THE EFFECT OF CORRECTIVE CLAW TRIMMING ON THE GAIT ANLYSIS OF SOWS

by

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(Under the Direction of Kylee J Duberstein)

ABSTRACT

The purpose of this experiment was to explore if correctively trimming sow claws would beneficially change the manner in which the sow walks. Welfare of the sows is a growing issue within the swine industry, and a major welfare problem is lameness. In this experiment, sows were walked through a chute pre, one hour post and forty-eight hours post corrective trimming. The gait of each sow was captured using high-speed cameras to record video footage of each side of the sow simultaneously as she walked through a 2.5 meter recording frame. The data were analyzed using Kinovea kinematics system and analyzed for swing, stance, break over, stride length, two- and three-limb support with comparisons being made between time points. The results show marked difference between the sow's gait pre and post corrective trimming for stride duration. The changes allow for a decreases in discomfort and degeneration of the skeletal system.

INDEX WORDS: Sow, Lameness, Corrective Trimming, Gait Analysis

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DEDICATION

To my family for always reminding me to believe in myself and to never say never.

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CHAPTER 1

INTRODUCTION

Lameness within the swine industry is known to be a problem. It is recognized as the second leading cause of culling animals within the herd and the leading cause of euthanasia. Among gilts, lameness can be responsible for up to twenty five percent of culling. Studies have shown that reproduction and performance for a lame animal suffer due to their tendency to not eat or drink as much as they normally would. Not only is this a financial issue due to the decrease in production and the cost of treatment, but it is a welfare issue. Lame animals that are unable to eat and drink enough to maintain body condition are unable to reach peak production. This change in behavior harms the productivity and the health of the animal. The need to maintain animal welfare is a driving force for improvement of the detection and prevention of lameness.

With the change in the industry towards group housing over the conventional individual confinement housing, there has been a rise in lameness seen in gestating sows. Group housing allows for a larger area in which the sows can move. This allows for a decrease in physical injuries, such as limb lesions, and behavior vices, such as habitual pawing. While decreasing these issues is beneficial, pawing has been shown to maintain claw shortness and health. Group housing also has been shown to cause an increase in aggressive interactions among sows. The aggressive acts are seen consistently with dynamic herds, where sows are moved in and out due to their gestation status. The aggression will occur with the introduction of new sows due to the re-establishment of herd hierarchy. Herds that maintain the same sows from one parturition to another are less likely to have continuous aggression once the hierarchy is set within the group. Groups that show higher aggression levels also possess higher levels of lameness.

Locomotion within a herd is a measurement of welfare level of the farm. Lameness is expected to be treated as soon as possible for the benefit of the animal. However, treatment of lameness is sometimes too late. Lameness does not always present on a high level, instead it is common for lameness to be a low grade, chronic issue. When observed by managers, lameness is less likely to be diagnosed than if a trained outside observer is rating the sows gait. It has been shown that by the time that lameness is seen, irreversible damage has already occurred within the limb. When lameness reaches this point, it is most often unable to be resolved and will likely always be observed, leading to the culling of the animal.

Gait analysis is useful in observing lameness due to subtle locomotor changes that occur that are not observable without detection devices. Within the pig industry there are a handful of gait studies, all of which focus on improving the welfare of the sow. Studies have shown that gait quality is not improved with treatment after lameness is present. Preventative treatments, such as foot baths, with chemicals are hazardous to the environment or health of the workers. Claw trimming is a treatment that studies have bypassed due to the difficulty of restraining the sows during the trimming. With the release of Zinpro’s Feet First Chute, there is a safe and reliable way to restrain a sow for claw trimming. Claw trimming is now a reasonable process to perform on a regular basis on a production farm if there is improvement to the sow’s health.

CHAPTER 2

LITERARY REVIEW

Lameness

Lameness is a major factor for welfare. The 2012 Swine Report by the USDA-APHIS showed that 6.8 percent of sows were culled due to lameness. Farms that had 250-499 sows had a higher incidence at 10.3 percent. When lame, the sow will have behavioral changes due to physically reduced locomotor ability, pain, or general discomfort and sickness behavior (Heinonen et al., 2013). These changes have a direct impact on the sow's welfare. Lameness can be related to locomotion disturbances, leg weakness, joint disorders and claw disorders (Thorup et al., 2007). These conditions are compounded by each other and can lead to larger lameness problems. The lame sow is expected to have a reduction in activity level, social and explorative behavior, and feeding behavior (Heinonen et al., 2013). This activity change challenges the freedoms of the sow. It has been shown that sows that are lame have significantly lower daily water intake than sound sows (Heinonen et al., 2013). This decrease causes a drop in the reproduction efficacy of the sow, which is unable to compete with healthy-legged sows for food and water (Heinonen et al., 2013).

Overall there are significant differences between survival rates of lame and non-lame sows in a commercial herd (Anil et al., 2009). The significant difference in survival rates reflects the high cull and early euthanasia rates that are associated with lame sows. In a sow herd, lame sows survive around 140 days after first farrowing, whereas non-lame sows survived an average of 302 days after farrowing (Anil et al., 2009). Being able to keep a sow sound allows her to be productive and healthy within the herd for a longer period of time. There is a need to minimize the incidence of lameness and to remove lame sows from the herd as early as possible when treatment and recovery is not an option (Anil et al., 2009). Early removal of lame animals increases the value and welfare of the herd.

Lameness is a major issue that has been shown to be the second major cause of culling within a sow herd (Devillers et al., 2012). Culling resulting from lameness causes strain on the production herd to replace the sows. Some sows that are culled for reproductive reasons can trace their problem back to lameness (Abell et al., 2014). Thus, the total impact of lameness on the industry economy is unknown. There is also long term economic loss with keeping a lame sow in the herd. Sows that are lame may stay in the herd due to being late in gestation, or their lamenesses may be less pronounced at weaning due to reduction in body weight during lactation (Anil et al., 2009). This allows sows that are predisposition to lameness to pass on the predisposition to their offspring.

Within the replacement herd, lameness is an important criterion in gilt selection and accounts for up to 25% of culling reasons in gilts (Devillers et al., 2012). Lameness therefore has a major economic impact on the swine industry. When looking at culled sows, 85% postmortem had at least one superficial lesion on at least one claw (Abell et al., 2014). Such a high incidence of lesions creates a negative impact on the economic production of the farm. Herds with a high prevalence of lameness have higher mortality rates, due to early euthanasia (Devillers et al., 2012). Lameness is a massive burden to farms that need to minimize culling and euthanasia for optimal production. When comparing sows within the herd, third parity sows are at the greatest risk of cracks in the wall of the claw. These cracks lead to lameness and culling from the herd. Fourth parity sows have the same incidence of cracks of the claws as second parity sows, therefore by the fourth parity the sows have undergone a selection process for good claw health (Diaz et al, 2014).

Lameness is not a singular disease but a common clinical symptom of various ailments, both structural and functional that are observable by changes in gait (Starakakis et al., 2014). Because lameness can be caused by multiple factors, it can be highly difficult to treat successfully within a production setting. The leading causes of lameness have been found to be genetic or acquired musculoskeletal weakness, infections, injures, nutrition deficiencies and systematic diseases that attack the musculoskeletal system (Stavrakakis et al., 2014). Some of the issues are more difficult to prevent, such as injury and infection, yet it is possible to reduce the chance of injury and help to decrease the stress on the musculoskeletal system by correcting small issues before they lead to long term damage.

Lameness is defined as the inability to use one or more limbs in a normal fashion while generally displaying a normal degree of alertness and coordination in the unaffected limbs (Abell et al., 2014; Pluym et al., 2013). Lameness severely limits the welfare of the sows and impacts the health of the sow negatively. In the sow herd about 5-20 percent of lameness is due to foot lesions, the most common of which is the overgrowth of the claw (Pluym et al., 2013). Overgrown claws inhibit the sow from normal locomotion and behavior. This overgrowth can lead to leg weakness, which causes the sow to be unable to nutritionally maintain production of milk. This lower production of milk lowers the weaning weight of her piglets (Pluym et al., 2013). For both the wellness of the sow and her litter, lameness negatively effects the overall welfare of the animals.

Claw Lesions

The most common claw lesions are cracks, overgrowth or tear of the different parts of the main claws or the dew claws (Nalon, et al., 2013). These issues are sub-categorized by location such as side wall, white line, sole, heel, heel-sole junction (Nalon et al., 2013). There is a need for trimming in the cases of claw and dewclaw overgrowth on the farm (Pluym et al., 2013). Corrective trimming is important as a preventative measurement when combating lameness. Long dew claws can get stuck in the slots of slatted floors, putting the sow at risk of amputated claws (Pluym et al., 2013). Tearing the dew claw is extremely painful due to exposure of the corium, which leads to lameness. Treatment of any type of lameness is frequently awkward with low rates of recovery (Pluym et al., 2013). Being neither economical nor productive, treatment is not the best route to follow for a producer. As treatment yields inconsistent results, there is merit in utilizing preventative techniques (Pluym et al., 2013).

With sows that are in group housing, there is a higher prevalence of claw lesions compared to individually stalled sows (Pluym et al., 2013). The increase is due to increase in movement around the pen, which increases the chance of amputation of the claw or dewclaw, along with an increase in possible aggressive interactions where on sow pushes another sow around and causes claw injury. This increase in claw lesions means that there is going to be a continued growth in lameness of sows as more farms switch to group confinement. In multiple studies, the majority of sows were found to have at least one or more claw lesions (Diaz et al., 2014). Claw lesions have been shown to be a major cause of lameness in sows (Diaz et al., 2014).

Sow Housing

Housing of sows is changing due to welfare concerns. While stalls have benefits, such as easy management, individual feeding and reduced aggressive encounters between individuals, there are drawbacks to individual stalls such as freedom of movement, which is severely restricted (Harris et al., 2006). Within individual stalls, sows do not have to move around to reach their feed and water. Thus, these confined sows have been shown to have reduced cardiovascular fitness, reduced muscle weight and bone strength, increased morbidity, and they engage in more unresolved aggression (Harris et al., 2006). The move towards group housing is driven by the attempt to help the overall welfare of the sow.

Lameness has been shown to be higher in group-housed sows than their individual-stalled counterparts, primarily due to aggressive interactions and increased mobility (Anil et al., 2009). The increase in sow interactions, along with the danger of limbs being stepped on, causes group housing to yield more injuries within the herd as compared to stall housing. Negatives of the stalls have led to gestation stalls being banned or phased out of some European countries (Harris et al., 2006). While European countries have moved away from stalls, the United States has not followed this trend. Approximately two-thirds of sows in the United States spent their pregnancy in stalls (Harris et al., 2006). With welfare becoming a growing issue within all industries, it is not farfetched to expect the creation of a law phasing out stalls in the United States.

One of the major drawbacks to group housing is the poorer condition of grouped gilts' feet and legs (Harris et al., 2006). This decrease in limb health could transform lameness into a larger issue within a sow herd than currently seen. The poorer condition of the claws results in a higher lameness visual score (Harris et al., 2006). With larger numbers of animals with high lameness scores, the welfare of the herd as a whole is compromised. The higher lameness could be linked to pen design features and the opportunity for increased locomotion on uneven slatted floors (Harris et al., 2006). Sows have more opportunity to be injured due to increased walking and having to compete to get to feed and water (Diaz et al., 2014). Another contributing factor with grouped housing is mounting by estrus sows (Harris et al., 2006). Sows that have skeletal weakness would not be able to successfully tolerate being mounted without injury occurring.

Flooring

Concrete slatted flooring has a negative effect on the leg health, with dew claw overgrowth and wrenching, heel lesions all of which negatively effects the sows' gait pattern (Candor et al., 2014). In large-group housing systems the risk factor for leg disorders increases (Candor et al., 2014).It is also suggested that feeding practices also affect sow leg disorders (Candor et al., 2014). This could be a direct effect of feed not matching the needs of a gestating sow. Overall, it has been thought that extreme body conditions might be detrimental to leg health (Candor et al., 2014). Both ends of the spectrum would put the sow under more stress. When looking at gilts, the risk of culling due to lameness is higher than in sows (Candor et al., 2014). The higher nutritional requirements of the gilt due to growth maybe a cause of higher lameness rates.

Another risk factor is dirty floors and high ammonia levels in activity areas (Candor et al., 2014). Dirty floors decrease the coefficient of friction of the floor, causing more slipping to occur compared to clean floors. The ammonia also reduces horn solidity and horn elasticity (Candor et al., 2014). The weakening of the horn promotes the degradation of keratin by bacterial enzymes and may cause foot injuries (Candor et al., 2014). Bacterial penetration of the claw is responsible for painful inflammations and is facilitated on dirty floor (Candor et al., 2014). The inflammation increases the lameness score of the sow. Yet freshly cleaned floors increase slipping rates, which can lead to claw lesions (Candor et al., 2014). Wet concrete causes high slipping rates compared to dry concrete.

In the study by Diaz et al. (2014) 42 sows were housed in slatted concrete floored gestation stalls and 43 sows were housed in slatted concrete floored loose-housing with 20 solid concrete resting pads. Sows from each group were then moved into farrowing crates, 48 crates with slatted steel floors and 37 crates with cast iron. Results showed that the sows that were loose-housed during gestation had a greater risk of being lame when transferred to farrowing crates. The loose-housed sows were in dynamic groups, which lead to high levels of aggression. The higher aggression within the group lead to higher lameness compared to the gestation stall group. The slatted floors that were in the loose-housing did not provide adequate support to claws during aggressive interactions. In the study, narrow slats were used, which have been found to be associated with more lameness than wider slats (Diaz et al, 2014). Slatted concrete floors have been shown to be a major cause of claw lesion formation. The space between slats, roughness of surface and edge design all contribute to injuries (Enokida et al., 2009) All of the sows in the Diaz et al. (2014) study had deterioration of claws after they moved into farrowing crates. This is due to both the slatted steel and cast iron having large void ratios that increased pressure on the claw that is in contact with the slate (Diaz et al, 2014).

Sow Health

Lameness causes sows to be unable to attain optimal breeding efficiency due to culling before they attain their peak production (Anil et al., 2009). This causes a large turnover of breeding animals, which leads to the animal not reaching maximum financial productivity. Not only are the sows culled before they reach peak production, but they are also under extra scrutiny when shipped to market for sale (Anil et al., 2009). This means that producers are unable to make up for the money they lose when culling a younger animal.

When looking at different lameness levels based on gait abnormalities, it is relatively easy to distinguish a severely lame sow from healthy sow but is difficult to correctly distinguish a mildly lame sow from a healthy sow (Anil et al., 2009).

This shows that the subjective tests have inconsistency from sow to sow. Even though it is difficult to differentiate, early detection is critical in preventing the afflicting condition from deteriorating (Anil et al., 2009). This early detection favors using gait analysis to differentiate lame and non-lame sows. Early detection allows producers to receive the full salvage value of the sow or provide her with timely and effective treatment (Abell et al., 2014). This allows for better management of the sow and a decrease in lost revenue due to a permanently lame sow.

The total number of pigs born alive per sow farrowed was less for lame sows than non-lame sows (Anil et al., 2009). This is a combination of fewer farrowing cycles and not reaching peak productivity before being culled. This is illustrated by a reduction in longevity, fewer live born pigs, and fewer numbers of such sows that farrowed again, along with possibly crushing piglets due to a decreased ability to make postural changes in lame sows (Anil et al., 2009). A low producing sow, that also has an increased chance of crushing the piglets, is an economically poor choice when compared to a sow that has more piglets that are not at a high risk of being crushed. The lower production can be connected back to reduced feed intake by the sow, which leads to lower weaning weights and higher mortality rates (Abell et al., 2014). These smaller and lighter litters will compound the revenue loss that is seen while trying to treat lameness in the sow.

Immune Response

Lameness causes a release in cytokines due to inflammatory processes, which can induce anorexia and lethargy (Anil et al., 2009). Sows will be less social as well as less likely to maintain hydration and body condition. These effects, plus the decreased desire to move due to pain and discomfort, causes a marked decrease in feed intake and movement (Anil et al., 2009). With a drop in body condition, the sow will have less reserves to provide milk for her piglets and will not be as breeding sound as a well-conditioned animal. Sows that ate less than 3.5 kilograms of feed per day during the first two weeks of lactation were more likely to be removed from the herd before their next parturition (Anil et al., 2009). This means that sows that are unwilling to eat enough to maintain healthy body weight will not make it within the herd.

It has been found that lateral claws are larger than medial claws (Pluym et al., 2013). The difference between claws is more pronounced on rear feet than on front and increases as pigs age (Pluym et al., 2013). As the pig ages, the small differences between the two claws will expand. As the difference increases, the frequency of claw lesions increases (Pluym et al., 2013). The unevenness of the two claws will cause the lateral claw to carry all of the weight of the limb, while the medial claw will grow without contact with the floor. The discrepancy has been associated with a higher culling risk (Pluym et al., 2013). Sows that have this attribute will always be predisposed to a higher rate of lameness due to structural failure of their claws. The difference in the claw size has been shown to be hereditary to a certain extent. This means that selection of replacement gilts with evenly -sized toes may help to control the development of claw lesions (Pluym et al., 2013). Evenly-sized claws help to keep the pressure constant across the claw to decrease lameness and lesions from occurring. The problem of uneven claws is exacerbated by the natural swivel gait in the rear limbs which displaces more weight onto the outside claws (Van Amstel, 2011). This causes claws that were already carrying the majority of the weight to have more force placed on them, allowing the uneven distribution to be magnified.

Claw Trimming

Claw trimming is routine in other industries, such as the equine, ovine and bovine industries, yet is not common in the swine industry. Older studies suggest routine claw trimming in pigs is necessary, however more recent studies do not recommend claw trimming as a prophylactic measure in group- housed sows (Pluym et al., 2013). This discrepancy leads to an industry that largely does not trim claws as a preventative measure. In one study it was found that preventative claw trimming did not show improved longevity or a clear effect on claw lesion development, therefore not supporting the additional labor and costs associated with regular, preventive claw trimming (Pluym et al., 2013). Even though some studies have deemed claw trimming as unproductive, most professionals suggest that trimming is needed for the health and welfare of the sows.

Trimming is strongly recommended when the claws of the sow are overgrown as a corrective treatment. Trimming includes using hoof nippers and grinders to shorten and reshape the claws. The overgrowth of the claw is trimmed using hoof nippers to decrease the length of the claw to 45-50 millimeters (Van Amstel, 2011). Cutting the length of the claw first with nippers shortens the time that is needed to shape the hoof with the grinder. Then the grinder is used to reshape the walls of the hoof to take out the curving that occurs with overgrowth of claws (Van Amstel, 2011). Straightening the wall helps to maintain the correct pattern of growth for longer after trimming. Dew claws can also be trimmed back to prevent trauma and interference during normal locomotion (Van Amstel, 2011). Trimming dew claws helps to decrease the risk of lameness due to injury. Foot baths have also been recommended, with or instead of trimming. It has been suggested to use copper sulfate, zinc sulfate and formalin (Pluym et al., 2013). The mixture within the foot bath would dry and harden the horn of the claw to prevent injury due to soft and weakened claws. Environmental concerns over copper and zinc sulfate cause them to be ill-advised to use, and formalin is a known carcinogen (Pluym et al., 2013). Therefore while this mixture is useful on the farm, it should be carefully used by diligent workers.

Lameness problems can be corrected for by trimming claws when problems are noted (Van Amstel, 2011). Early detection is essential for correction to help the sow overcome her lameness. Structures such as the corium, basement membrane and germinal layers of epidermis are critical for horn formation and growth of claw (Van Amstel. 2011). Learning how to maintain the health of these structures is extremely beneficial for prevention of lameness. When claw lesions involve the corium, they cause pain and lameness (Van Amstel, 2011). These two reactions cause the welfare of the sow to be compromised, creating the need for producers to prevent these claw lesions from occurring. The most likely causes of corium becoming compromised are inflammation due to trauma, infection or inappropriate nutrition (Van Amstel, 2011). These issues all lead to the claw becoming unable to function naturally due to structural integrity degeneration. When blood flow to the corium is compromised, horn growth is affected which causes horizontal or vertical wall cracks, erosions and ulcers in the sole or heel of the animal (Van Amstel, 2011). Each of the defects of the claw causes the sow to be uncomfortable while walking, therefore causing her to be less likely to behave like she naturally would. Claw makeup is based on nutrients that include fatty acids, the amino acids cysteine and methionine, the minerals calcium, zinc, copper, selenium, manganese and chromium and vitamin A, D, E and biotin (Pluym et al., 2013). These nutrients are provided to the sow through her diet, yet maybe in deficit during lactation when the sow's nutrient needs are extremely high. Dietary needs should be carefully assessed during the different stages of production to assure that the diet meets the sow's nutrient profile.

Subjective Analysis

Lameness can be assessed using subjective methods, such as gait and locomotion scoring (Stavrakakis et al., 2014). These methods are useful on farms for looking at the herd on a daily basis, but are dependent on the scorer being knowledgeable and proficient with the scoring system. Scoring systems are successful in allowing the observer to quickly and affordably quantify lameness prevalence in the herd on any particular day (Abell et al., 2014). This helps the producer to regularly check the herd for lameness issues without having to bring an expert into the farm.

One of the major problems with lameness scoring systems is that there can be disagreement between lameness scores that are given to a sow (Abell et al., 2014). These discrepancies between scorers can be attributed to viewing the sow day after day. This leads to inter- or intra-scorer variation, where the same sow is given two different scores by the same or two different scorers (Abell et al., 2014). Giving two different scores to the same sow means that her lameness is downgraded in one of the scores, which allows a lame sow to stay in the herd.

Visual scoring requires substantial training to make users both accurate and proficient when evaluating sows for lameness (Abell et al., 2014). The training time needed to create a skilled worker for evaluating lameness makes the process an expensive for the producer to have to validate. The long time frame that it takes to produce skilled evaluators, along with high employee turnover rates, makes this practice inefficient to train for lameness detection (Abell et al., 2014). While the scoring system is relatively cheap and is used at most farms, there is a commitment that must be made to maintain a trained evaluator on the farm. By having objective measurements, the discrepancies between scorers will be eliminated and uniform method to detect sow lameness will be established (Abell et al., 2015). This would provide a sensitive and definitive detection for lameness.

Gait Analysis

Gait analysis is a widely accepted useful tool that is more accurate in assessing gait deviation that visual gait assessment (Wren et al., 2011). With the evolution of higher definition cameras that capture higher frames per second, experiments can now be run by looking at motion in a frame by frame process. Look at the different measurements of time and motion, patterns occur that distinguish lame and sound sows from each other (Mohling et al., 2014). The systems that are used allow for less user error due to less control going to the user to define measurements. Using gait analysis verses subjective methods of classification is more successful in targeting longevity characteristics and preventing lameness (Stavrakakis et al., 2014). Isolating for these characteristics increases welfare and improves economic output. The increase that is seen, in conjunction with sows that are included in the herd for longer, makes each sow a higher producer. Yet the biomechanical study of sows is a complex process that require simplification before it will be usable on farms (Stavrakakis et al., 2014). The system is expensive and labor intensive, and has technical details when setting up that would not make it useful on a farm.

Even with a subjective method that works, it is important to develop a system that uses quantitative methods to identify gait parameters that are more sensitive than what is visible to the observer (Stavrakakis et al., 2014). Lameness is a progressive problem that can cause long term damage to the musculoskeletal system before visible signs appear. It has been shown that using gait analysis parameters detect pigs with abnormalities which are not observed by visual observation (Stavrakakis et al., 2014). This illustrates that the system is more sensitive and can be used to detect issues before they visibly impair the pig. An increased sensitivity system has the potential to complement or even replace existing subjective selection of breeding animals (Stavrakakis et al., 2014). The ability to select for decreased lameness in the breeding herd would have the potential to decrease turnover rates and increase production in the long term. The increase in production would be due to an increase in longevity, an important quality when selecting future breeding stock (Stavrakakis et al., 2014) which leads to sows reaching their full breeding potential. Focusing on musculoskeletal conformation, mobility and freedom of disease is essential for increasing longevity in sows (Stavrakakis et al., 2014). By increasing the musculoskeletal correctness and health, longevity will be greatly increased compared to current animal's predicted lifespan.

Biomechanics

When studying lameness, or even how an animal moves naturally, there needs to be set measurements between animals to help differentiate problems from the normal gait pattern. Biomechanics is the study of the mechanical nature of biological processes. In the case of this experiment, it is the study of how the animal's locomotion is occurring and what is disrupting the natural movement. Walking is a four-beat gait with alternating two- and three-limb support phases (Thorup et al., 2007). The pattern holds true for the majority of quadrupeds due to their step patterns. Sound sows will have a steady pattern of the two and three limb support phases during their walking gait cycle. Sows carry 54% of their weight on their forelimbs (Thorup et al., 2007). The distribution of weight is seen in quadrupeds because their center of mass is located around their shoulder area. The higher load and impacts on the forelimbs due to weight distribution causes leg problems at a higher frequency in fore rather than rear legs (Thorup et al., 2007). This difference in weight distribution also leads to differences in gait biomechanics when comparing the rear legs to the front.

In lame sows, there is a tendency of shorter stride lengths, lower velocity, and longer stance times than sound sows (Abell et al., 2014). While the differences may not be clear to the eye, they are detected by the cameras and can be analyzed in a kinematic software program to give producers distinctions between lame and non-lame sows. Variations in stride pattern, due to pain, are present in sows with poor limb structure more often than in sows with desirable limb structure (Abell et al., 2014). Having measurements that can be used to compare limbs during movement can help to prevent issues with the sows before long term issues arise.

Gait analysis has been shown to be an objective tool compared to traditional systems of lameness scoring, which are highly subjective with varying degrees of inter- and intra-observer correlation (Mohling et al., 2014). This allows measurements to be more consistent with gait analysis, therefore caretakers have a reliable method in which to judge the lameness level of the sow in which the user error is decreased. It has been shown that gait analysis programs are good tools that exhibit differences in gait characteristics between sound and most lame sows (Mohling et al., 2014). The ability for more sensitive measurements to differentiate levels of lameness that are undetectable to the naked eye makes quantitative gait analysis a promising tool for diagnosis of early lameness symptoms. Yet the systems are hardly applicable on farm, being costly and time consuming to do the analysis in the program (Devillers et al., 2012). While the systems are expensive, they have the potential to save the producer money.

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CHAPTER 3

THE EFFECT OF CORRECTIVE CLAW TRIMMING ON THE GAIT ANALYSIS OF SOWS.

Introduction

Lameness is a major issue within the swine industry. Sows that are lame are unable to compete successfully for feed and water (Heinonen et al., 2013). This decreases the productivity of the sow, and her welfare is impaired (Heinonen et al., 2013). Sow's welfare is a growing concern for producers and consumers. A product of the concern for welfare is the move from gestation crates to open-housed pens for sows. It has been shown that sows in open-housed pens have a higher incidence of lameness as compared to sows in gestation crates (Pluym et al., 2013). With the move towards open-housed pens due to consumer perception, lameness is a looming crisis. Studying how to help prevent and treat lameness is a nascent field with very few answers as to the underlying causes, let alone productive treatment.

Hoof trimming is a preventative treatment in bovine, equine and ovine industries to help prevent overgrowth and injuries due to hoof overgrowth. (Kummer et al. 2006, Smith et al. 2014, Beteg et al. 2011) Similarly, claw trimming in sows may help to prevent future lameness injuries and is an area that warrants further investigation. Gait analysis can be used to determine if changes occur due to trimming. Gait analysis can be used to detect abnormalities in swine that are not observable visually (Stavrakakis et al., 2014). Gait analysis programs illustrate the differences in gait characteristics of lame sows (Mohling et al., 2014). This helps to provide a basis on which to compare changes in gait quality.

Experiment

Experimental protocols were approved by the University of Georgia (UGA) Institutional Animal Care and Use Committee. In this study, 52 PIC C29 sows were video recorded pre, one hour post and forty-eight hours post trimming. Pigs were an average of 4.7 parities at the time of the study, with four pigs coming back through the study over six months after their first trimming. Each time, the pigs were walked through a circular chute with a straightaway that allowed for a straight path for the pig to follow during recording. Two high speed GigEye Ethernet Cameras (IDS Imaging Development Systems, Obersulm, Germany) were positioned perpendicular to the track straightaway, with the track centered 3 meters from either camera. Cameras were set 24 cm in height. Footage was captured on Equine Tec (Monroe, Ga) at 60 frames per seconds and cameras were synchronized through an IDS computer driver. The straightaway was 0.6 meters in width with 2.4 meters pre-recording distance, 2.4 meters recording distance and 1.7 meters post-recording distance. Electrical timers (Farmtek, Wylie, TX) were placed on each end of the recording frame. Times for each repetition were recorded, and repetitions that were outside of ten percent of the mean were eliminated from analysis. Pigs were walked through the chute until at least 5 useable repetitions were recorded that met the ten percent mark. Commercial hog panels formed the chute walls and at the straightaway was raised 26.5 cm off the ground so that all claws were visible.

Once pre-trim videos were recorded, sows were taken into a separate room for foot trimming. Sows were loaded into a Feet First chute that had a padded bar along the midline of the sow. After the gates on the front and the back of the sow were secured, the chute was raised up to allow the trimmers access to the claws. Hobbles were used on the front limbs, closely tightened around the pasterns. Two power grinders with 8 diamond grinding pads were used to grind the claws of each sow. Each claw was marked at 5.5 centimeters from the coronary bands, and dewclaws were marked to be even with the coronary band of the claws. Claws were trimmed to get as close to the lines marked on each claw as possible. Claws were carefully shaped so that each claw did not interfere with its partner and maintained a rounded edge to lessen the bluntness of the freshly shortened claw. Each claw was checked to make sure that pressure going onto the claw would be distributed evenly across both claws and the heel.

One hour after trimming, sows were moved back to the track, where they were walked for another 5 repetitions of consistent speed and momentum. Once 5 useable repetitions were achieved, the sows were moved back to their individual pens and allowed to adjust to the post trim claws. Forty-eight hours after trimming, pigs were moved back to the recording chute and filmed again until 5 usable repetitions were achieved. They were then sent back to the breeding farm.

Video Analysis

Videos were uploaded and analyzed using the kinematics software, Kinovea (France). Individual frames from each video were isolated and analyzed for the following parameters of each limb: stance duration, swing duration, break over time, stride length, total stride duration, swing to stance ratio, break over as a percent of stride duration, and stance as percent of stride duration, along with two and three limb support times.

Stance duration was recorded as the time from the claw coming in contact with the ground until the first frame where the claw comes off the ground. Swing duration was measured as the time that the limb is moving through the air from when claw first leaves the ground until the claw touches the ground again. Break over was defined as the time from the heel starting to lift off of the ground until the toe of the claw is no longer in contact with the ground. Stride length is the distance between sequential footfalls of a given limb measured at the front of the lateral claw. Total stride duration is the total time in which it takes for the combination of swing and stance phases to be completed. Swing to stance is the ratio of the two measured phases, which illustrates the balance of the two phases within a stride pattern. Break over as a percent of stride duration is the ratio between the measurements and can be used to look at the impulse of the sow during push off. Stance as percent of stride duration is the ratio that illustrates the ground contact time of the limbs relative to the entire stride cycle.

Measurements were recorded for each video. Each sow was used as her own control by comparing the pre, post and forty-eight hours post videos pig. The recorded measurements for each video were analyzed looking at the front limbs as one set and the rear limbs as another set. The average values of the right and left limb were compared for both the front and rear limbs across the times. The difference between the values of the right and left limb were also compared for both front and rear limbs across the times. The data were analyzed in SAS using a PROC MIXED program using time as a variable. A P value of $P<0.05$ was considered significant for all parameters measured.

Chapter 4

RESULTS

Spatiotemporal Changes

In the study, it was found that there was an improvement in the sow's gait quality from pre to forty-eight hours post. The stance duration showed a decrease from both pre and post to forty-eight hours post for the front limbs ($P < 0.01$, 0.6608, 0.6512, 0.6168 s for pre, post and 48 post respectively, Figure 3-1). The average rear stance duration decreased from pre and post to forty-eight hours ($P<0.01$, 0.713, 0.6913, 0.6595 s for pre, post and 48 post respectively, Figure 3-1). There was a decrease in swing duration for front limbs from pre to post and forty-eight hours post ($P<.0001$, 0.3815, 0.3689, 0.3667 s for pre, post and 48 post respectively, Figure 3-2). The rear limb decreased from pre to forty-eight hours ($P<0.05$, 0.4293, 0.417, 0.4066 s for pre, post and 48 post respectively, Figure 3-2). The ratio of swing to stance in the front limbs had a significant increase from post to forty-eight hours post ($P<0.05$, 0.6025, 0.5916, 0.6178 for pre, post and 48 post respectively, Figure 3-3). The change in the rear limb for swing to stance was not significant for any of the times (0.6381, 0.6309, 0.6499 for pre, post and 48 post respectively, Figure 3-3).

The average front limb stride duration decreased from pre and post to forty-eight hours post ($P<0.05$, 1.0423, 1.0201, 0.9835 s for pre, post and 48 post respectively, Figure 3-4). The rear stride duration average was also different, with pigs showing a shorter stride duration across the times ($P<0.05$, 1.1406, 1.1083, 1.0661 s for pre, post and 48 post respectively, Figure 3-4). Stride length for the front limbs decreased from pre to post and increased post to forty-eight hours post. The change was significant between the pre and post ($P<0.05$, 106.55, 103.74, 104.52 cm for pre, post and 48 post respectively, Figure 3-5).The rear limbs stride length was not significantly different for any of the times (103.54, 102.00, 103.49 cm for pre, post and 48 post respectively, Figure 3-5). Velocity of the front limbs increased from pre to forty-eight hours post and post to forty-eight hours post ($P<0.05$, 104.86, 105.14, 109.72 cm/s for pre, post and 48 post respectively, Figure 3-6). The hind limb velocity average also increased from pre to forty-eight hours post and post to forty-eight hours post ($P<0.001$, 93.2343, 95.2354, 101.29 cm/s for pre, post and 48 post respectively, Figure 3-6).

Improved Break Over

Break over duration decreased over the times measured for front claws ($P< 0.01$, 0.1233, 0.1115, 0.1024 s for pre, post and 48 post respectively, Figure 3-7) and rear claws ($P<0.05$, 0.1362, 0.1202, 0.1108 s for pre, post and 48 post respectively, Figure 3-7). The break over to stride duration was significantly decreased from pre to post and forty-eight hours post ($P<0.05$, 0.1197, 0.116, 0.1066 for pre, post and 48 post respectively, Figure 3-8). Break over to stride duration had a significant decrease from pre to post and pre to forty-eight hours post ($P<0.01$, 0.1209, 0.1097, 0.1067 for pre, post and 48 post respectively, Figure 3-8).

Two Limb Support Phase Increased

The average for the three limb support duration out of stride duration of the front limb decreased from pre to post and pre to forty-eight hours post (P<0.05, 0.6213, 0.6528, 0.6463 for pre, post and forty-eight hours post respectively, Figure 3-9). The average for the rear limb percent of three limb support decreased from pre to post and pre to forty-eight hours post (P<0.05, 0.6489, 0.6455, 0.62 for pre, post and forty-eight hours post respectively, Figure 3-9). The percent of stride duration spent in the stance duration for the front limbs decreased from post to forty-eight hours post (P<0.01, 0.6284, 0.6324 0.6222 for pre, post and 48 post respectively, Figure 3-10). The average for the rear limbs during the percent of stride duration spent in the stance duration showed no significant differences between the times (0.6174, 0.6177, 0.613 for pre, post and 48 post respectively, Figure 3-10).

Improved Gait Symmetry in Some Gait Parameters

The difference between front limbs in stance duration was not significant but did show a slight decrease (0.05071, 0.04503, 0.04553 s for pre, post and 48 post respectively, Figure 3-19). The rear limbs difference decreased from pre to post and pre to forty-eight hours post (P< 0.01, 0.08392, 0.0688, 0.06649 s for pre, post and 48 post respectively). The difference between the right and left limb for front swing duration was not significant between time points (0.03832, 0.03349, 0.03712 s for pre, post and 48 post respectively, Figure 3-12). The difference between the right and left limb for rear limb swing du-ration decreased from pre to post and forty-eight hours post (P<0.01, 0.06057, 0.04852, 0.04742 s for pre, post and 48 post respectively, Figure 3-12). The front limb difference for swing to stance increased for post to forty-eight hours post ($P<0.01$, 0.08818, 0.07499, 0.09473 for pre, post and 48 post respectively, Figure 3-13). The difference in the swing to stance of the rear limbs decreased between pre and post ($P<0.01$, 0.1231, 0.1027, 0.1123 for pre, post and 48 post respectively, Figure 3-13).

The stride duration difference between front limbs was significant from pre to post and forty-eight hours post with pigs showing a more symmetrical gait post trimming ($P<0.05$, 0.05472, 0.04648, 0.04697 s for pre, post and 48 post respectively, Figure 3-14). The difference in stride duration of the rear limbs was also significant from pre to post and pre to forty-eight hours post, again with pigs showing more symmetry post trimming ($P<0.01$, 0.09136, 0.07331, 0.07577 s for pre, post and 48 post respectively, Figure 3-14).

The difference between the front limbs stride length was not significantly different between any of the times but was smaller for the post and then returned to the bigger difference for the forty-eight hours post (7.4698, 6.8271, 7.4366 cm for pre, post and 48 post respectively, Figure 3-15). The rear limb stride length decreased from pre to forty-eight hours post ($P<0.01$, 8.0343, 7.113, 6.2629 cm for pre, post and 48 post respectively, Figure 3-15). The difference in right and left limbs for the front limb velocity decreased pre to post and then increased post to forty-eight hours post ($P<0.05$, 9.2839, 8.1753, 9.8342 cm/s for pre, post and 48 post respectively, Figure 3-16). The rear limb difference between right and left limbs for velocity showed a significant decrease from pre to post and pre to forty-eight hours post ($P<0.01$, 11.0617, 8.7337, 8.8689 cm/s for pre, post and 48 post respectively, Figure 3-16). The difference in break over between the right and left limbs in the front limb decreased over the all times measured (P<0.05, 0.01668, 0.01361, 0.01147 s for pre, post and 48 post respectively, Figure 3-17). The difference between the right and left limbs for the rear limb break over decreased from pre and forty-eight hours post (P<0.05, 0.02199, 0.01614, 0.01375 s for pre, post and 48 post respectively, Figure 3-17). The difference in the front limbs for break over to stride duration decreased from pre to post and pre to forty-eight hours post (P<0.05, 0.01736, 0.01450, 0.01354 for pre, post and 48 post respectively, Figure 3-18). The rear limb difference between days for break over to stride duration decreased from pre to post (P<0.05, 0.02211, 0.0144, 0.01535 for pre, post and 48 post respectively, Figure 3-18).

The percent of three limb support duration decreases from pre to post and pre to forty-eight hours post for the front limb (P<0.05, 0.06944, 0.05873, 0.06033 for pre, post and forty-eight hours post respectively, Figure 3-19). The rear limb percent of three limb support duration decreased from pre to post and pre to forty-eight hours post (0.07275, 0.05255, 0.06013 for pre, post and forty-eight hours post respectively, Figure 3-19). The difference in the percent stance duration the front limbs for the stance of stride duration increased from post to forty-eight hours post (P<0.05, 0.03332, 0.02953, 0.03542 for pre, post and 48 post respectively Figure 3-20). The rear limbs showed a decrease in the percent stance duration from pre to post (P<0.01, 0.04575, 0.03799, 0.0406 for pre, post and 48 post respectively, Figure 3-20).

Discussion

Looking at the results of the experiment, it can be seen that there is an improvement in the gait of the sows. The decrease in swing duration, stance duration, and stride duration indicates a quicker stride, therefore it takes less time for the sow to go through a stride cycle. Break over duration decrease as a direct effect of the shortening of the toe and allows the sow to move fluidly from stance to swing phase, potentially decreasing the strain on soft tissue of the lower limb. Improving ease of break over may lead to a decrease in injuries occurring from locomotor causes. The shorter stride duration is due to the shorter time in both the stance and swing. Stride length shows that the ground that is covered decreased for the front limbs and the time it takes to cover the distance also decreased. However, when examining velocity (distance/time), an increase was seen from pre to forty-eight hours post which shows that sows are not reducing the distance covered by the same proportion that their stride is quickening. Hence, though front stride length decreases somewhat post trimming, stride frequency increases to a higher level to still allow for an increase in velocity post trimming. It is possible that the decrease in front stride length is a result of the change in angulation of the claw and will lead to a decrease in slipping due to the legs being kept more underneath the body.

Stance to stride duration supports that the sow gait pattern is not impaired by long lasting hoof soreness that may arise from the corrective trimming. Since the ratio does not decrease from pre to forty-eight hours post, the sow is not showing signs of lameness by forty-eight hours post trimming. The break over to stride duration illustrates that the sow is able to push off the ground more efficiently to move into the swing phase. The percent two limb support increased; this along with the change in percent stance duration shows that the sow has more propulsion to her stride. The difference between the right and left limbs, for both front and rear limbs for stance, swing, stride duration, stride length, velocity, break over, percent break over, and percent three limb support illustrates that there is an improvement to gait symmetry following claw trimming. This improvement is most pronounced in the hind limbs, possibly due to the front limbs having less asymmetry at the beginning of the study.

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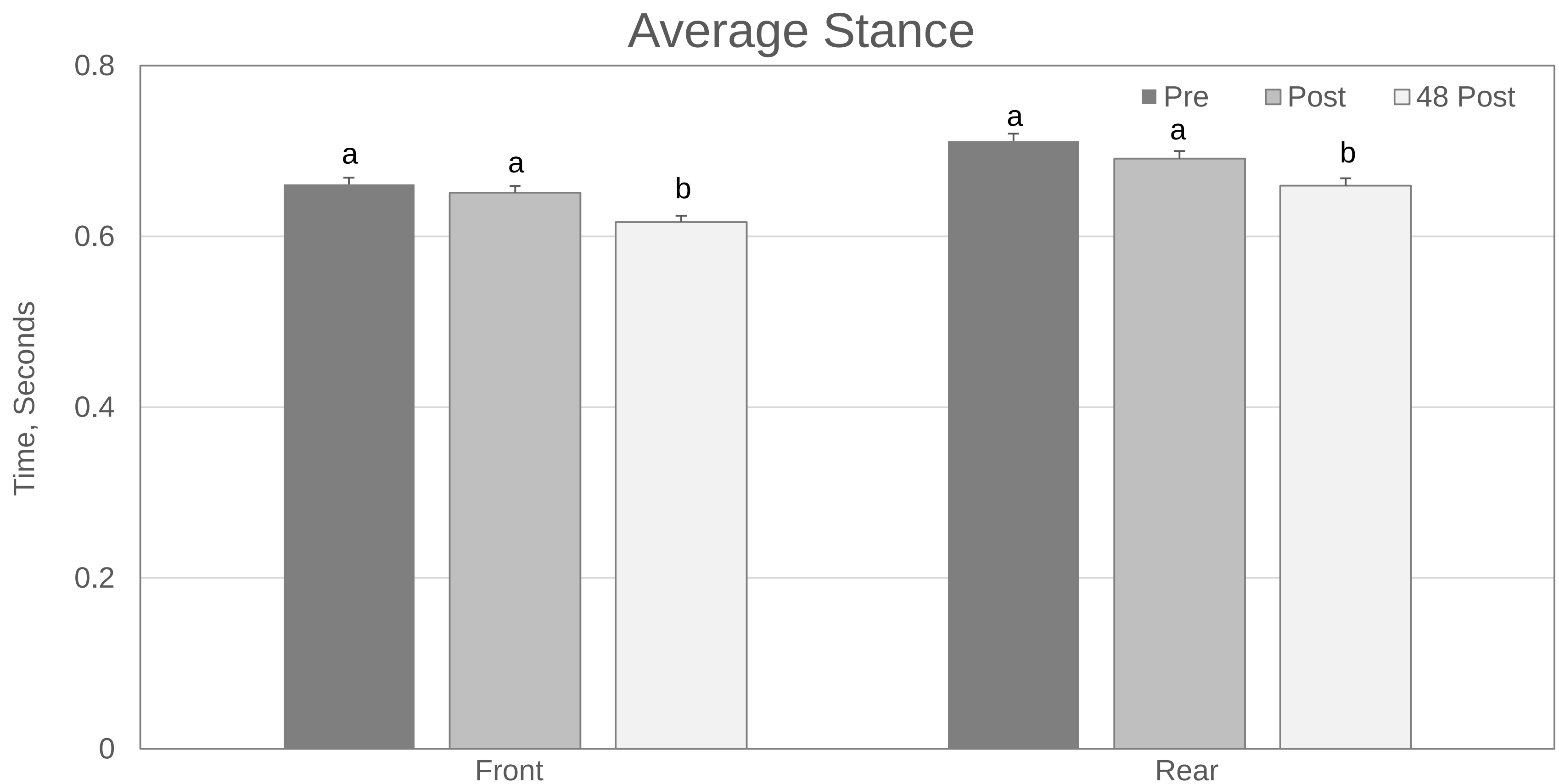

Figure 3-1. Average Stance for Front and Rear Limbs. Front limb average was $p<0.05$ for pre to 48 post and post to 48 post. Hind limb average was $p<0.05$ pre to 48 post and post to 48 post.

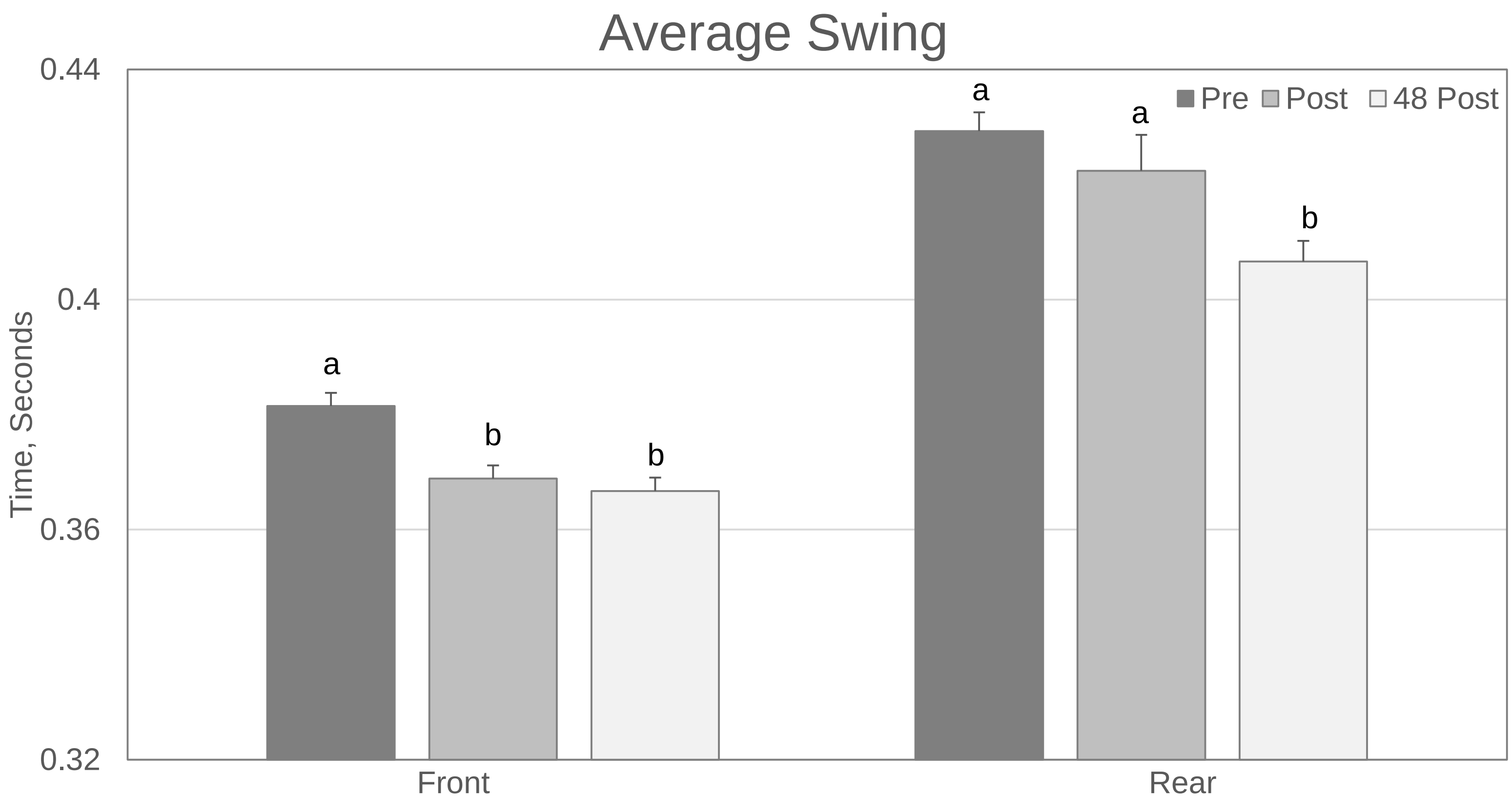

Figure 3-2. Average Swing for Front and Rear Limbs. The front limb was $p<0.05$ pre to post and pre to 48 post. The rear limb was $p<0.05$ across all the times.

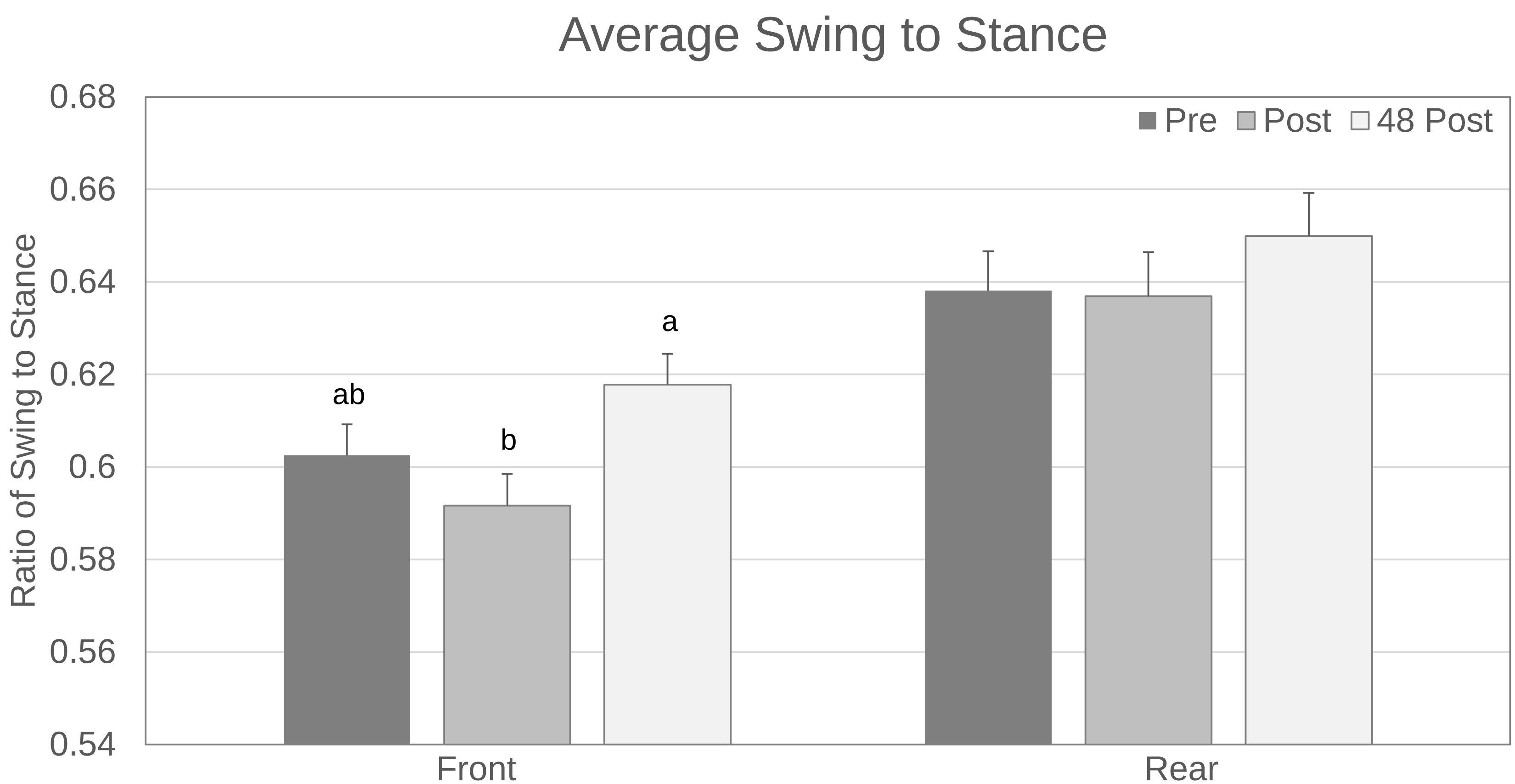

Figure 3-3. Average Swing to Stance for Front and Rear Limbs. Front limb average was $p<0.05$ for post to 48 post. For rear limb average there was no significant differences between the times.

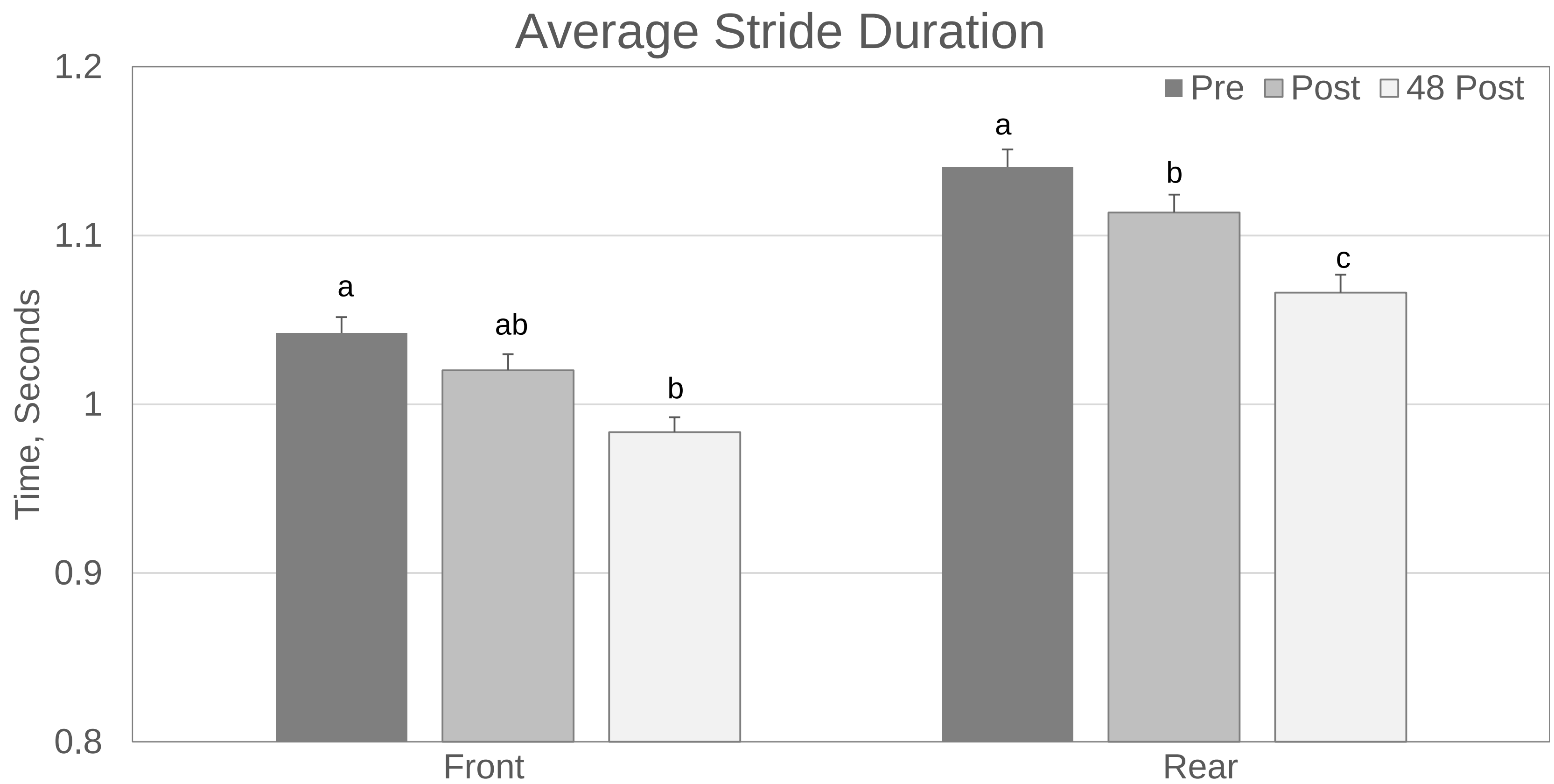

Figure 3-4. Average Stride Duration for Front and Rear Limbs. Front average was p<0.05 for pre to 48 post and post to 48 post. Rear limb average was p<0.05 for pre to post, pre to 48 post, and post and 48 post.

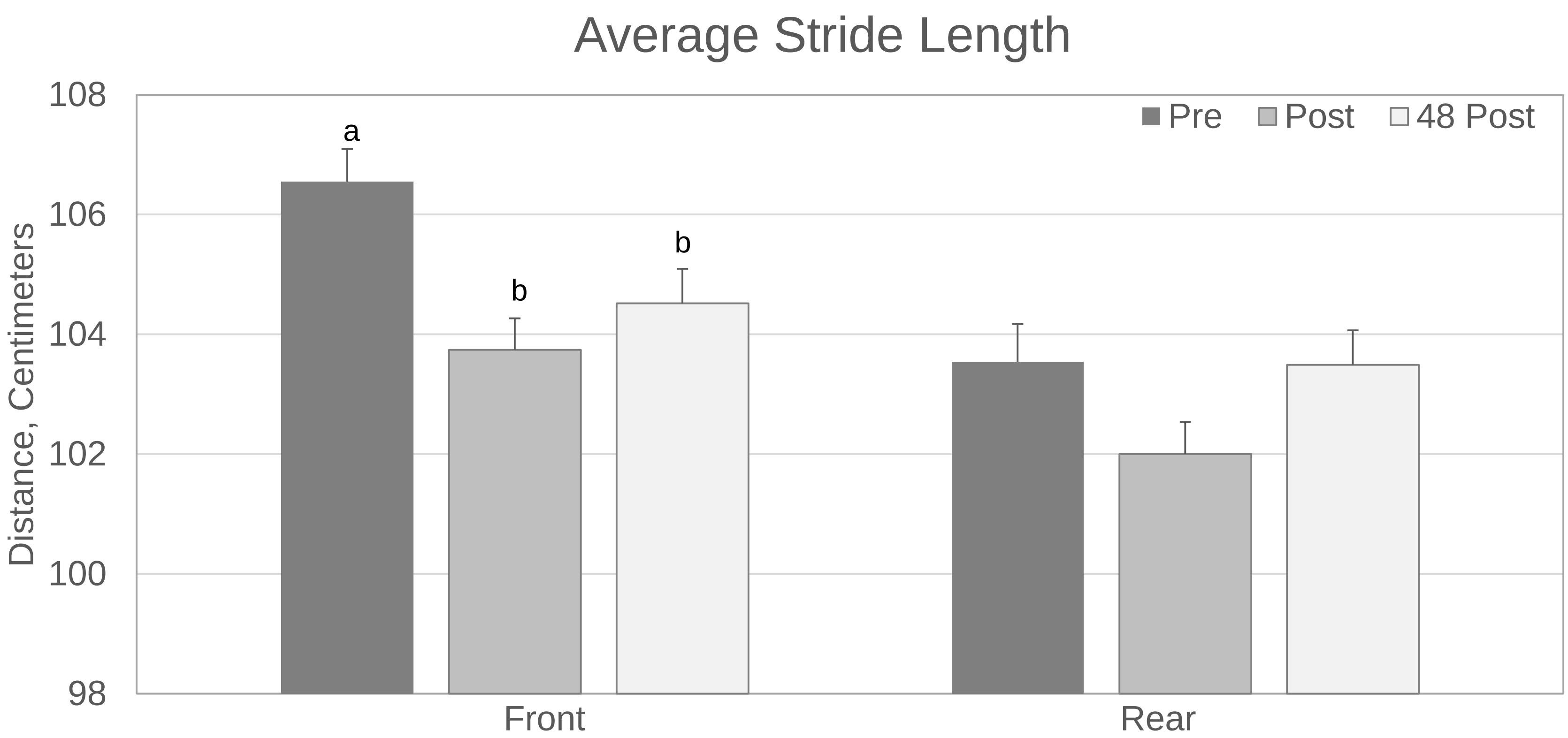

Figure 3-5. Average Stride Length for Front and Rear Limbs. Front limb average was p<0.05 from pre to post and pre to 48 post. For rear limb average was there was no significant change between times.

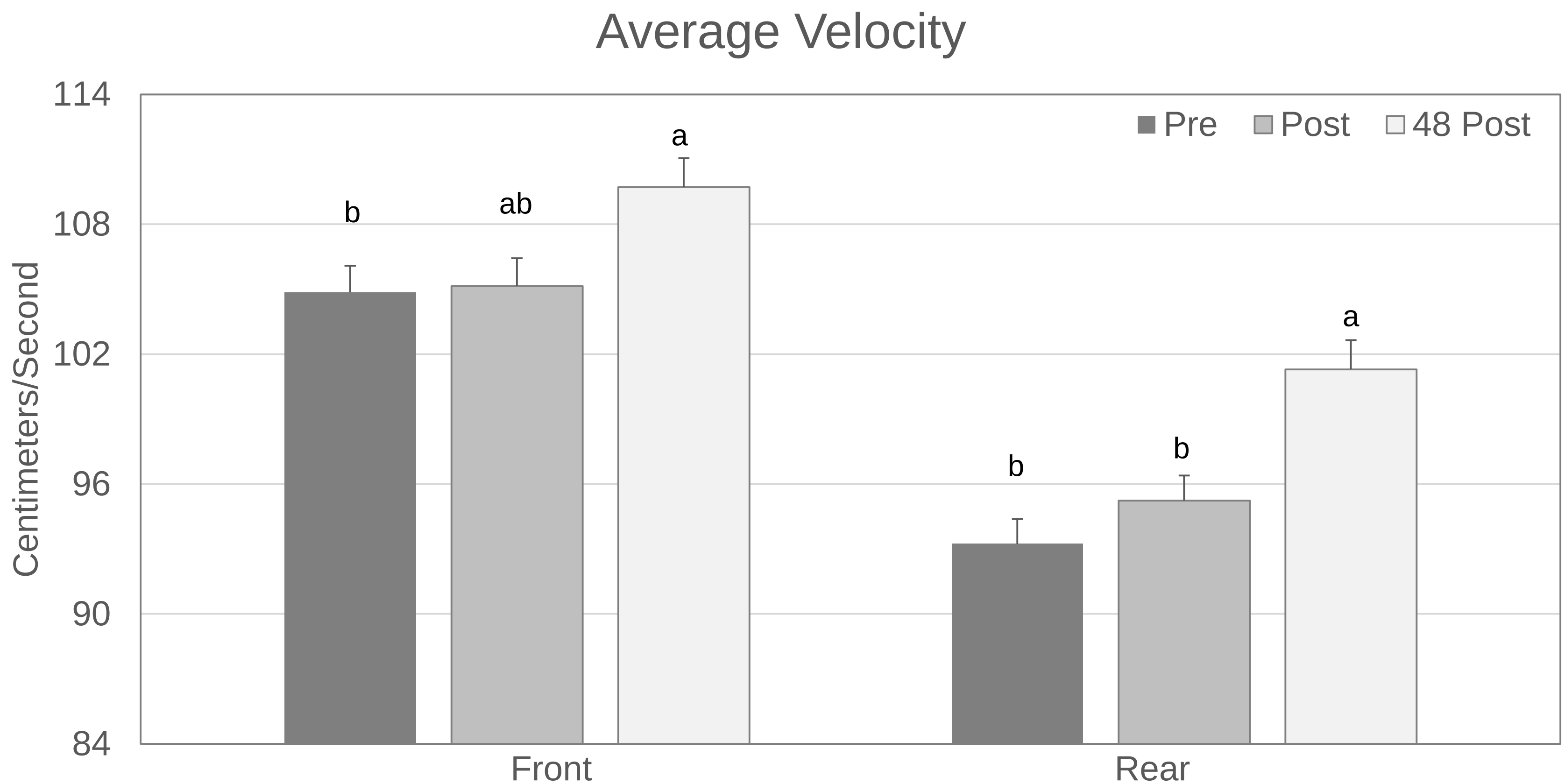

Figure 3-6. Average Velocity for Front and Rear Limbs. The average front velocity was $p<0.05$ from pre to 48 post. The rear average velocity was $p<0.05$ from pre to 48 post and post to 48 post.

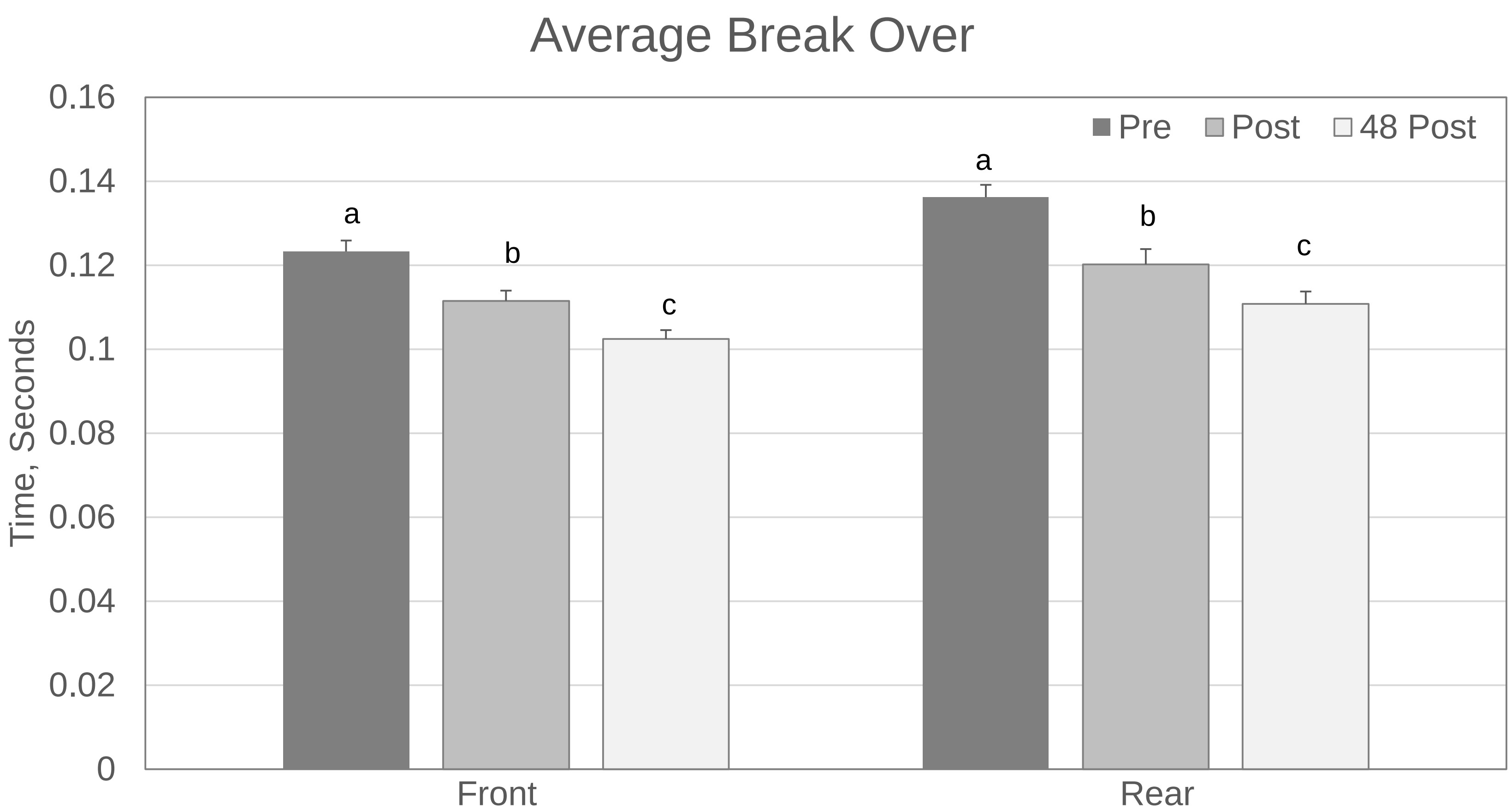

Figure 3-7. Average Break Over for Front and Rear Limbs. The front limb was p<0.05 across all of the times. The hind limb was p<0.05 across all of the times.

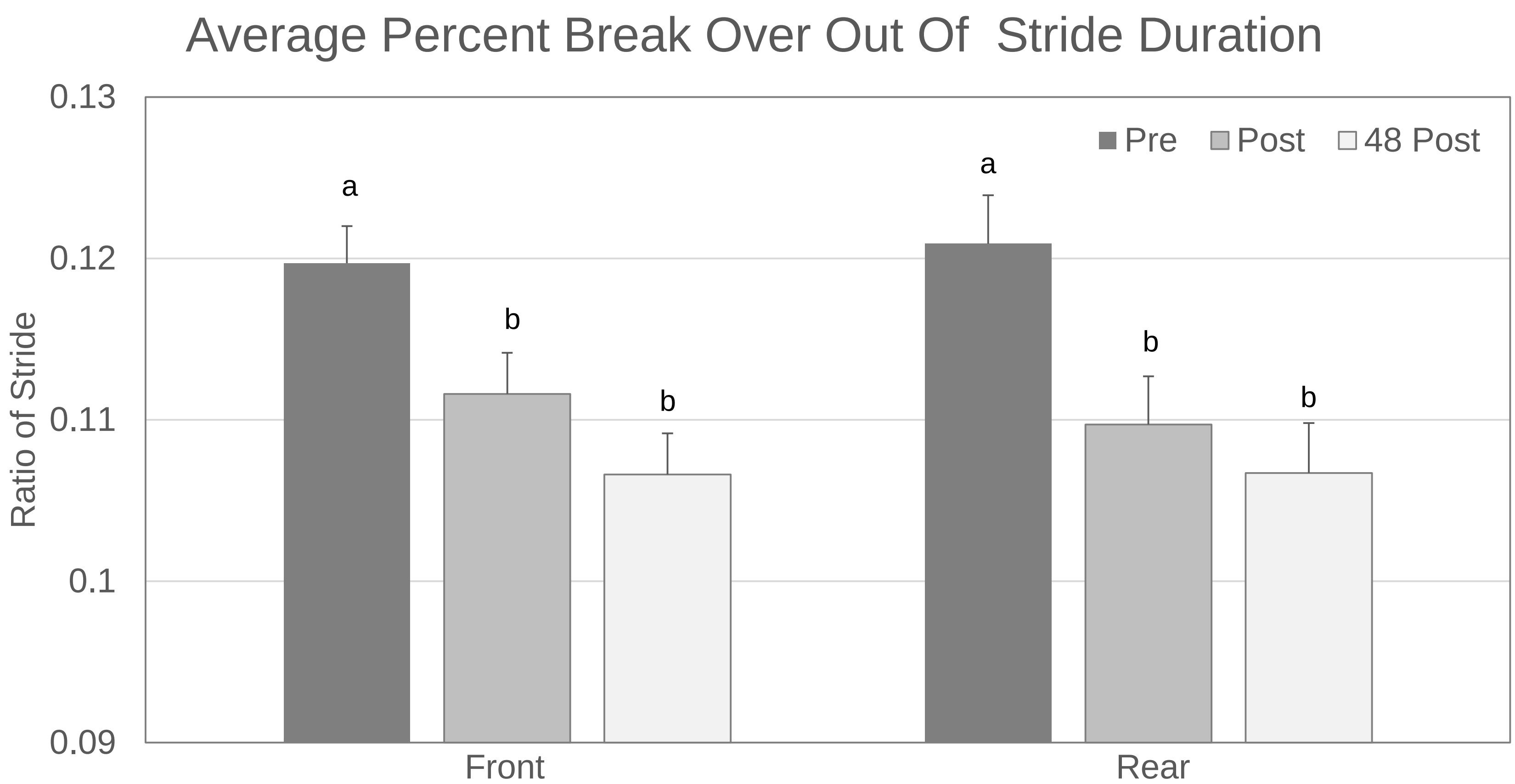

Figure 3-8. Average Percent Break Over Out of Stride Duration for Front and Rear Limbs. Both front and rear limbs are reported. Front limb average was $p<0.05$ pre to post and pre to 48 post. Rear limb average was $p<0.05$ pre to post and pre to 48 post.

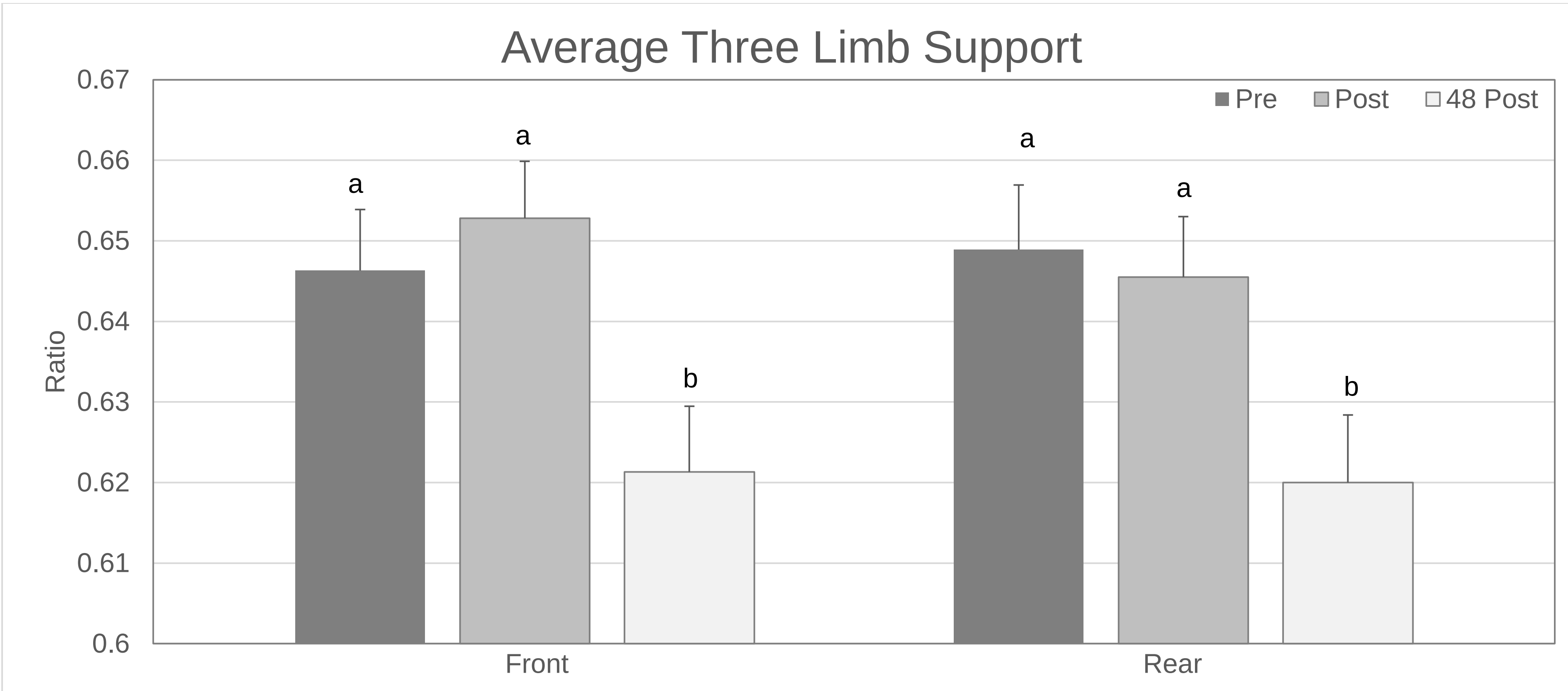

Figure 3-9. Average Three Limb Support for front and rear limbs. The front limbs average was $p<0.05$ for pre to 48 post and post to 48 post. The hind limb average was $p<0.05$ for pre to post and post to 48 post.

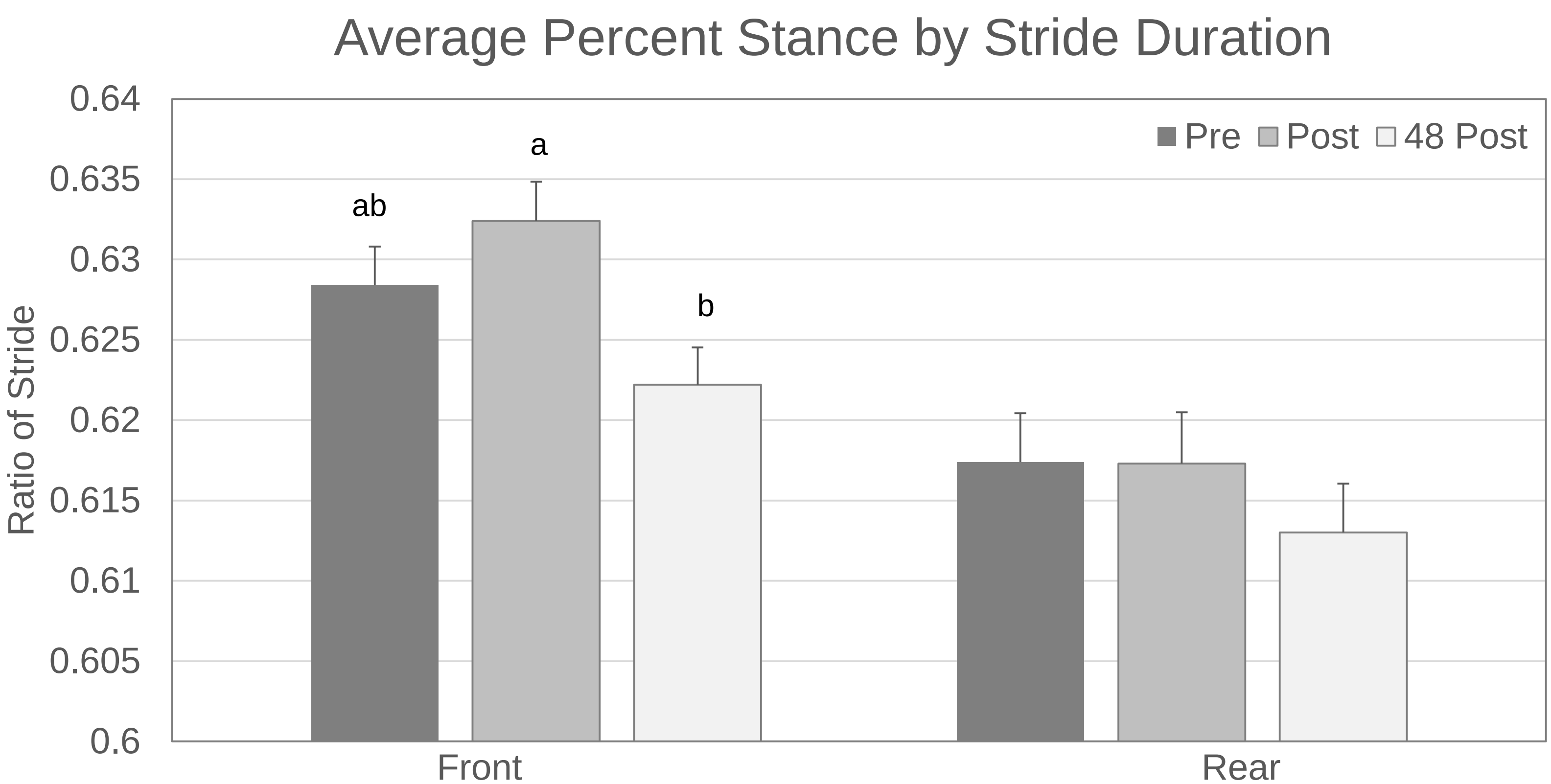

Figure 3-10. Percent of Stance Duration Out of Stride Duration for Front and Rear Limbs. Front limb average was $p<0.05$ for post to 48 post. Rear limb average there was no significant difference across the times.

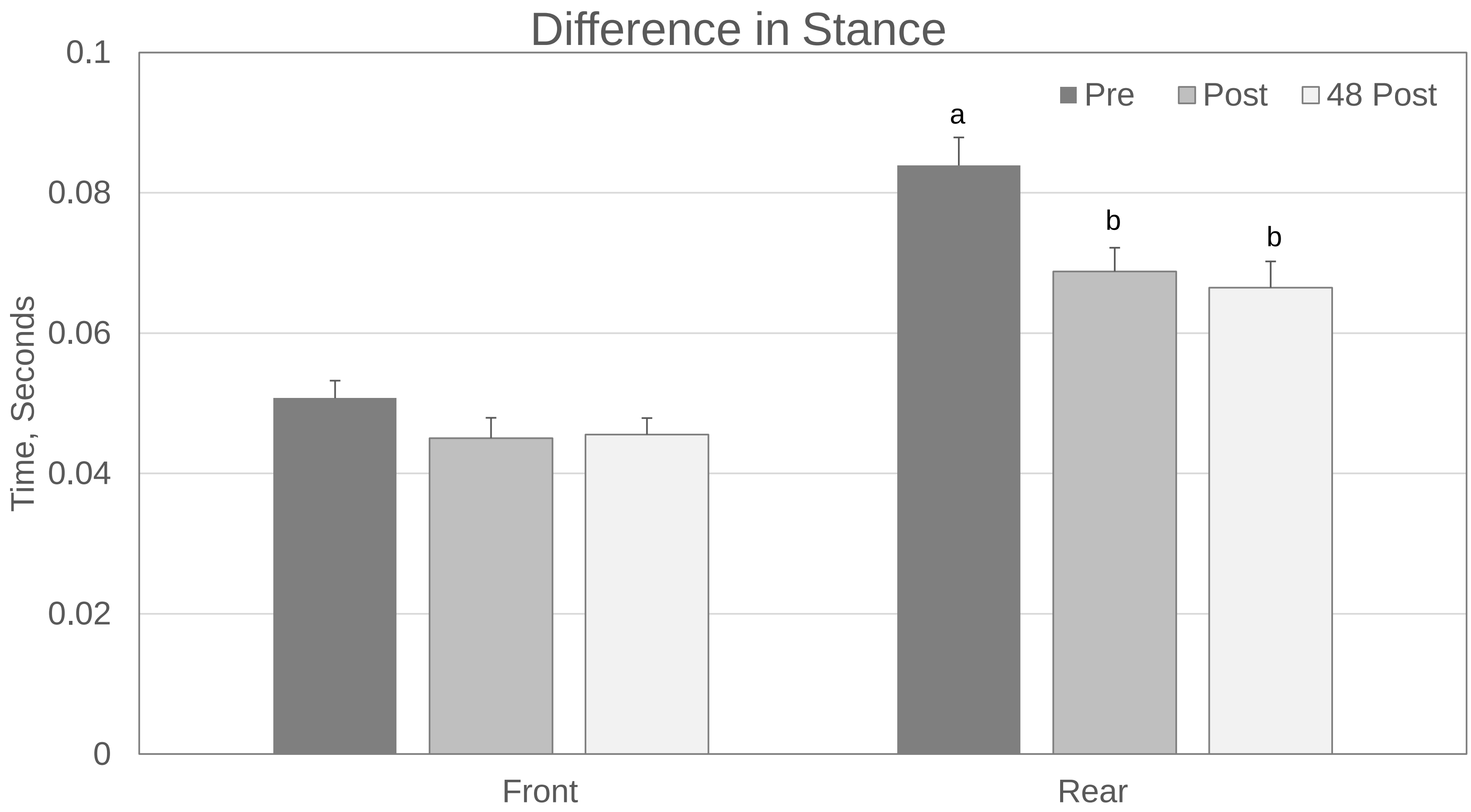

Figure 3-11. Difference in Stance for Front and Rear Limbs. The difference in stance was not significant between the front limbs. The difference in the rear limb stance was $p<0.05$ from pre to post and pre to 48 post.

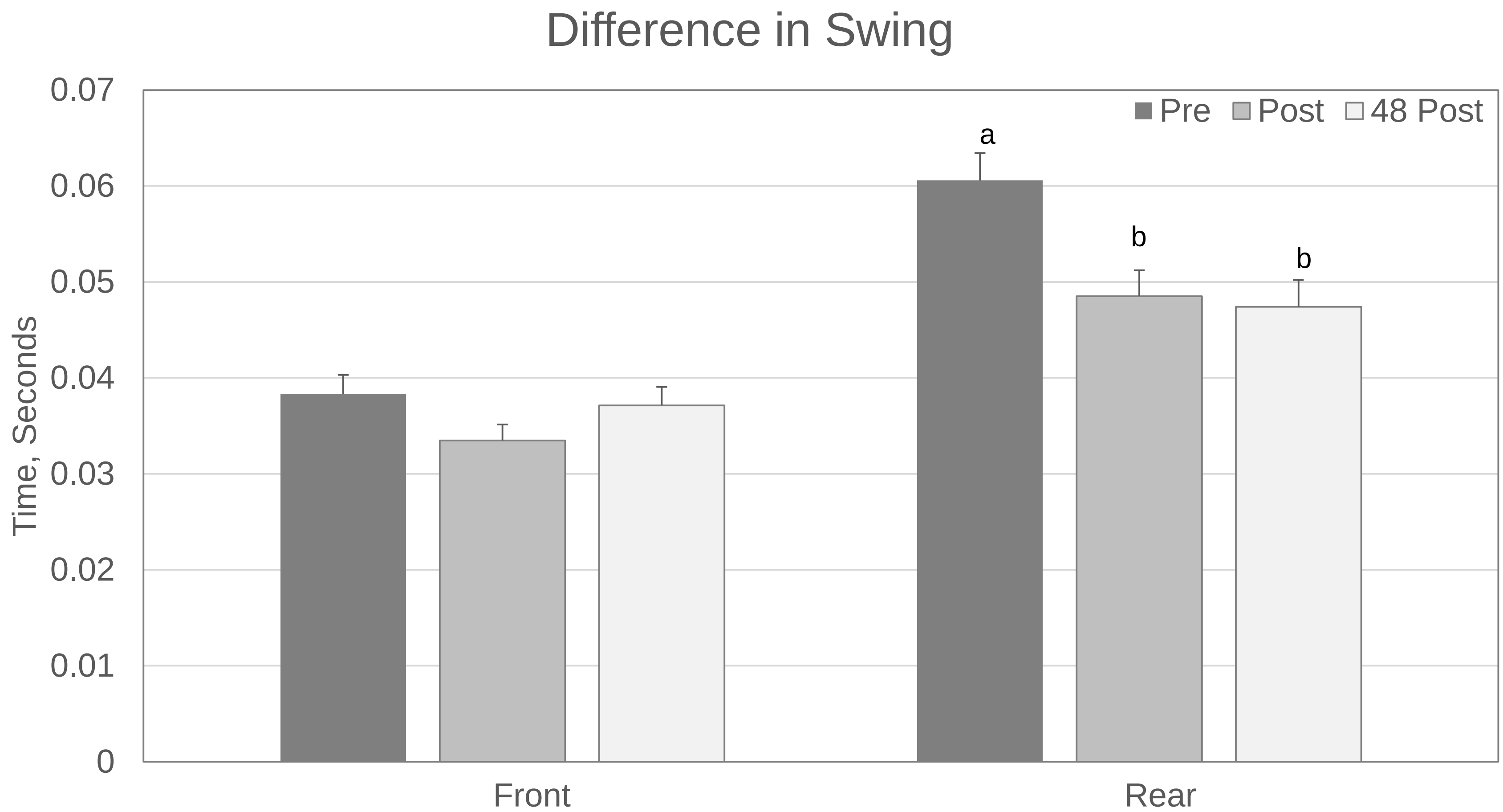

Figure 3-12. Difference in Swing for Front and Rear Limbs. The difference in the front limbs was not significant between the times. The difference in the rear limbs was $p<0.05$ pre to post and pre to 48 post.

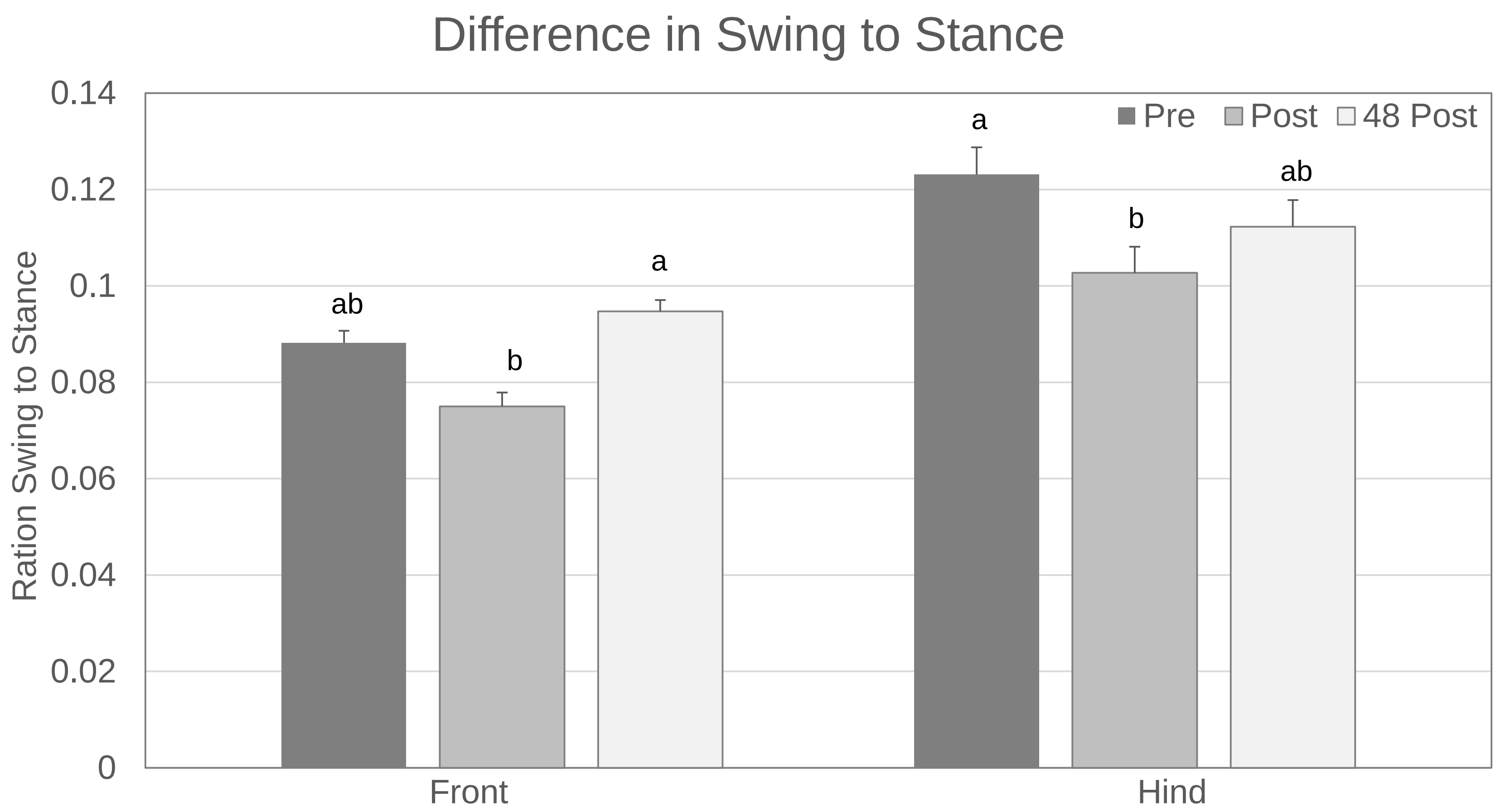

Figure 3-13. Difference in Swing to Stance for Front and Rear Limbs. The difference in the front limbs was $p<0.05$ from pre to post. The difference in the rear limbs was $p<0.05$ between post and 48 post.

Figure 3-14. Difference in Stride Duration for Front and Rear Limbs. Difference between front limbs was $p<0.05$ pre to post and pre to 48 post. Difference between hind limbs was $p<0.05$ for pre to post and pre to 48 post.

Figure 3-15. Difference in Stride Length for Front and Rear Limbs. The difference between the front limbs across the times was not significant. The difference between the rear limb was $p<0.05$ from pre to 48 post.

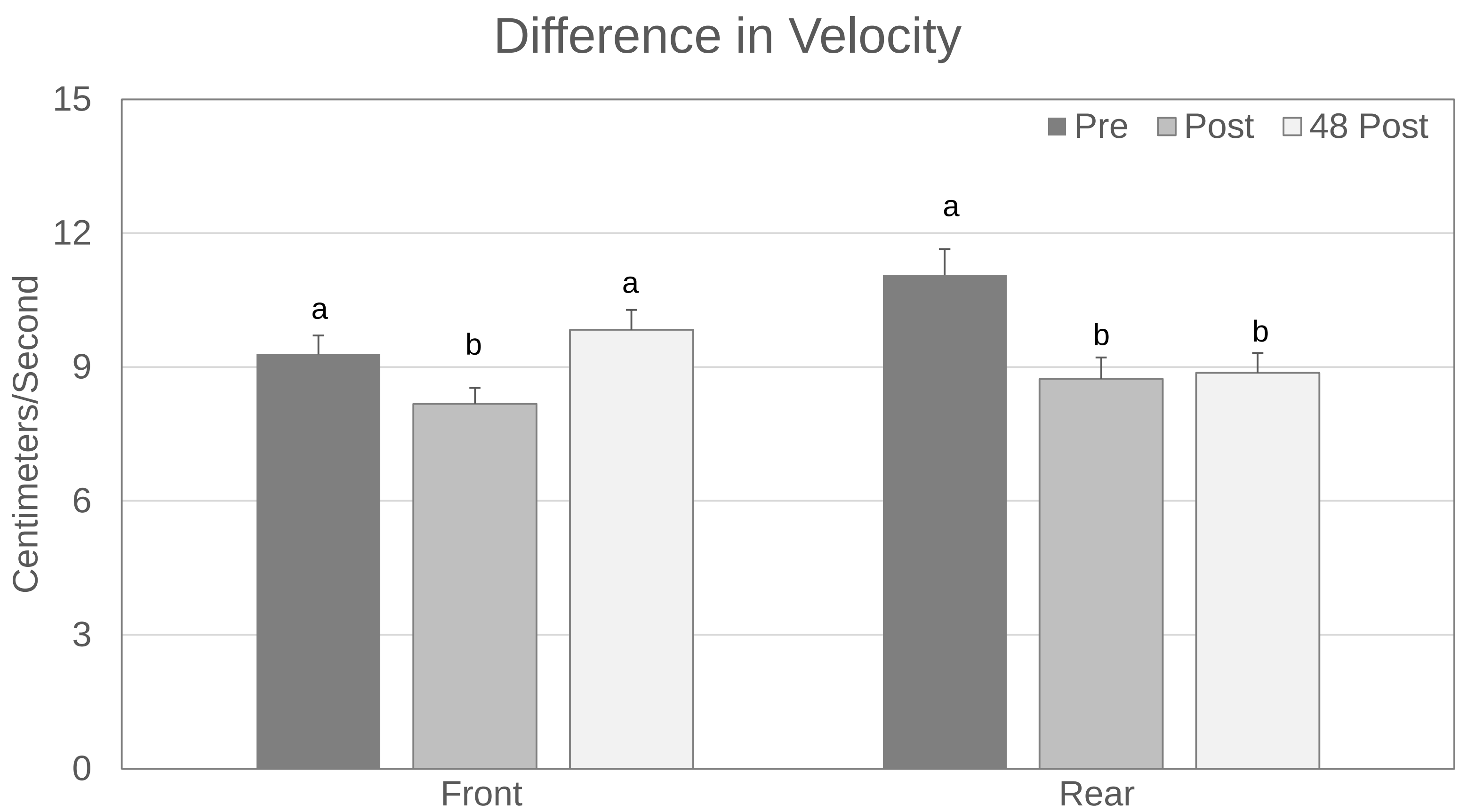

Figure 3-16. Difference in Velocity For Front and Rear Limbs. The difference of the front limbs was $p<0.05$ from pre to post and post to 48 post. The difference in the hind limbs was $p<0.05$ from pre to post and pre to 48 post.

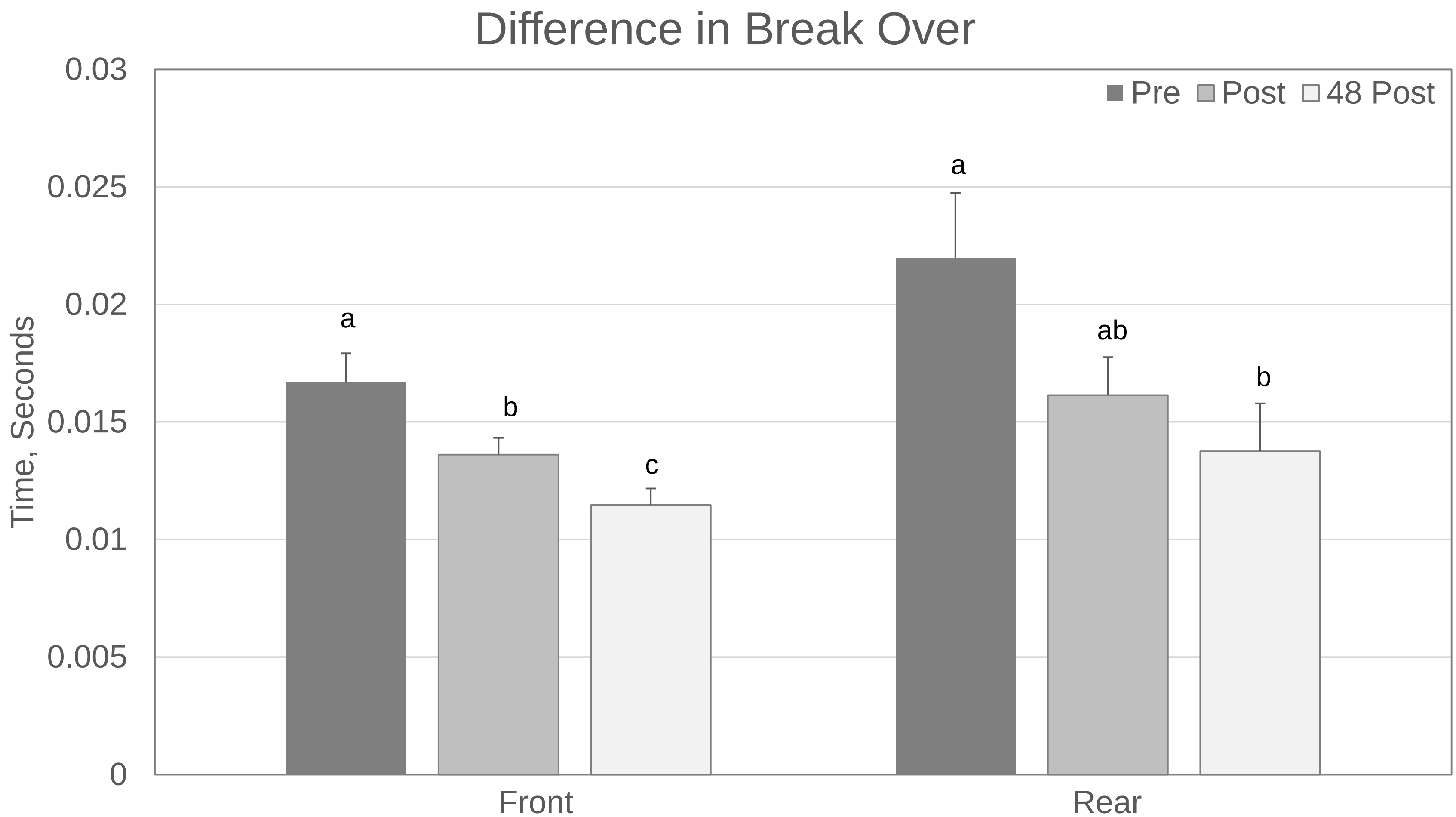

Figure 3-17. Difference in Break Over for Front and Rear Limbs. The front limb break over was $p<0.05$ for all times. The rear limb break over was $p<0.05$ for pre to 48 post.

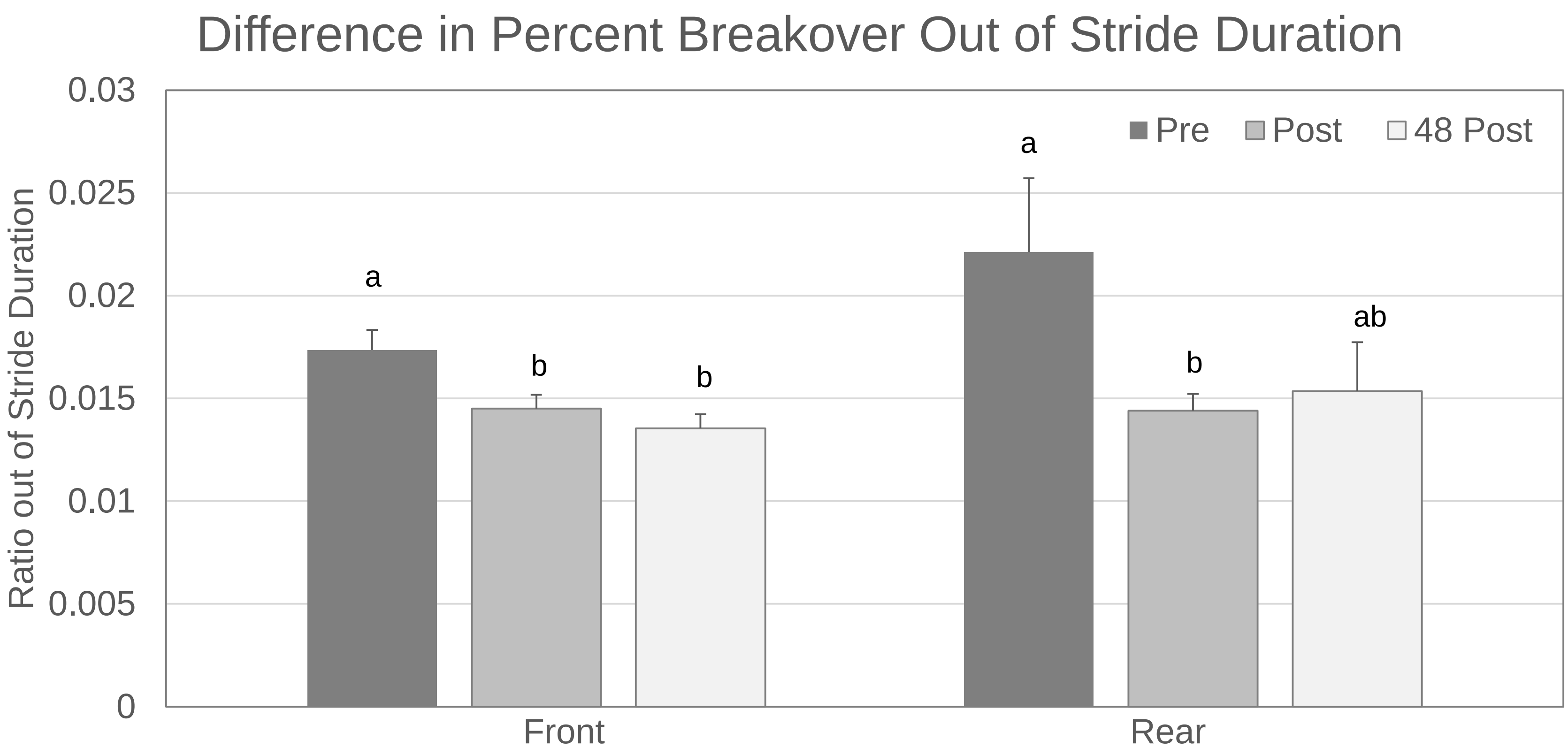

Figure 3-18. Difference in Percent Break Over Out of Stride Duration for Front and Rear Limbs. The difference in the rear limbs $p<0.05$ was from pre to post and pre to 48 post. The difference in the rear limbs $p<0.05$ was from pre to post.

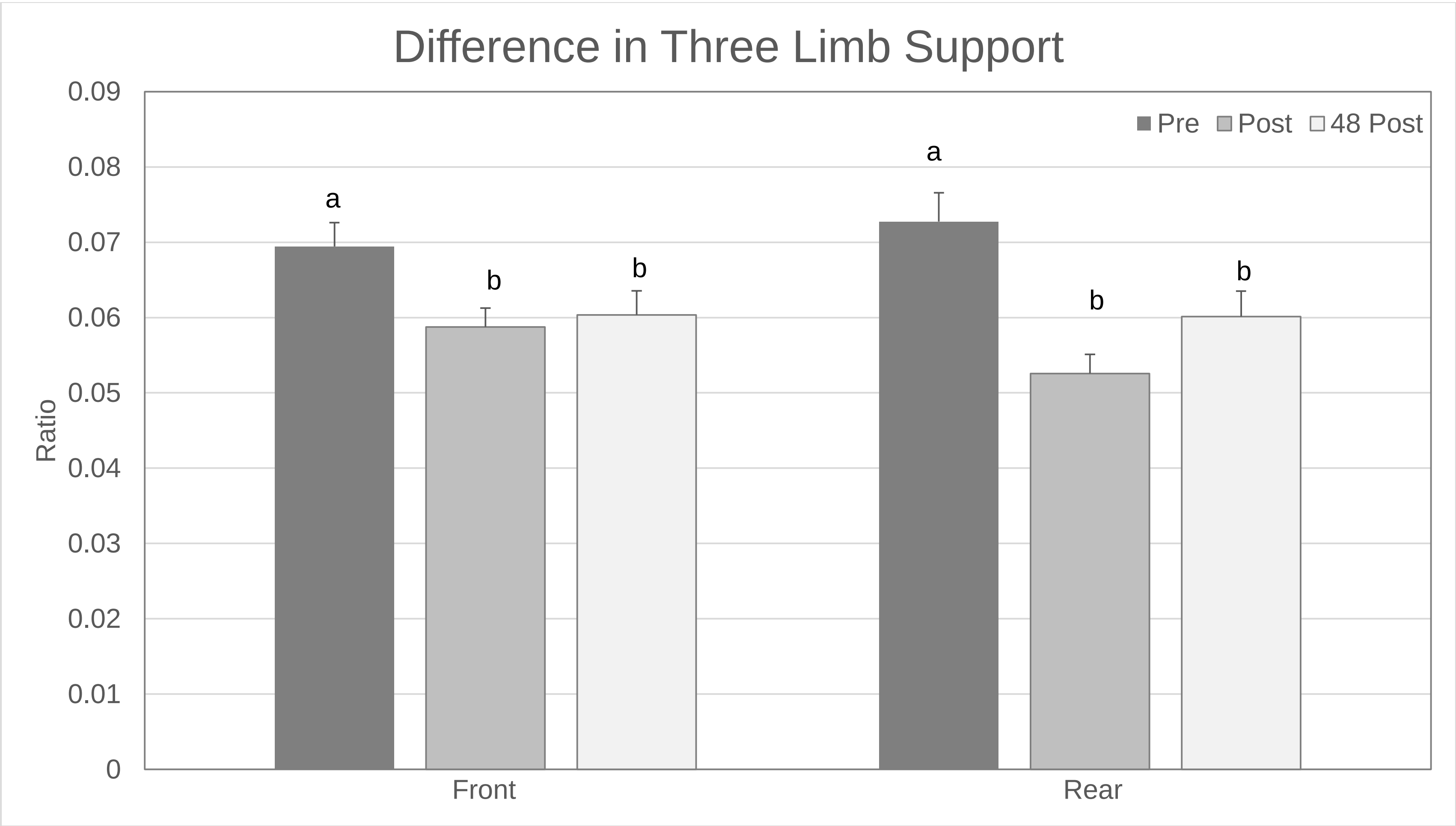

Figure 3-19. Difference in Three Limb Support for Front and Rear Limbs. The front limb difference was $p<0.05$ for pre to post and pre to 48 post. The difference between the hind limbs was $p<0.05$ for pre to post and pre to 48 post.

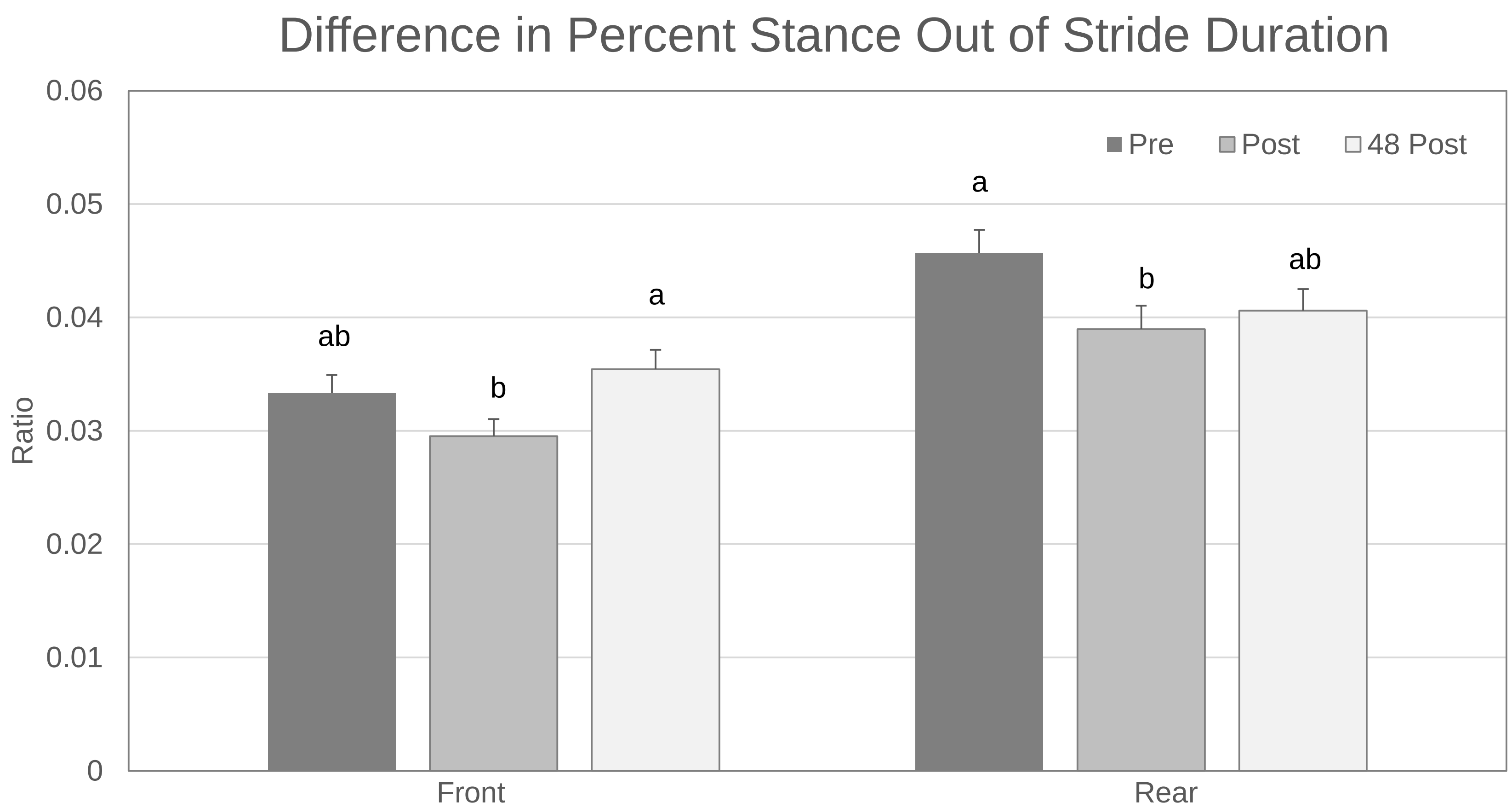

Figure 3-20. Difference in Percent Stance Out of Stride Duration for Front and Rear Limbs. The difference in the front limbs was $p<0.05$ for post to 48 post. The difference in the hind limbs was $p<0.05$ for pre to post and pre to 48 post.

Table 3-1. Average for Stance, Swing, Stride Duration, Stride Length, and Swing by Stance.

	Measurement Values			P-Values		
	Front/Rear			Pre	Pre	Post
	Pre	Post	48 Post	to Post	to 48 post	to 48 Post
Stance Duration, s	0.6608	0.6512	0.6168	0.3936	<0.0001	0.0014
	0.7113	0.6913	0.6595	0.1120	<0.0001	0.0092
Swing Duration, s	0.3815	0.3689	0.3667	< 0.0001	<0.0001	0.4873
	0.4293	0.417	0.4066	0.0079	<0.0001	0.0336
Stride Duration, s	1.0423	1.0201	0.9835	0.0981	<0.0001	0.0048
	1.1406	1.1137	1.0661	0.0300	<0.0001	0.0050
Stride Length, cm	106.55	103.74	104.52	0.0002	0.0102	0.3188
	103.54	102	103.49	0.0643	0.9569	0.0584
Swing by Stance, %	0.6025	0.5916	0.6178	0.2526	0.1072	0.0062
	0.6381	0.6369	0.6499	0.9284	0.3506	0.3328

Table 3-2. Average of Break Over, Velocity, Stance Out of Stride Duration, Three Limb Support, and Break Over Out of Stride Duration.

	Measurement Values			P-Values		
	Front/Rear			Pre	Pre	Post
	Pre	Post	48 Post	to Post	to 48 Post	to 48 Post
Break Over, s	0.1233	0.1115	0.1024	0.0009	<0.0001	0.0056
	0.1362	0.1202	0.1108	0.0011	<0.0001	0.0446
Velocity, cm/s	104.86	105.14	109.72	0.8733	0.0074	0.0138
	93.2343	93.5354	101.29	0.2226	<0.0001	0.0007
Stance Out of	0.6284	0.6324	0.6222	0.2382	0.0669	0.0026
Stride Duration, %	0.6174	0.6177	0.613	0.9310	0.3043	0.2667
Three Limb Support, %	0.6463	0.6528	0.6213	0.5278	0.0250	0.0036
	0.6489	0.6455	0.6200	0.7595	0.0129	0.0235
Break Over Out of	0.1197	0.1116	0.1066	0.0193	0.0002	0.1647
Stride Duration, %	0.1209	0.1097	0.10674	0.0081	0.0010	0.4849

Table 3-3. Differences of Stance, Swing Stride Duration, Swing to Stance, and Stride Length.

	Measurement Values			P-Values		
	Front/Rear			Pre	Pre	Post
	Pre	Post	48 Post	to Post	to 48 post	to 48 Post
Stance, s	0.05071	0.04503	0.04553	0.1401	0.1335	0.8945
	0.08392	0.0688	0.06649	0.0038	0.0014	0.6463
Swing, s	0.03832	0.03349	0.03712	0.0630	0.6636	0.1555
	0.06057	0.04852	0.04742	0.0022	0.0010	0.7745
Stride Duration, s	0.05472	0.04648	0.04697	0.0285	0.0208	0.8879
	0.09136	0.07331	0.07577	0.0014	0.0056	0.6495
Stride Length, cm	7.4698	6.8271	7.4366	0.0901	0.9347	0.1128
	8.0343	7.1130	6.2629	0.1144	0.0015	0.0774
Swing by Stance, %	0.08818	0.07499	0.09473	0.0512	0.3792	0.0023
	0.1231	0.1027	0.1123	0.0094	0.1739	0.2144

Table 3-4. Difference of Break Over, Velocity, Stance Out of Stride Duration, Three Limb Support, and Break Over Out of Stride Duration.

	Measurement Values			P-Value		
	Front/Rear			Pre	Pre	Post
	Pre	Post	48 Post	to Post	to 48 Post	to 48 Post
Break Over, s	0.01668	0.01361	0.01147	0.0335	0.0003	0.0324
	0.02199	0.01614	0.01375	0.0673	0.0162	0.3583
Velocity, cm/s	9.2839	8.1753	9.8342	0.0452	0.3698	0.0039
	11.0617	8.7337	8.8689	0.0022	0.0030	0.8374
Stance Out of	0.03332	0.02953	0.03542	0.0857	0.3748	0.0105
Stride Duration, %	0.04575	0.03799	0.04060	0.0045	0.0633	0.3242
Three Limb Support, %	0.06944	0.05873	0.06033	0.0083	0.0435	0.6940
	0.07275	0.05255	0.06013	<0.0001	0.0131	0.0732
Break Over Out of	0.01736	0.0145	0.01354	0.0162	0.0014	0.3201
Stride Duration, %	0.02211	0.0144	0.01535	0.0366	0.1171	0.7061

CHAPTER 5

CONCLUSION

The welfare of the sow is an important part of the swine industry. This study showed that corrective claw trimming of sows improved the locomotor efficiency. This study was a short study from pre to forty-eight hours post trimming, but illustrates the changes in gait that may lead to a decrease in sow injury and lameness. A longer study of sows may provide more distinct and long term results. Potential behavior changes from trimming were not studied and may provide more evidence to validate the use of claw trimming in the industry.