fitzpatrick, 2011; Teixeira, 2021). Amputation may be a useful intervention in some cases; generally, when owners have a positive opinion of the amputation the canine recovers well (Kirpensteijn, 1999).

Ectrodactyly is a condition where there are missing carpal, metacarpal and/or phalanges. Having missing digits in this case prevents the animal from using its limb correctly and may produce more discomfort for the affected animal preventing proper utilization of the limb. Prostheses may be helpful in allowing the animal to utilize the affected limb in a more biomechanically correct and thus more comfortable way (Marcellin-Little, 2015). Both canine and feline ectrodactyly have been treated effectively with prosthetic intervention (Schneck,1974). Other examples of veterinary prosthetics are canine thoracic and pelvic limb prosthesis (Mich, 2014). Prosthetics improve gait mechanics when compared with a quadruped

that has had an amputation (Kaufmann, 2014). In some instances, a prosthesis is placed surgically with a limb or digit to replace a missing, or damaged anatomical component; as these devices are completely encased within the biologic structure these are referred to as endoprostheses. Endoprostheses have been used effectively in treatment of canine radial osteosarcoma (Séguin, 2019), the most common bone cancer in dogs. Two significant concerns in these cases include management of infection, and the biocompatibility of the implant; titanium has been proven to be an effective implant material (Sidambe, 2014).

Veterinary amputation and prosthetic intervention have also been described for large animal species, including horses, cattle, and small ruminants- goats and sheep (Gamsjaeger, 2018). Horses have had reasonable longevity following amputation and have survived to 111 months post amputation (Crawley, 1989). Koger described the process of amputation and prosthesis in a horse (1963, 1970). Other authors have also described this process and the devices associated with these amputations (Kelmer, 2010; Vlahos, 2010; Zehr, 1977).

Amputations and fitment of prosthetics have also been described on bovines; Orsini described the process of amputation and fitting of a prosthetic on a calf and the associated adjustments that were made as the calf grew (1985). Amputation and prosthetics in cattle were described at multiple anatomical levels by St. Jean and the related prostheses that were developed to support the animal (1996). Due to their smaller body size compared to other livestock, goats and sheep may be better candidates for veterinary amputation, resulting in longer survivability following amputation and prosthetic intervention (Gamsjaeger, 2018). Beyond livestock, interventions on large zoo and exotics species have been described, including a forelimb amputation on a radiated tortoise (Claubaugh, 2005).

Prosthetics are useful on more than just animal limbs. Prosthetic beaks have been used to rehabilitate birds that have had traumatic injuries that have reduced the functionality of their beaks (Kleinschmidt, 2019). Depending upon the species of the bird, beaks serve a variety of functions and if their beak is affected, it may reduce the ability of the bird to survive. There are several examples of such interventions in the literature such as prosthetic bills on Ramphastidae birds (Crosta, 2002), prosthetic beaks on marabou storks (Morris, 1990), a prosthetic bill on an African ground hornbill (Peters, 2008) and a prosthetic beak on a salmon-crested cockatoo (Sleamaker, 1983).

Recommendations

Veterinary orthotic and prosthetic interventions are performed on a wide variety of animal species and may be used to facilitate rehabilitation and healing of a variety of pathologies. There are numerous examples of animals that have been fit with a variety of prostheses or orthotic devices in the literature, from orthotics for canines with torn cranial cruciate ligaments or for chickens with sprains to prostheses in horses with an amputated limb and prosthetic beaks in species, as well as a variety of other devices that were designed, constructed and fit to a plethora of species. Though it has been common school of thought that animals such as dogs adapt well to a complete disarticulation of an entire limb, this produces additional wear and can lead to premature deterioration of compensatory structures. Therapeutic farriery may also be considered as an orthotic intervention and has been practiced for thousands of years.

The knowledge of the anatomy and biomechanics of the animal for which the device is being built is crucial for the success of these devices. Veterinarians are resourceful and often

construct devices out of a variety of materials that they can obtain easily or are familiar with. If veterinarians were more aware of the options associated with veterinary orthotic and prosthetic interventions, they may be more apt to do partial limb amputation on small animals rather than complete limb disarticulation allowing the device to be fit to the animal. Additionally, if veterinarians were more aware of what can be accomplished with orthoses it may be possible to avoid surgery in some instances. Another topic discussed in the literature related to veterinary orthotics and prosthetics is the topics of the importance of maintenance and repair of the devices (Marcellin-Little, 2015). Repair and maintenance need to be completed by professionals that are knowledgeable and familiar with the design, materials, and methods used in the construction of these devices. Follow-ups should be completed with a qualified professional so that the integrity of the animal's residual limb and the device can be inspected for wear or deterioration.

Additionally, research literature discusses the importance of rehabilitation after amputation and fitting of the device to the animal so that the animal can coaptate to the device (Kaufmann, 2014; Kleinschmidt, 2019). The use of slings, carts, hobbles, or other methods of redistributing the ground reaction force experienced by the limb or digit may be necessary during rehabilitation of an animal post-surgery whether it is so the animal can coaptate to a device or recover from the surgery (Borghese, 2013; Adamson, 2005). Like humans, animals fit with orthotics or prosthetics need to be taught to use their new device.

Another concept discussed in the literature was the importance of having a thorough understanding of the anatomical structures and appropriate fabrication materials and methods involved in constructing such devices successfully (Kleinschmidt, 2019; Wendland, 2019). Additionally, understanding the requirements of different animals in terms of what they need of

their device: load capacities, range of motion permitted, traction requirements, and understanding the biomechanics of the limb or digit of the animal are all important considerations.

Conclusion

There have been numerous articles written on the topic of veterinary orthotics and prosthetics; to date little has been written on the frequency of different interventions. It would be useful to have data on the prevalence of how often different interventions occur in order to prioritize what interventions would be most beneficial to further research. To our knowledge, the current body of literature does not have a description of the frequency of the level of the amputation or intervention based on species; it is the purpose of this thesis to complete research to help fill this void.

Chapter 2: Methodology

This study aimed to determine the frequency, cause, and nature of veterinary interventions that may have benefited from orthotic and prosthetic interventions. The data were collected through an electronically administered survey distributed among veterinarians and veterinary orthotic and prosthetic professionals. The collected data were statistically analyzed to understand the associations and significance of orthotic and prosthetic interventions. The study posed minimal physical risks to the participants, and there were no direct benefits or monetary costs involved. Informed consent was obtained from participants, and privacy was ensured through de-identification and secure data storage. No deception was used in the study. The outcomes of the investigation may have contributed to enhancing the knowledge surrounding veterinary amputations, arthrodesis, and the use of orthotic and prosthetic interventions in veterinary medicine.

Participants

The proposal for this study estimated 50 responses. The participants for this study were veterinarians and veterinary orthotic and prosthetic professionals who had experience with veterinary orthotic and prosthetic interventions or those who were interested in using orthotic and prosthetic interventions. They provided self-reported data through an electronically administered survey. Informed consent was obtained from all participants, and the collected data were de-identified and stored securely. The study posed minimal physical risks, and there were no incentives, direct benefits or monetary costs involved.

Instruments

The study involved collecting self-reported data from veterinarians and veterinary orthotic and prosthetic professionals using an electronically administered survey using Qualtrics; the survey was specifically drafted for this project and all respondents used the same survey questions. These instruments gathered specific information about participants' experiences, knowledge, and their opinions related to veterinary interventions or different pathology that may have benefited from orthotic and prosthetic interventions. The survey included multiple-choice, open-ended, and demographic questions. The survey was designed to be completed in 5-10 minutes.

Procedures

The survey was drafted, submitted for IRB approval, and, once approved, published to generate a URL pointing directly to the survey. The survey was available for 6 weeks, and the survey URL was shared through various channels such as veterinarian email listservs, social media, and personal connections. The researchers used the electronically administered survey to collect detailed information from participants regarding their experiences, knowledge, and opinions about veterinary interventions that may have benefited from orthotic and prosthetic interventions. The survey included multiple-choice questions, open-ended questions for qualitative responses, and demographic questions to gather background information. These instruments and distribution methods aimed to gather comprehensive data from veterinarians and veterinary orthotic and prosthetic professionals to gain insights into the potential benefits and applications of orthotic and prosthetic interventions in veterinary medicine.

Ethical Considerations

This study had a low-risk design, with no physical harm or monetary costs for

participants. Informed consent was obtained, and data privacy was maintained through de-identification and secure storage. The study aimed to contribute to veterinary interventions' knowledge without direct benefits to participants, and no deception was used. The study design demonstrated ethical soundness. Although the study did not directly benefit participants, it has the potential to advance veterinary interventions and contributes to the body of knowledge.

Conclusion

In conclusion, this study involved collecting self-reported data from veterinarians and veterinary orthotic and prosthetic professionals using an electronically administered survey which gathered specific information about participants' experiences, knowledge, and opinions related to veterinary interventions that may have benefited from orthotic and prosthetic interventions. The survey was distributed through various channels such as veterinarian email listservs, social media, and personal connections and included multiple-choice, open-ended, and demographic questions. This study prioritized and adhered to ethical principles by ensuring the well-being of participants, obtaining informed consent, and protecting privacy through de-identification and secure data storage.

Chapter 3: Results

The survey results included data from 48 respondents. 40 of the of the respondents were veterinarians (*Table 1*). Additionally, the majority of these respondents had either incorporated or expressed interest in incorporating orthotic or prosthetic interventions into their care plans *(Table 2)*. This indicates a recognition among veterinarians regarding the potential benefits of such interventions.

Intervention Purpose and Species Involved

The survey responses encompassed a wide variety of interventions, reflecting the diverse approaches and techniques employed in veterinary orthotics and prosthetics. Furthermore, the survey responses included a diverse range of species *(Figure 1)*, highlighting the applicability of these interventions across different animals. The species in which respondents indicated performing interventions included birds, cats, cows, dogs, exotics, goats, horses, sheep, and "other".

The majority of survey respondents indicated that the purpose of the orthotic or prosthetic interventions that they performed were, in order of decreasing importance, to improve the animal's mobility, to improve the animal's productive life, and to improve the animal's longevity *(Figure 2)*.

Intervention Type and Application

Among the orthotic or prosthetic devices reported in the survey responses, a significant proportion were utilized on the thoracic or "front" and pelvic or "hind" limbs *(Figure 3)*. Most devices were supplied to aid in the treatment of traumatic injury followed by supporting the animal with a congenital issue *(Figure 4).* Specifically, most devices were provided for the ulnohumeral or tibiofemoral joint. However, some respondents also mentioned interventions at

the level of the acetabulofemoral or glenohumeral joint *(Figure 5)*.

In contrast, there were relatively few responses received regarding interventions for the cervical spine and thoracic spine. No respondents reported providing orthotic devices for the lumbar spine. This may indicate a gap or a need for further research and development in this particular area of veterinary orthotics and prosthetics.

When asked about materials used when performing prosthetic or orthotic interventions, respondents reported using the following materials: PVC; fiberglass casting materials; thermoplastic; molded rubber; metal tube; wire, plastic, wooden, and spoon splints, wood blocks, and custom commercial orthotics. In addition, respondents mentioned using material such as popsicle sticks, tongue depressors, syringe casing, pool noodles, clothes hangers, welding rods, padding, and tape in their prosthetic or orthotic devices. In their survey response, one respondent also indicated that access to 3D printers would be revolutionary.

Finally, when respondents were asked about the usefulness of orthotic or prosthetic devices, the most frequent responses involved trauma or fractured bones. Respondents indicated that orthotics or prosthetics would be useful to address the general situations of trauma (fractures, luxations/subluxations), congenital defects, mobility concerns, and situations where a patient is young or not a good surgical candidate for various reasons. Specific situations mentioned by respondents where an orthotic or prosthetic would be useful included amputations, contracted tendons, frostbite limb loss, facilitate ankylosis failures, and long-term stifle braces for canine CCL tears. In addition, one respondent indicated that orthotics and prosthetics are frequently used in their practice where surgical fixation is not possible due to patient size or financial limitations.

Conclusion

In conclusion, the survey findings provide valuable insights into the world of veterinary orthotics and prosthetics. The high participation of veterinarians and their expressed interest in incorporating these interventions into their care plans demonstrate the growing recognition of their potential benefits. The survey results shed light on the current landscape of veterinary orthotics and prosthetics, highlighting the interest, variety, and potential areas for further exploration in this field.

Chapter 4: Discussion

The results of the survey on veterinary orthotics and prosthetics, including the wide variety of interventions reported and the inclusion of diverse species underscore the versatility and applicability of orthotics and prosthetics in veterinary medicine. One key finding was the high participation of veterinarians and their expressed interest in incorporating these interventions into their care plans. This suggests a growing recognition of the potential benefits of orthotics and prosthetics in veterinary medicine.

Applications

A significant finding was the diversity of interventions reported in the survey, which spanned a wide range of anatomical areas and species. This highlights the versatility and applicability of orthotics and prosthetics in veterinary care.

The focus on thoracic and pelvic limbs, particularly the ulnohumeral and tibiofemoral joints, was also notable. These areas are commonly affected by injuries or conditions that can benefit from orthotic or prosthetic support. Some respondents also mentioned interventions at the level of the acetabulofemoral or glenohumeral joint, showcasing the breadth of anatomical areas that can be addressed through orthotics or prosthetics. However, the limited responses regarding interventions for the cervical and thoracic spine suggests that orthotic or prosthetic interventions may be less commonly utilized in these regions, perhaps due to the complexity or limitations associated with such applications. More research and understanding may be needed in these regions.

The absence of orthotic devices for the lumbar spine was another interesting result. This presents an opportunity for further research and development in this area of veterinary orthotics and prosthetics, which may ultimately improve the treatment options for conditions affecting

the lumbar spine in animals.

Finally, the emphasis on trauma and fractured bones in the perceived usefulness of orthotic and prosthetic devices highlights their role in aiding the rehabilitation and support of animals recovering from such injuries.

Overall, the results of this survey provide valuable insights into the current landscape of veterinary orthotics and prosthetics. These findings can guide future advancements and innovations in this field, ultimately leading to improved quality of life and mobility for animals in need.

Limitations

There are a couple of limitations to consider regarding the survey data. Firstly, the method of data collection did not allow for further analysis or dissection of the data to determine which species the respondents provided the specific devices for. This limitation restricts a more detailed understanding of the specific applications and preferences within different animal populations.

Another limitation is the potential bias introduced by the researcher's connections and the distribution of the survey through certain email listservs, which were predominantly targeted towards food animal veterinarian associations. This could have influenced the respondent pool and skewed the results towards a specific focus or perspective, potentially overlooking the perspectives and experiences of veterinarians in other areas of specialization. Additionally, those who are more interested in the subject matter are probably more likely to participate in a survey on this topic.

These limitations highlight the need for future studies to employ more comprehensive data collection methods that enable a more thorough analysis of species-specific applications

and ensure a diverse representation of veterinary professionals across different fields. This would contribute to a more comprehensive understanding of the current landscape of veterinary orthotics and prosthetics.

Recommendations for Further Research

Based on the results and limitations of the survey on veterinary orthotics and prosthetics, there are several recommendations for future research in this field: species-specific applications, exploration of underrepresented areas, lumbar spine interventions, diverse representation of veterinary professionals, and comprehensive data collection methods.

Species-specific applications: To gain a more comprehensive understanding of the applications of orthotics and prosthetics, future research should focus on species-specific interventions. This could involve targeted surveys or case studies that delve into the specific devices used for different animal species, allowing for a more detailed analysis of their effectiveness and potential improvements.

Exploration of underrepresented areas: Given the limited responses regarding interventions for the cervical and thoracic spine, further research should be conducted to explore the use of orthotics and prosthetics in these regions. Understanding the challenges, potential benefits, and effective interventions for these areas could contribute to expanding the scope of veterinary orthotics and prosthetics.

Lumbar spine interventions: Since no respondents reported providing orthotic devices for the lumbar spine, there is a clear need for research and development in this particular area. Future studies could investigate the specific requirements and challenges associated with developing orthotics and prosthetics for the lumbar spine in animals, potentially leading to new treatment options and improved outcomes for animals with lumbar spine conditions.

Diverse representation of veterinary professionals: To overcome the potential bias introduced by targeted listservs, future research should aim for a more diverse representation of veterinary professionals from various specializations. This could involve collaborating with multiple veterinary associations and organizations to ensure a broader range of perspectives and experiences are captured in the data.

Comprehensive data collection methods: Employing more comprehensive data collection methods would enable a deeper analysis of the survey data. This could involve implementing additional data fields to capture information such as specific species, detailed anatomical areas, and reasons for device selection. Such data would provide richer insights into the applications and preferences within different animal populations.

Conclusion

By addressing these recommendations, future research can further advance the field of veterinary orthotics and prosthetics, enhancing our understanding of their applications, improving treatment options, and ultimately benefiting the quality of life and mobility of animals in need.

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Tables

Respondent's Profession	
Veterinarian	40
Orthotic and/or Prosthetic Provider	2
Veterinarian Technician	1
Other	1

Table 1

Have Performed, Plan to perform or Collaborate In an Veterinary Orthotic or Prosthetic Intervention	
Yes	33
Maybe	8
No	3

Table 2

Conditions an Orthotic or Prosthetic Would be Useful	
Condition	Number of Responses
Amputation	2
CCL tear	1
Congenital Defects	3
Congential Laxity	2
Contracted Tendons	2
Distal Limb Fracture	1
Fracture	7
Limb Loss Due to Frostbite	2
Luxation	2
Mobility	1
To Facltate Ankylosis	1
Trauma	2
When not Surgical Candidate	1

Table 3

Materials Used as Improvised Orthotic or Prosthetic	
Material	Number of Responses
Cast padding	2
Clothes Hanger	1
Commercial Splint with metal stay	1
Custom Orthotic/Prosthetic	1
Fiberglass Casting Material	13
Metal Tube	1
Molded Rubber	1
Paper clips	1
Plastic Splints	3
Pool Noodle	1
Popsicle Sticks	1
PVC pipe	10
Spoon splint	2
Spring	1
Syringe case	1
Tape	1
Thermoplastics	1
Tongue Depressor	1
Welding Rod	1
Wire	1
Wooden Blocks	1
Wooden Splints	3

Table 4

Figures

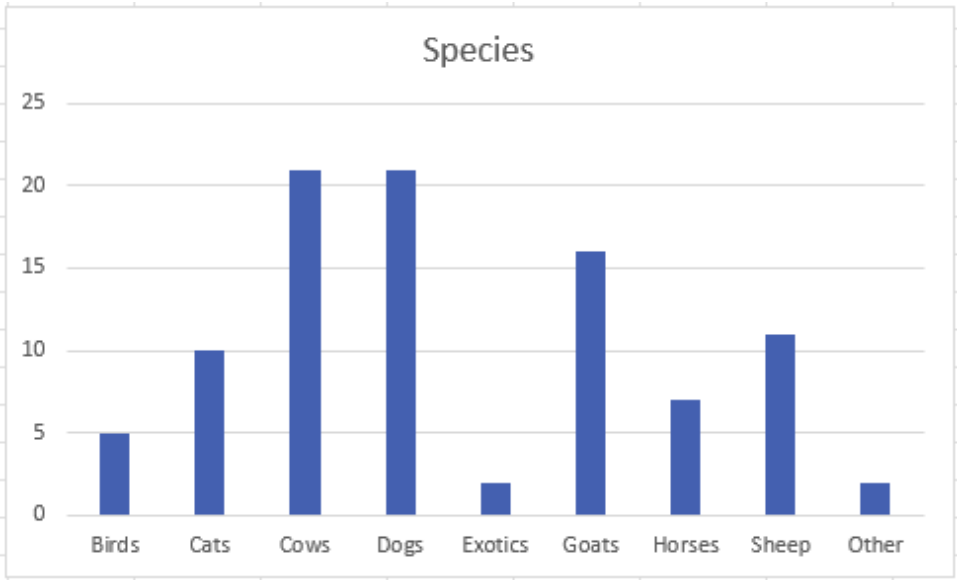

Figure 1

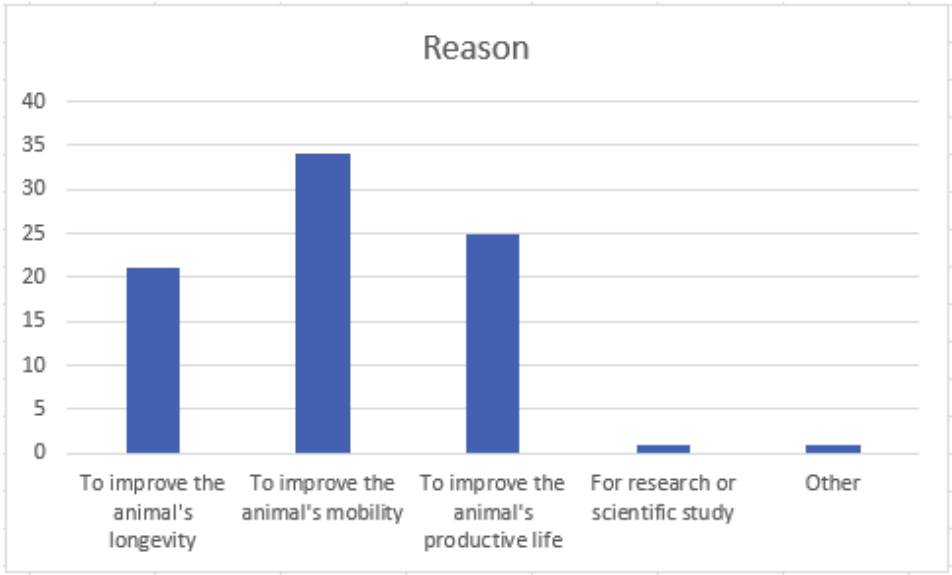

Figure 2

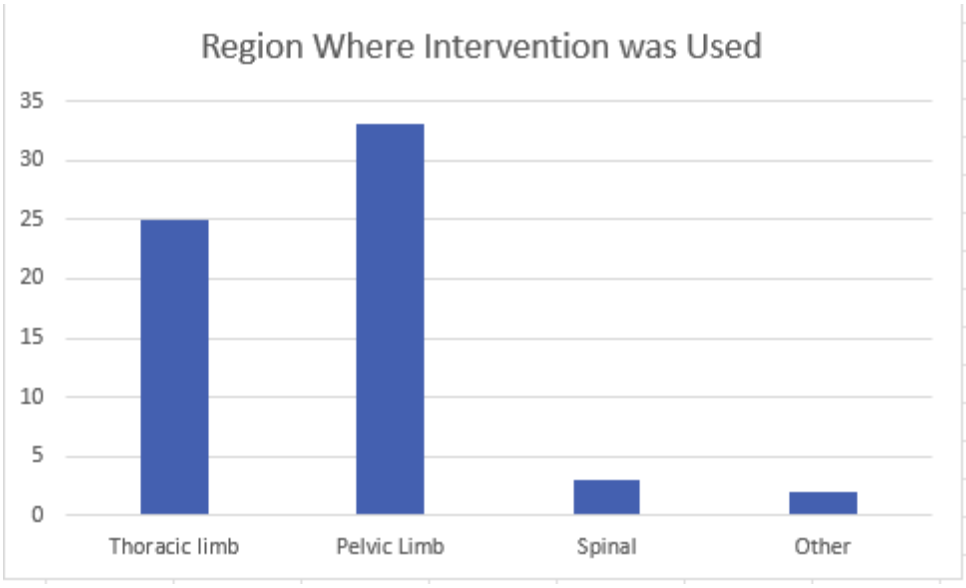

Figure 3

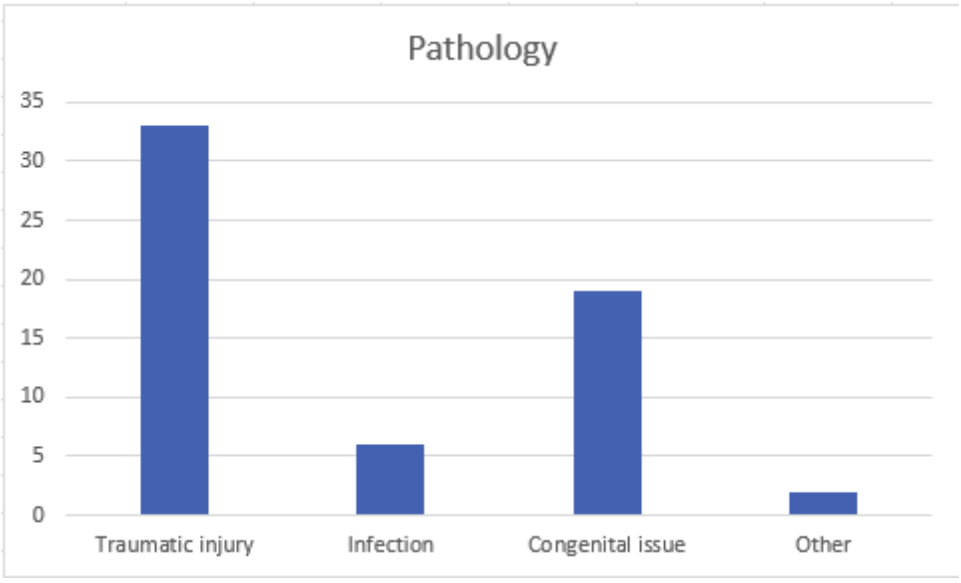

Figure 4

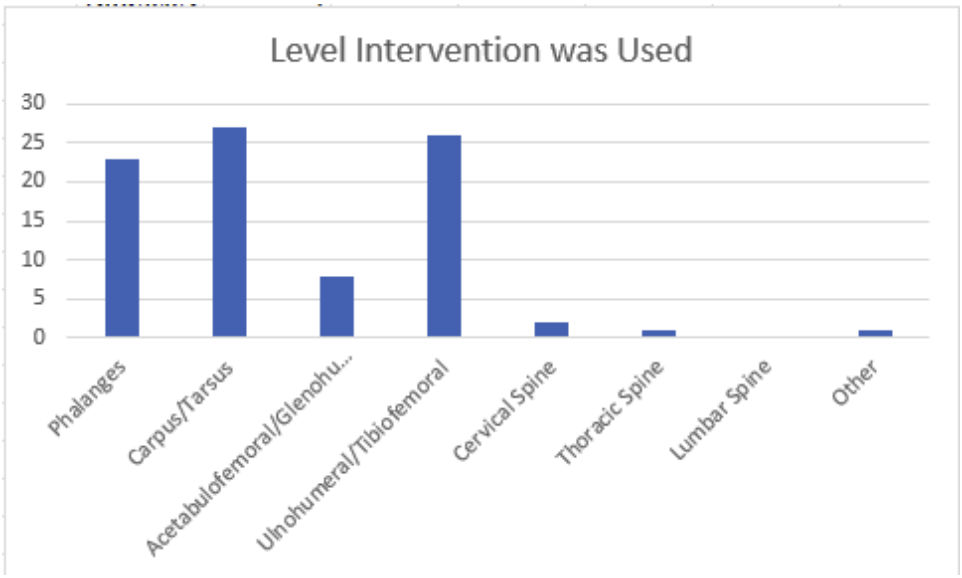
Level Intervention was Used
30
25
20
15
10
5
0
Phalanges
Carpus/Tarsus
Acetabulofemoral/Glenohu...
Ulnohumeral/Tibiofemoral
Cervical Spine
Thoracic Spine
Lumbar Spine
Other

Figure 5

Appendices

Appendix 1: Consent Form

CONSENT FORM

INTERVENTION TYPES AND FREQUENCY IN ANIMAL ORTHOTICS AND PROSTHETICS

You are invited to participate in a research study to collect data to determine the frequency of different surgical interventions that may benefit from Veterinary Orthotic and Prosthetic interventions by species. We ask that you read this form and ask any questions you may have before agreeing to be in the study.

This study is being conducted by: Ray J. Lee, MS, CF; Graduate Student at Concordia University St. Paul – College of Health and Science: Master of Orthotics and Prosthetics.

Background Information

The purpose of this study is: To collect data to determine the frequency of different surgical interventions that may benefit from veterinary Orthotic and Prosthetic interventions by species.

Procedures:

If you agree to be in this study, we would ask you to do the following things:

To complete an electronically administered survey to collect self-reported data from the veterinary surgeons and veterinary Orthotic and Prosthetic professionals. Data will be collected to determine the frequency, cause and orthotic and or prosthetic interventions associated with species

Risks and Benefits of being in the Study

The study has a minimal amount of risk. You will be participating in a self-reporting electronic survey.

You will likely not receive any direct benefits from being in the study: however, the outcomes from this investigation may provide information that can be used to enhance the body of knowledge surrounding the practices of veterinary amputations, arthrodesis, and the use of

Veterinary Orthotic and Prosthetic intervention.

Compensation:

We thank you for your participation in this study. You will not receive compensation for your participation in this study.

Confidentiality:

The records of this study will be kept private. In any sort of report we might publish, we will not include any information that will make it possible to identify you. Research records will be stored securely and only the researcher in this study will have access to the records.

Voluntary Nature of the Study:

Participation in this study is voluntary. Your decision whether or not to participate will not affect your current or future relations with Concordia St. Paul College of Health and Science: Master of Orthotics and Prosthetics. If you decide to participate, you are free to not answer any question or withdraw at any time without affecting those relationships.

Contacts and Questions:

The researcher conducting this study is: Ray J. Lee. You may ask any questions you have now. If you have questions later, you are encouraged to contact him at leer8@csp.edu. You may also contact his faculty advisor at Concordia University St. Paul, Dr. Darren Wiens, at wiens@csp.edu.

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher(s), you are encouraged to contact Steve Ross, chair, Human Subjects Review Committee, at irb@csp.edu or 651-641-8723.

Statement of Consent:

I have read the above information. I have asked questions and have received answers. I consent to participate in the study.

Signature:_____ Date: _____

Signature of Investigator:_____ Date: _____

Appendix 2: IRB Exempt Approval

Concordia
UNIVERSITY·SAINT PAUL

TO: leer8@csp.edu
CC: Humans Subjects Review Committee File

The IRB Human Subjects Committee reviewed the referenced study under the exempt procedures according to federal guidelines 45 CFR Part 46.104d (2): RESEARCH THAT ONLY INCLUDES INTERACTIONS INVOLVING EDUCATIONAL TESTS (COGNITIVE, DIAGNOSTIC, APTITUDE, ACHIEVEMENT), SURVEY PROCEDURES, INTERVIEW PROCEDURES, OR OBSERVATION OF PUBLIC BEHAVIOR (INCLUDING VISUAL OR AUDITORY RECORDING).

Study Number: 2023_027
Principal Investigator: Ray Lee
Title: Intervention Types and Frequency in Animal Prosthetics and Orthotics

Classification: __X__ Exempt ___Expedited ___ Full Review

Approved __X__

Approved with modifications: ____ [See attached]

Declined ____ [See attached]

Upon receipt of this letter, you may begin your research. Please remember that any changes in your protocol need to be approved through the IRB Committee. When projects are terminated or completed, the IRB Committee should be informed in order to comply with Department of Health and Human Services (HHS) Regulations, Title 45 Code of Federal Regulations Part 46 (45 CFR 46). If you have questions, please call the IRB Chair at (651) 641-8723.

Stephen D. Ross
Signature, Chair Human Subjects Review Committee

March 10, 2023
Date

Appendix 3: Survey Questions

Survey Questions

Question 1:

CONSENT FORM

INTERVENTION TYPES AND FREQUENCY IN ANIMAL ORTHOTICS AND PROSTHETICS

You are invited to participate in a research study to determine the frequency, cause, and nature of different interventions (e.g., amputations, arthrodesis, etc.) that may benefit from veterinary orthotic and prosthetic interventions by species. You were selected as a possible participant because you are a veterinarian and/or veterinary orthotic and prosthetic professional. We ask that you read this form and ask any questions you may have before agreeing to be in the study. This study is being conducted by: Ray J. Lee, MS, CF; Graduate Student at Concordia University St. Paul – College of Health and Science: Master of Orthotics and Prosthetics.

Background Information The purpose of this study is: to determine the frequency of different interventions that may benefit from veterinary orthotic and prosthetic interventions by species.

Procedures: If you agree to be in this study, we would ask you to do the following things: Complete an electronically administered survey collecting self-reported data from you as a veterinarian and/or veterinary orthotic and prosthetic professional.

Risks and Benefits of being in the Study: The study has a minimal amount of risk. You will be participating in a self-reporting electronic survey. You will likely not receive any direct benefits from being in the study; however, the outcomes from this investigation may provide information that can be used to enhance the body of knowledge surrounding the practices of veterinary amputations, arthrodesis, and the use of veterinary orthotic and prosthetic intervention.

Compensation: We thank you for your participation in this study. You will not receive compensation for your participation in this study.

Confidentiality: The records of this study will be kept private. In any sort of report we might

publish, we will not include any information that will make it possible to identify you. Research records will be stored securely and only the researcher in this study will have access to the records.

Voluntary Nature of the Study: Participation in this study is voluntary. Your decision whether or not to participate will not affect your current or future relations with Concordia St. Paul College of Health and Science: Master of Orthotics and Prosthetics. If you decide to participate, you are free to not answer any question or withdraw at any time without affecting those relationships.

Contacts and Questions: The researcher conducting this study is: Ray J. Lee. You may ask any questions you have now. If you have questions later, you are encouraged to contact him at leer8@csp.edu. You may also contact his faculty advisor at Concordia University St. Paul, Darren Wiens, at wiens@csp.edu. If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher(s), you are encouraged to contact Steve Ross, chair, Human Subjects Review Committee, at irb@csp.edu or 651-641-8723. Statement of Consent: I have read the above information. I have asked questions and have received answers. By proceeding to the next question, I consent to participate in the study.

Question 2:

For the purposes of this study:

Orthosis describes the correction of disorders of the limbs or spine by use of braces and other devices to correct alignment or provide support.

Prosthesis describes an artificial body part such as a leg either partial or complete.

Question 3:

Have you ever or do you plan to ever provide, participate in, or collaborate on a veterinary orthotic and/or prosthetic intervention?

Yes, No, Maybe

Question 4:

What is your profession?

Veterinarian, Orthotic or Prosthetic Provider, Other (fillable)

Question 5:

In which species have you performed procedures that have involved an orthotic or prosthetic intervention? Select all that apply.

Birds, Cats, Cows, Dogs, Exotics, Goats, Horses, Sheep, Other (fillable)

Question 6:

What would you describe as the purpose of the orthotic or prosthetic interventions that you have performed? Select all that apply.

To improve the animal's longevity, To improve the animal's mobility, To improve the animal's productive life, For research or scientific study, Other (fillable)

Question 7:

Please select the reason the orthosis or prosthetic was required. Select all that apply.

Traumatic injury, Infection, Congenital issue, Other (fillable)

Question 8:

What area have you used prosthetic or orthotic intervention on? Select all that apply.

Front limb, Hind limb, spinal, Other (fillable)

Question 9:

At which level was this intervention used? Select all that apply.

Distal limb (Phalanges), Carpus/Tarsus, Proximal limb (Hip, Glenohumeral), Ulnohumeral/ Tibiofemoral, Cervical spine, Thoracic spine, Lumbar spine, Other (fillable)

Question 10:

Is there anything else you feel the researchers should be aware of?

(fillable)