Motion asymmetry and body fat in Swedish riding school horses

– Is there a connection?

Rörelsesymmetri och kroppsfett hos svenska ridskolehästar – finns det ett samband?

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Degree project/Independent project • 30 hp
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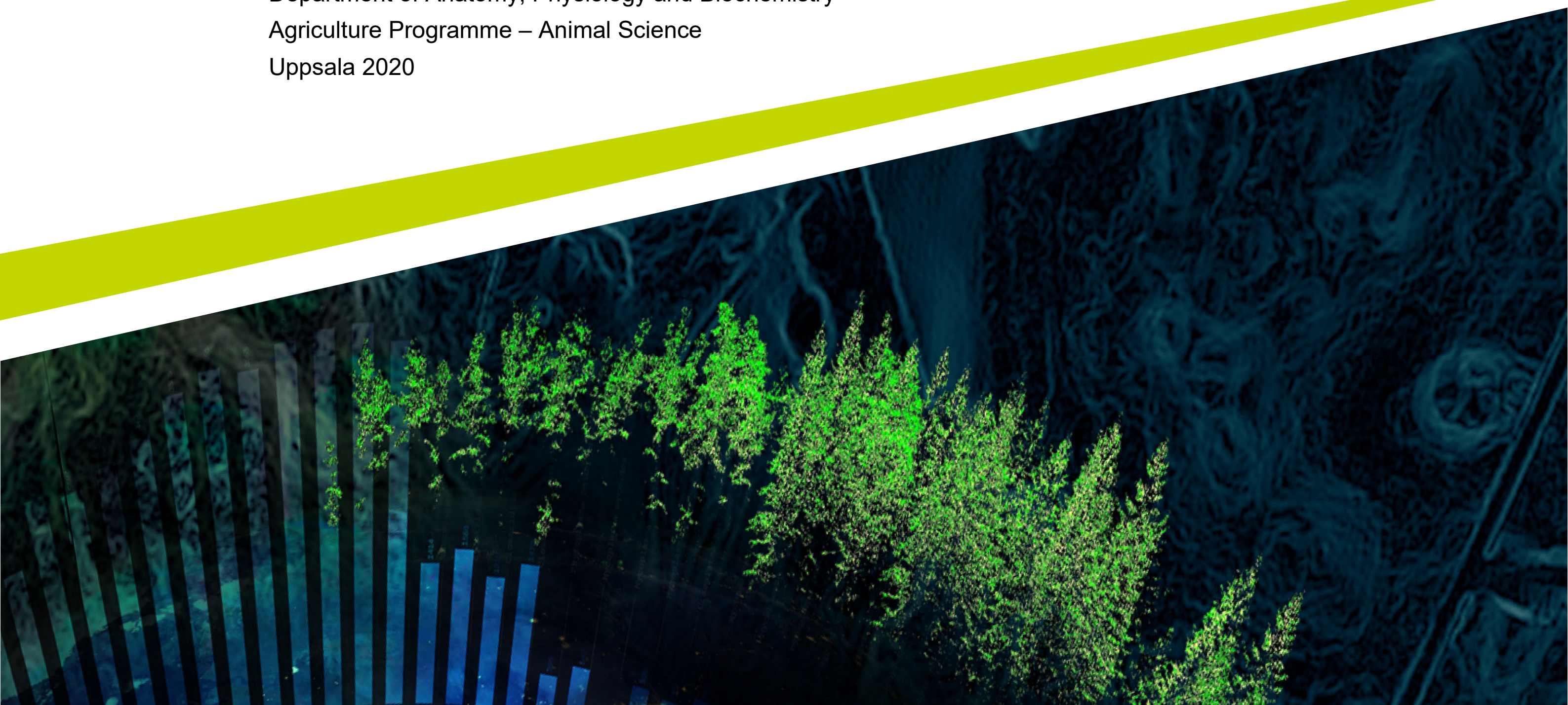
Uppsala 2020



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Credits: 30 hp
Level: A2E
Course title: **Självständigt arbete i husdjursvetenskap**
Course code: **EX0872**
Programme/education: **Agriculture Programme – Animal Science**
Course coordinating dept:

Place of publication: **Uppsala**
Year of publication: **2020**

Keywords: **Horse, equine, motion asymmetry, BCS, body fat, riding school, lameness**

Swedish University of Agricultural Sciences
Faculty of Veterinary Medicine and Animal Science
Department of Anatomy, Physiology and Biochemistry

Publishing and archiving

Abstract

In Sweden, there are about 18 000 riding school horses and in 2018 almost five million riding hours took place in Swedish riding schools. A recent study found that overweight is common in riding school horses, 28 % had a BCS ≥ 7. It has been reported that the prevalence of overweight and obesity in the equine population has increased worldwide. If the horse is overweight or obese there is an increased risk for various health problems. In humans it has been found that obesity is a risk factor for both hip and knee osteoarthritis. A connection between obesity and osteoarthritis is not well documented in horses. However, lameness is the most common cause for veterinary care and life insurance claims for Swedish riding schools.

This master's thesis aim is to analyse if there is a relationship between a high body condition score and motion asymmetry in Swedish riding school horses.

Body condition score (BCS), cresty neck score, subcutaneous fat, heart girth circumference and motion asymmetry were measured in 109 riding school horses in the current study. Body condition was assessed with a nine-point scale and cresty neck score was assessed with a five-point scale. Subcutaneous fat was measured with ultrasound at two locations on the rump. The measured thickness was used to estimate percent body fat. Motion asymmetry was measured objectively by the inertial sensory system Lameness Locator. The horses were trotted at hand in a straight line for approximately 100 meters. The maximum and minimum position for both head and pelvis were used to calculate vector sums. A questionnaire was sent to the participating riding schools and questions about their routines and the horses' temper were asked. Statistical analyses of motion asymmetry and questionnaire answers were made in SAS 9.4 and multiple linear analyses of variance were made using the GLM procedure. Correlations for all included parameters were made with the PROC CORR procedure.

BCS was not significantly correlated with percent body fat. BCS did not have an effect on front limb asymmetry ($P > 0.05$) but a tendency for an effect on hind limb asymmetry ($P = 0.09$). In the correlation analysis the higher the BCS the more asymmetric hind limb motion ($r = 0.18$, $P = 0.06$). There were no significant differences in motion asymmetry between horses with a BCS < 6 and horses with a BCS ≥ 6 or in horses with < 10 % body fat and horses with ≥ 10 % body fat. Percent body fat did not affect front limb asymmetry but had a tendency to affect hind limb asymmetry ($P = 0.08$). Asymmetry in both front and hind limbs had a weak negative correlation with subcutaneous fat thickness measured 15 cm from the apex of the croup towards the tailhead (front limb asymmetry: $r = -0.19$, $P < 0.05$ and hind limb asymmetry: $r = -0.21$, $P < 0.05$). Asymmetric movement in hind limbs had a weak negative correlation with percent body fat ($r = -0.20$, $P < 0.05$). Number of lessons a horse was used per week did not affect motion asymmetry. Horses that spent < 11 h/day outside were less asymmetric in front limbs compared to horses that spent > 11 h/day outside ($P < 0.05$). Horses with a BCS < 6 scored higher for how willing a horse was to work and how energetic the horse was compared to horses with a BCS ≥ 6.

The results of this study showed no significant relationship between body condition score and motion asymmetry in riding school horses but there was a statistical tendency for horses with higher body condition score to be more asymmetric in hind limbs. However, there were also conflicting results as horses with higher percent body fat were less asymmetric in hind limbs. More studies need to be done in this area to see if BCS affects the motion pattern of horses. Future studies should include a larger study material and more background data about the horses' health.

Keywords: horse, equine, motion asymmetry, BCS, body fat, riding school, lameness

Sammanfattning

I Sverige finns det ca 18 000 ridskolehästar och under 2018 utfördes nästan fem miljoner ridtimmar på svenska ridskolor. En nyligen genomförd studie fann att övervikt är vanligt hos ridskolehästar, 28 % hade en hullpoäng ≥ 7. Det har rapporterats att övervikt och fetma ökar blad hästpopulationer världen över. Med övervikt kommer en ökad risk för olika hälsoproblem. Hos människa anses fetma vara en riskfaktor för både höft- och knäartros. Ett samband mellan fetma och artros hos häst är inte väldokumenterat. Hälta är däremot den vanligaste orsaken till veterinärvård och begäran om utbetalning av livförsäkring bland svenska ridskolor.

Syftet med den här uppsatsen är att undersöka om det finns någon samband mellan ett högt hullpoäng och rörelseasymmetri hos svenska ridskolehästar.

I den aktuella studien mättes hullpoäng, poäng för nackfett, underhudsfett, bröstomfång och rörelseasymmetri hos 109 ridskolehästar. För bedömning av hull användes en niogradig skala och för bedömning av nackfett användes en femgradig skala. Underhudsfetttjockleg mättes med ultraljud på två punkter på hästens bakdel. Den uppmätta tjockleken användes för att uppskatta procent kroppsfett enligt en tidigare föreslagen formel. Rörelseasymmetri mättes objektivt med det sensorbaserade systemet Lameness Locator. Hästarna travades vid hand på rakt spår i ungefär 100 meter. Högsta och lägsta position för huvud och bäcken användes för att räkna ut vektorsummor, vilka i det här arbetet används som mått på asymmetri. Ett frågeformulär skickades till de deltagande ridskolorna med frågor om deras dagliga rutiner och hästarnas temperament. Statistiska analyser av rörelseasymmetri och svar från frågeformulär utfördes i SAS 9.4 och multipel linjär variansanalys utfördes med GLM proceduren. PROC CORR proceduren användes för att få korrelationer för alla inkluderade parametrar.

Hullpoäng var inte signifikant korrelerat med procent kroppsfett. Hullpoäng hade ingen påverkan på frambensasymmetri ($P > 0.05$), men en tendens till signifikant effekt på balbensasymmetri ($P = 0.09$). Hästar med ett högre hullpoäng tenderade att vara mer asymmetriska i sina bakben ($r = 0.18$, $P = 0.06$). Det var ingen signifikant skillnad mellan hästar med ett hullpoäng < 6 och hästar med ett hullpoäng ≥ 6, inte heller mellan hästar med andel kroppsfett < 10 % och hästar med andel kroppsfett ≥ 10 %. Asymmetri i både fram- och bakben påverkades av underhudsfettets tjocklek mätt 15 cm från korsets högsta punkt mot svansroten (frambensasymmetri: $r = -0.19$, $P < 0.05$ och bakbensasymmetri: $r = -0.21$, $P < 0.05$). Asymmetrisk rörelse i bakben hade en svag negativ korrelation med procent kroppsfett ($r = -0.20$, $P < 0.05$). Antal lektioner en häst gick per vecka påverkade inte rörelsesymmetrin. Hästar som var ute < 11 h/dag var mindre asymmetriska i sina framben jämfört med hästar som var ute < 11h/dag ($P < 0.05$). Hästar med ett hullpoäng < 6 fick högre poäng för hur arbetsvillig hästen var och hur energisk hästen var jämfört med hästar med ett hullpoäng ≥ 6.

Resultaten i den här studien visade inget signifikant samband mellan hullpoäng och rörelseasymmetri hos ridskolehästar, däremot hade hästar med högre hullpoäng en statistisk tendens till att vara mer asymmetriska i bakben. Resultaten var även i konflikt med varandra då hästar med högre procent kroppsfett var mindre asymmetriska i bakben. Fler studier måste utföras i detta område för att kunna ta reda på om BCS påverkar rörelsemönstret hos hästar. Framtida studier bör inkludera ett större studiematerial och mer bakgrundsdata om hästarnas hälsa.

Nyckelord: ridskolehäst, equine, rörelseasymmetri, hullpoäng, kroppsfett, ridskola, hälta

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Abbreviations

BCS	Body condition score
CNS	Cresty neck score
HG	Heart girth circumference
TotFat	Total percent body fat
Fat1	Subcutaneous fat thickness at location one of the rump
Fat2	Subcutaneous fat thickness at location two of the rump
Fat%1	Percent body fat calculated from location one of the rump
Fat%2	Percent body fat calculated from location two of the rump

1. Introduction

In Sweden, there are about 350 000 horses whereof 18 000 horses are kept at riding schools around the country (Swedish Board of Agriculture, 2017). The most common horse types (~ 65 %) at Swedish riding schools are ponies and warmbloods (including mixes) (Kielén *et al*., 2018). According to the Swedish Equestrian Association (Svenska ridsportförbundet) (2019) about 450 clubs affiliated with the Swedish Equestrian Association manage riding schools and at these riding schools five million riding hours took place in 2018. Depending on the size of the riding school and the number of horses relative to the number of students, a riding school horse can have to be used for more than one lesson per day. In a recent study, riding schools stated that their horses where used, on average, for about 8-12 hours per week (Yngvesson *et al*., 2019).

It has been shown that the most common cause for veterinary care and life insurance claims for riding school horses is lameness (Egenvall *et al*., 2009). The total cost for veterinary care insurance claims for lameness in riding school horses during the years 1997-2002 was seven million Swedish crowns. Also, in a more recent study, riding school managers stated lameness as the most common health-related problem (Yngvesson *et al*., 2019). According to the participating managers the prevalence of lameness for the group housed horses (n = 150) was 8 % and, in the tie-stall/box housed horses (n = 177) the prevalence was almost 10 %. The second most common health problem was skin lesions (7.3 %) for the group housed horses and hoof injuries (7.3 %) for the tie-stall/box housed horses.

In the study by Yngvesson *et al*. (2019) they assessed lameness in riding school horses subjectively and found that four (out of 158) of the studied riding school horses had mild lameness. Egenvall *et al*. (2010) subjectively evaluated 99 riding school horses and found that 15 horses received moderate remarks considering movement (walk, trot and canter). Of the 15 horses six had a 2-degree lameness score in a zero to five scale (0 = sound and 5 = non-weight bearing lameness). Motion asymmetries has been found in riding horses where the owners assessed their horses as sound. Rhodin *et al*. (2017) studied 222 horses that were perceived as sound by their owners. When objectively measuring motion asymmetry they found that 72 % of the studied horses showed asymmetries according to the levels set by the manufacturer (asymmetries > 6 mm for head movement and > 3 mm for pelvic motion). Pfau *et al*. (2016) also studied horses that were perceived as sound by their owners and they found, when assessing lameness objectively, that 60 % of the studied horses (n = 23, including horses and ponies) were outside what the authors considered to be normal limits for a sound horse. Normal limits for symmetrical movement were defined as symmetry index for head 0.82-1.18 and for pelvis 0.83-1.17 (Starke *et al*., 2012).

According to the Swedish regulations about horse management, horses are supposed to be given a diet based on fibrous feeds that results in a healthy body condition (SJVFS 2019:17). It has, however, been shown that the prevalence of overweight and obesity is increasing among horses. Studies conducted worldwide have shown a widespread prevalence of equine overweight and obesity using body condition score (BCS) as a tool to measure local fat depositions in the horses. Potter *et al*. (2016) found that among pleasure horses and ponies in Australia the prevalence of overweight or obese horses were 37 % (BCS ≥ 6 on a scale of 1-9). Among riding horses in Scotland, Wyse *et al*. (2008) found that 45 % were fat or very fat (BCS ≥ 5 on a scale of 1-6). Robin *et al*. (2015) found that the prevalence of obesity (BCS ≥ 5 on a scale of 1-6) was 31 % among horses and ponies in Great Britain. In Virginia, USA, Thatcher *et al*. (2012) found that 51 % of the studied horses were overweight or obese with a body condition score ≥7 on a scale of 1-9. In a recent Swedish study, it was found that about 28 % of the studied horses housed at different riding schools in Sweden had a BCS ≥ 7 (Yngvesson *et al*., 2019).

Excessive deposition of adipose tissue increases the risk for the horse to get various health problems. One of these is the equine metabolic syndrome (EMS) a multifactorial disease which comprises of hyperinsulinemia, insulin resistance and obesity which in turn increases the risk for laminitis (Frank, 2011). In addition to the metabolic diseases due to overweight or obesity, there might also be a risk for problems in the musculoskeletal apparatus due to the increased load to the weightbearing joints, although this is not well documented in horses yet. In humans, however, obesity has been established as a risk factor for both hip and knee osteoarthritis (Cooper *et al*., 1998; Grotle *et al*., 2008). Osteoarthritis often causes pain and might inhibit movement. It has also been shown that in overweight or obese dogs with hindlimb lameness due to hip osteoarthritis, weight reduction can improve clinical signs of lameness (Impellizeri *et al*., 2000). In horses, osteoarthritis has, however, so far been more connected to training than overweight, especially in young horses (Di Filippo *et al*., 2019).

Considering the high prevalence of both a high body condition score and motion asymmetries found in previous studies and the established relationship between overweight or obesity and osteoarthritis in humans and dogs, it would be of interest to study a possible relationship between overweight or obesity and motion asymmetries in horses. Therefore, this thesis aims to analyse if motion asymmetries in riding school horses are connected to a high body condition score. The hypothesis was that horses with a higher body condition score or percent body fat were to be more asymmetric in their movement pattern at trot compared to horses with a lower body condition score or percent body fat.

2. Literature review

2.1. Feeding the horse

Horses are grazing animals that spend most of their time awake foraging fibrous feeds. Duncan (1980) found that free-living Camargue horses spent 50-60 % of their time foraging while Salter and Hudson (1979) found that feral horses in western Alberta spent about 75 % of their time foraging. The diet of feral horses mostly consists of different grass species, but with variation depending on season (Salter & Hudson, 1979). In a study by Elia *et al*. (2010), they recorded behaviour of horses stabled for 24h that were fed either hay or pellets. When the horses were fed hay, they spent 50 % of the time eating while in contrast, they only spent 10 % of the time eating when fed pellets. Yngvesson *et al*. (2019) found that restricted eating time is common for riding school horses and that more than half of the participating riding schools in the study included concentrate in their feed rations. Concentrate has a high energy content and increases the risk of exceeding the energy demand for horses with a low activity level which in turn increases the risk of overweight (Tatcher *et al*., 2012).

2.2. Risk factors for overweight or obesity in equines

Risk factors for equine obesity can be divided into two main groups; management-level and horse-level (Robin *et al*., 2015). In the risk factor group on management-level, feeding regime, intensity of exercise and turnout regime have been identified. Horse-level risk factors have been identified as breed, height, easy keeping, level of fitness (Robin *et al*., 2015) and age (Visser *et al*., 2014). Potter *et al*. (2016) and Visser *et al*. (2014) found that ponies were at a greater risk of being overweight/obese than horses. It has also been shown that several different breeds are more prone to overweight/obesity compared with Thoroughbreds (Thatcher *et al*., 2012; Robin *et al*., 2015). Thatcher *et al*. (2012) found that Rocky Mountain Horse, Tennessee Walking Horse and Warmbloods were more likely to be overweight compared to Thoroughbreds whilst Robin *et al*. (2015) could see that cob-type, Welsh and other native British breeds were more prone to overweight than Thoroughbreds. In a study by Ragnarsson & Jansson (2010) they found that Icelandic horses increased in body weight while Standardbred horses decreased in body weight when given the same feed and energy intake per kilogram body weight. The middle-aged horse, 4-18 years, seems to be at a higher risk of getting overweight compared to younger or older horses (Visser *et al*., 2014).

When managing horses, their energy requirement needs to be considered in the feeding practice. Horses' energy requirement changes depending on different life stages; growth, gestation, work etc (National Research Council, 2007). These changes need to be considered when feeding horses with different demands to prevent the risk of the horse being fed too little or too much of the required daily intake. Feed analysis data can be used to calculate feed ratios optimised for the horses' energy requirement which decreases the risk of obesity due to overfeeding. However, in a recent Swedish study, Yngvesson *et al*. (2019) asked riding schools if they analysed the feed quality and about 70 % (11 out of 16) of the asked riding schools said that they did but less than half of these riding schools used the feed analysis data to calculate feed ratios.

2.3. Estimation of the horse's body composition

2.3.1. Assessment of body condition

To ensure that the horse has an optimal energy intake for its activity level, different tools can be used to monitor the body condition. One tool to monitor the horse's body condition is body condition scoring (BCS). There are different scoring systems used when assessing body condition which are based on both visually evaluation and palpating different areas of the body. One scale used for body condition scoring is the scale developed by Henneke and colleges (1983). This scale was developed to assess the body condition for Quarterhorse mares. The Henneke-scale ranges from one to nine, where one is extremely emaciated and nine is extremely fat. When assessing body condition using the Henneke-scale there are six areas of the horse's body that are focused during palpation. The areas are the lumbar spinous processes, ribs, tailhead, behind the shoulder, neck and withers. Another scale used to assess body condition is the scale by Carroll and Huntington (1988). This scale ranges from zero to five where zero is very poor and five is very fat. For the assessment of body condition using this scale, the main focus when palpating the horse are four different areas; neck, back, ribs and pelvis. To complement the body condition assessment, the scale by Carter *et al*. (2009), which only focuses on the crest of the neck, can be used. This scale ranges from zero to five, where score zero means that no fat can be felt with palpation and five means that the enlarged crest droops to one side. It is of interest to monitor the crest of the neck due to the found relationship between the crest of the neck and different metabolic diseases. Carter *et al*. (2009) found that horses and ponies with a CNS ≥ 3 were more prone to be hyperinsulinemic compared to horses and ponies with a moderate neck score (CNS < 3). It has also been found that with an increasing body condition score the concentrate of blood insulin also increases (Ragnarsson & Jansson, 2010; Jansson *et al*., 2016). Prolonged and elevated concentrations of blood insulin have been found to cause laminitis in horses that previously were not insulin resistant (De Laat *et al*., 2010).

Body condition scoring-systems give horse owners the opportunity to learn and use a helping tool for maintaining a desirable body condition for the horses, through increasing or decreasing the horse's energy intake. BCS as a tool is cheap and easy to use when not requiring anything else than the chosen scale's description. Although, body condition scoring is an easily used tool, studies have shown that horse owners tend to underestimate the body condition of their horse compared to professional assessors (Wyse *et al*., 2008; Jensen *et al*., 2016). In the study by Wyse *et al*. (2008) they found that owners to horses with a higher body condition score underestimated the body condition more than owners of horses with a lower body condition score.

Evaluation of body condition score-systems

Body condition score systems used to assess fat deposition has been evaluated for their accuracy in horses with varying amount of fat deposition. Henneke *et al*. (1983) and Gentry *et al*. (2004) found that body condition score was positively correlated with percentage body fat, estimated by measuring subcutaneous fat thickness at the rump with ultrasound. Gentry *et al*. (2004) found strong correlations between increasing BCS and subcutaneous fat for the tailhead, 13^{th} rib, rump and withers. In a third study, Martin-Gimenez *et al*. (2016) found significant differences between horses with BCS ≥ 7 and horses with lower BCS, in subcutaneous fat thickness at different sites of the body (shoulder, ribs, tailhead and rump), where horses with a BCS ≥ 7 had thicker subcutaneous fat at these sites. However, body condition scoring systems has been criticised for decreasing in accuracy when assessing body condition of horses with increasing BCS (BCS ≥ 7/9) (Dugdale *et al*., 2012). The scoring system used for neck fat has also been evaluated for its accuracy where Silva *et al*. (2016) found a significant correlation between cresty neck score and nape fat measured using image analysis of carcasses.

2.3.2. Estimation of percent body fat

In horses, the thickness of subcutaneous fat at the croup can be used for assessing percentage body fat. Studies have shown strong correlations between subcutaneous fat over the rump and carcass fat measurements (Westervelt *et al.,* 1976; Kane *et al.,* 1987). However, subcutaneous fat at the croup decreases in thickness from the tailhead towards the apex of the croup (Westervelt *et al*., 1976; Kane *et al*., 1987; Gentry *el al*., 2004). Kane *et al*. (1987) found that the correlation between ultrasonic measurement and carcass measurement were low at the apex of the croup due to too thin fat layer. In the study by Westervelt *et al*. (1976) fat thickness were measured with ultrasound at the centre of the pelvic bone. They found strong correlations between ultrasound measurement and carcass measurements ($r = 0.93$, $P < 0.01$). Therefore, sampling site is important when estimating percentage total body fat of a horse. This reduction in thickness of subcutaneous fat should also be considered when assessing BCS. In the BCS assessment, the area around the tailhead is more suitable than the apex of the croup due to a more noticeable change in stored fat around the tailhead with increasing BCS.

2.4. Lameness in horses

Lameness in horses can be a symptom for various diseases. The most common problem for riding horses is different orthopaedic diseases, where joint problems were found to be the most common diagnoses in the studies by Penell *et al*. (2005) and Egenvall *et al*. (2006). In the study by Penell *et al*. (2005) lameness with undefined cause was found to be the second most common diagnose for riding horses and signs from the locomotor apparatus was the third most common diagnose. In the study by Penell *et al*. (2005) they also found that hoof related problems, such a hoof abscesses and laminitis were common. Which activity the horse is used for will have different loads on the horse's locomotion apparatus (Murray *et al*., 2006). Dressage horses (both elite and non-elite) most commonly injure the suspensory ligament in hind limbs, while non-elite show jumping horses most frequently injure the navicular bone/ligaments and elite show jumping horses most commonly injure the suspensory ligament (Murray *et al*., 2006).

2.4.1. Motion pattern of trot

At trot, the horse's head and pelvis moves up and down two times during a single stride cycle (Kramer & Keegan, 2014). Therefore, in every stride it will be two maximum and minimum positions for the head and pelvis. The maximum position of the head is reached right before one forelimb has ground contact and the minimum position is reached near midstance of the same limb. In a sound horse the two maximum and minimum positions are approximately the same heights in relation to the ground (Kramer & Keegan, 2014). For the pelvis, the minimum position is reached in the middle of one of the back-limbs stance phase. At the end of this phase the first maximum position is reached. If there is an asymmetry in the movement, there will be a difference between either the two maximum positions or the two minimum positions.

2.4.2. Methods for assessing motion asymmetry in horses

When assessing lameness in horses it its common practice that a veterinarian subjectively evaluates the motion pattern of the lame horse during trot at hand in a straight line. If the asymmetry in the movement pattern is small there might be a risk that the assessing veterinarian does not perceive the asymmetrical movement. It has been found that hindlimb lameness is more difficult to assess than forelimb lameness and even more difficult if the asymmetry is small (Keegan *et al*., 2010). In the study by Keegan *et al*. (2010) they found that agreement between lameness evaluators of which limb was lame was about 60 % considering subtle lameness. Therefore, with subjective assessment of lameness in horses there is a risk of not finding some of the cases with subtle lameness. Objective assessment, however, measures asymmetries in horses' movement pattern that are too small for the human eye to see.

There are different methods used for objectively assessing motion asymmetry in horses. A system suitable of in-field assessments is the inertial sensor-based system Lameness Locator® (Equinosis, LLC). Lameness locator is a non-invasive system that uses three sensors connected via Bluetooth to a computer with a programme that analyses the collected data. The sensors are placed on the horse's head, right front limb and pelvis. The head and pelvis sensors contain accelerometers and the sensor attached on the forelimb contain a gyroscope (Keegan *et al*., 2011). The programme calculates the difference between the maximum and minimum positions of the head and pelvis and presents it as maximum head hight difference and minimum head hight difference as well as maximum pelvic height difference and minimum pelvic height difference (Keegan *et al*., 2011). In horses with perfect motion symmetry the maximum and minimum differences will be near zero whilst it in horses with asymmetrical movement the values will increase positively or negatively depending on which side (right or left) is asymmetric and what type (impact or push off) of lameness.

Another way to objectively measure motion asymmetry in horses is by using a force plate. A force plate is made by metal and has force transducers at the corners that measure the total force that hits the plates surface when a horse steps on the plate (Clayton, 2005). According to Donnell *et al*. (2015) force plates has been seen as the golden standard for objective evaluation of lameness in horses. However, Donnell *et al*. (2015) found that for subtle or mild lameness an inertial sensor system identified that lameness more easily than force plates. Agreement between the two systems (force plate and inertial sensor system) of which limb was lame was 36 % in the study by Donnell *et al*. (2015). However, the inertial sensory system and subjective assessment agreed more (about 50 %) compared to force plate and subjective lameness assessment (about 40-45 %).

3. Materials and methods

3.1. Riding schools and horses

Horses and ponies used for riding lessons at Swedish riding schools were studied in order to determine body condition, percentage body fat and motion asymmetry. Riding schools were chosen on the basis provided that they were within two and a half hours drive with car from Uppsala, Sweden. By browsing the internet, 48 riding schools where selected and then contacted with a request of participating. Of the 48 riding schools, eight agreed to participate. Horses and ponies were chosen with the criteria that they were not to be pregnant or lactating, they were between four to twenty years of age, had been at the riding school for at least six months and not been given any medication within two weeks from the day of measurements. This resulted in a total of 109 horses (Table 1). If a horse/pony was frightened or showed signs of stress in any of the steps of the measurements that horse/pony was excluded from the study. One person from the riding schools' personnel signed an informed consent document before measurements (Appendix 1).

Table 1. Number of horses per riding school

Riding school	Number of horses
1	13
2	13
3	8
4	23
5	9
6	16
7	24
8	3

3.2. Registered parameters

The measurements took place from February to June 2020. All measurements of the parameters for each individual horse was taken in the same day. Hearth girth circumference (HG), BCS, CNS, subcutaneous fat thickness and motion asymmetry was measured in all horses. Hearth girth was measured right behind the withers with a measuring tape. Body condition was scored using a Swedish modified version of the Henneke-scale (Jansson, 2019). The assessment was divided into five areas; back, shoulder, tailhead, neck and ribs. Each area got an individual score which later was used to calculate a mean score for the whole body, the score was then rounded to nearest half point. In the assessment of the CNS the scale from Carter *et al*. (2009) was used with a 0.5 points accuracy.

3.2.1. Subcutaneous fat thickness

To estimate percentage total body fat (TotFat) of the horses, subcutaneous fat was measured with ultrasound (SonoScape A6 equipped with a L745 probe, frequency used ~7.5-8.5 MHz) at two positions at the rump of the horse. Two squares, 2x5 cm, were clipped at the left side of the croup. The first square (location one, Fat1) was located at the top of the croup and five cm lateral from the midline. The second square (location two, Fat2) was located 15 cm from the first square towards to the tail, also approximately five cm lateral from the midline. The skin was cleaned with ethanol prior to measurements.

Total amount of percent body fat was calculated using the equation $Y = 8.64 + 4.70X$ from Westervelt *et al*. (1976) for location one (Fat%1) and $Y = 2.47 + 5.47X$ from Kane *et al*. (1987) for location two (Fat%2). In both equations X = cm of rump fat. The results of the two equations were later used to calculate an average total percent body fat for each horse.

3.2.2. Motion asymmetry

Motion asymmetry was measured during trot at hand in a straight-line with the sensor-based system Lameness Locator® (Equinosis, LLC). The trotted distance was about 100 meters in total, or enough to have collected at least 25 step strides, in an indoor or outdoor paddock with soft/deep footing. Staff at the riding schools led the horses while measuring motion asymmetry. Three sensors were used, of which one was attached to the halter, between the ears, the second was attached to the croup at the midline in line with *tubera sacrale* and the last sensor was attached dorsal to *proximal phalanx* of the right leg. Vector sums (VS) for head (front limbs, VSf) and pelvis (hind limbs, VSh) were calculated using the differences in left and right maximum and minimum position of both head and pelvis with the equation:

$$VS = \sqrt{max\ difference^2 + min\ difference^2}$$

3.2.3. Questionnaire

A questionnaire was made with Microsoft Office 365 where questions about the riding schools routines and the horses temper were asked. The questionnaire was sent to all participating riding schools and answering the questions was voluntary. The questions were (translated from Swedish):

1. How many hours per day are your horses outside?
2. How many horses are there per paddock?
3. How large are you paddocks?
4. How willing to work is (horses name) while training (scale 1-10 where 1 = very unwilling, 10 = very willing)?
5. How energetic is (horses name) while training (scale 1-10 where 1 = very lazy, 10 = very energetic)?
6. How many lessons per week does (horses name) participate in?

To answer question one, two, three and six the receivers could use their own words. Question four and five and were answered by choosing a number on a scale from one to ten. Horses were grouped based on mean hours/day/week they spent outside in paddocks. Horses that spent less than 11 hours outside were grouped together (group A) and horses that spent more than 11 hours outside were grouped together (group B). Two groups were also made considering how many lessons per week a horse was used for (group a: < 14 lessons/week, group b: ≥ 14 lessons/week).

3.3. Statistical analyses

3.3.1. Movement asymmetry

Excel (Microsoft office) was used to handle and structure the data. Statistical analyses were made in SAS 9.4 (SAS Institute). For the statistical analyses, horses were grouped based on BCS and also based on percent total body fat. Two groups were made for BCS (group 1: BCS < 6, group 2: BCS ≥ 6) and percent total body fat (group X: fat < 10 %, group Y: fat ≥ 10 %) respectively.

For analyses of movement asymmetry and questionnaire answers multiple linear regression analyses were made using the GLM procedure in SAS. The model used was:

$$Y_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \cdots + \beta_p X_{ip} + \epsilon_i$$

Where Y is the dependent variable VS (VSf and VSh), X_i is the independent variable, β_p is the regression coefficient and ϵ_i is the error variable. The effects of BCS, group BCS, percentage body fat, subcutaneous fat thickness at both locations (Fat1 and Fat2) and group fat included as independent variables were analysed separately one at a time together with the effect of riding school (RS) for effects on VSf and VSh. Separate analyses were run to study effects of either time spent outside (group A & B) or number of riding lessons per week (group a & b) on VSf and VSh. Scores for willingness to work and how energetic the horse was were analysed with a model including the effects or RS and group BCS. Analysis of correlations was made with the PROC CORR procedure in SAS 9.4 (SAS Institute) which produces a table of Pearson product moment where correlations for the parameters BCS, CNS, Fat1, Fat2, HG, VSf, VSh, and TotFat could easily be read.

Results are presented as least square means ± standard error (SE) unless otherwise stated. Results are considered significant if $P < 0.05$ and with a tendency for significance if $P < 0.1$.

4. Results

There were in total 109 horses/ponies included in the study, of which 68 were geldings and 41 were mares. The number of horses per riding school ranged from three to 24. In the analyses of motion asymmetry for hind limbs, four horses were excluded due to unclear data (n = 105, 41 mares and 64 geldings). There were five riding schools that answered the questionnaire making it a total of 59 horses. In the questionnaire, two horses (one in the question about how willing to work the horse is and one in the question about how energetic the horse is) were excluded due to unclear answers, making it a total of 58 horses when analysing question four and five. Regarding the question about paddock sizes, one answer was excluded due to an unclear answer.

4.1. Body condition scores and measured body fat

Body condition score group 1 (BCS < 6) consisted of 44 horses and group 2 (BCS ≥ 6) consisted of 65 horses. When grouped together considered percent total body fat it was 82 horses in group X (< 10 % body fat) and 27 horses in group Y (≥ 10 % body fat). Measured heart girth circumference range from 139.0 cm to 221.0 cm (178.7 ± 18.0 mean ± STD).

Body condition score and cresty neck score ranged from 4.5 to 7.5 (5.7 ± 0.6 mean ± STD) and 1.0 to 4.0 (2.3 ± 0.5 mean ± STD) respectively. Body condition score showed a positive correlation with both CNS and percent total body fat ($r = 0.73$, $P < 0.0001$ and $r = 0.23$, $P < 0.05$ respectively). BCS also had a positive correlation with subcutaneous fat thickness measured at location two (Fat2) ($r = 0.24$, $P < 0.05$). Body condition score was negatively correlated with heart girth ($r = -0.24$, $P < 0.05$). No correlations were found between BCS and subcutaneous fat thickness measured at location one of the rump (Fat1).

Measured subcutaneous fat thickness at location one ranged from 1.2 mm to 5.5 mm (2.4 mm ± 0.9 mm mean ± STD) and at location two from 2.2 mm to 21.5 mm (10.4 mm ± 4.6 mm mean ± STD). Fat2 was positively correlated with heart girth ($r = 0.4$, $P < 0.0001$). No other correlations were found between Fat1 and Fat2 and the included parameters for body measurements. Percent body fat for all horses ranged from 6.6 % to 12.0 % (9.0 ± 1.3 mean ± STD) and was positively correlated with heart girth ($r = 0.39$, $P < 0.05$). No correlation was found between total percent body fat and CNS.

4.2. Motion asymmetry

Motion asymmetry presented as vector sum for front limbs and for hind limbs ranged from 1.1 to 38.2 (9.7 ± 7.3 mean ± STD) and 0.4 to 16.6 (4.8 ± 3.1) respectively. Riding school did not affect motion asymmetry.

4.2.1. Effect of body condition score on motion asymmetry

Body condition score did not have an effect on VSf but showed a tendency for an effect on VSh ($P = 0.09$) (Figure 1; Figure 2). Horses with a higher body condition score tended to be more asymmetric in their hind limbs ($r = 0.18$, $P = 0.06$). There were no differences in motion asymmetry between the two body condition score groups (group one BCS < 6, group two BCS ≥ 6) (Figure 3). No correlation was found between BCS and VSf or VSh.

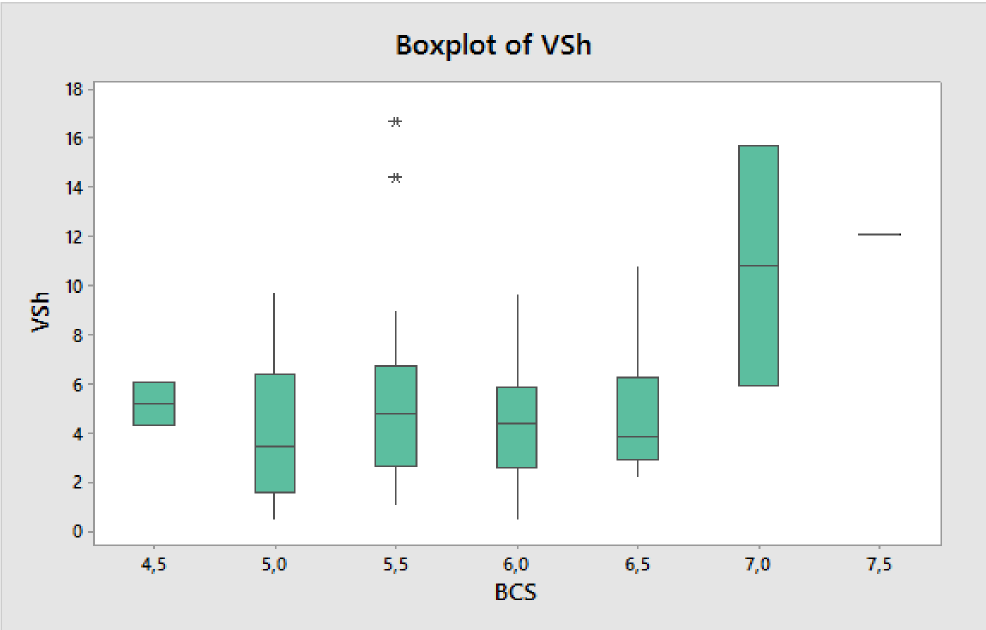

*Figure 1. Boxplot of VSh for different body condition scores, * indicate outliers*

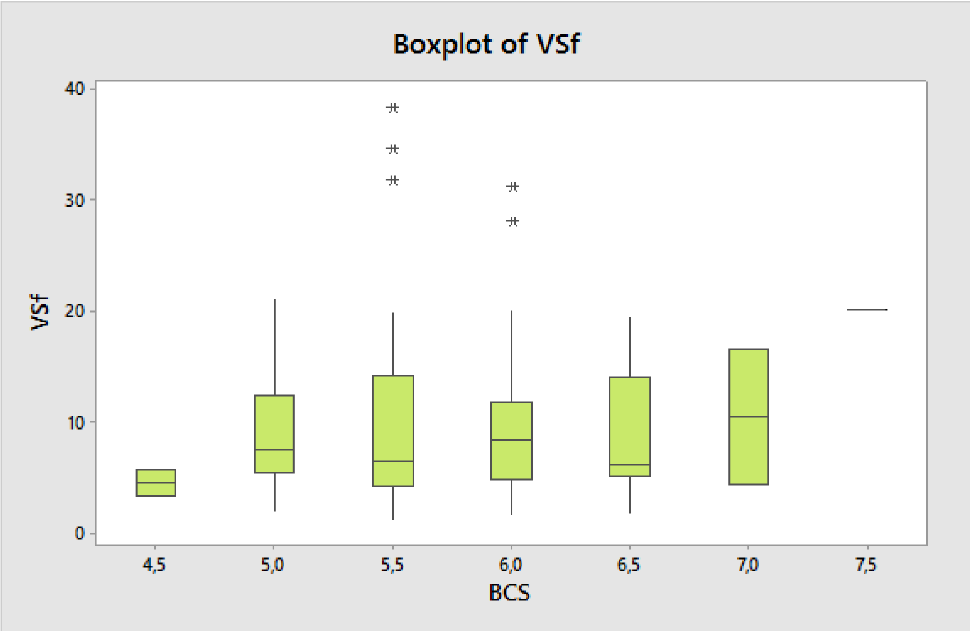

*Figure 2. Boxplot of VSf for different body condition scores, * indicate outliers*

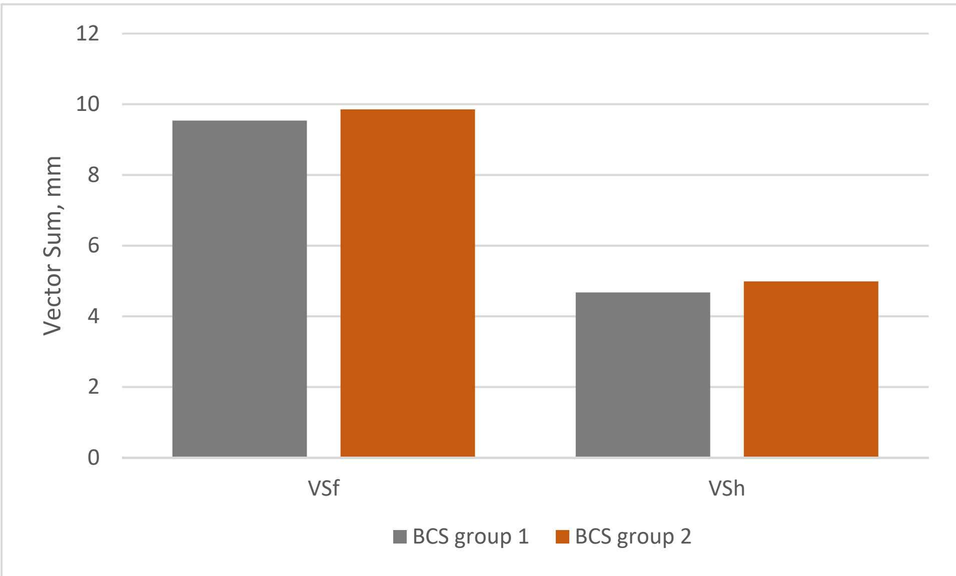

Figure 3. VS in the BCS groups (group 1: BCS < 6 and group 2: BCS ≥ 6), VSf: group 1: 8.4 ± 1.1 vs. group 2: 9.8 ± 1.2 (P > 0.05), VSh: group 1: 4.9 ± 0.5 vs. group 2: 5.0 ± 0.5 (P > 0.05)

4.2.2. Effect of body fat on motion asymmetry

Motion asymmetry was not affected by subcutaneous fat thickness measured at location one. Measured fat thickness at location two affected motion asymmetry in hind limbs (VSh $P < 0.05$) but did not affect asymmetry in front limbs. A thicker subcutaneous fat layer at location two was weakly correlated to less asymmetric movements in both front and hind limbs (VSf: $r = -0.19$, $P < 0.05$ and VSh: $r = -0.21$, $P < 0.05$). No correlation was found between Fat1 and VSf or VSh.

Percent body fat did not have an effect on motion asymmetry in front limbs but had a tendency to significantly affect motion asymmetry in hind limbs ($P = 0.08$). Percent body fat had a weak negative correlation with more motion asymmetry in hind limbs ($r = -0.20$, $P < 0.05$) (Figure 4). There were no differences in asymmetry between the two groups considered total percent body fat (group X: fat < 10 %, group Y: fat ≥ 10 %) (Figure 5). Heart girth circumference was negatively correlated to asymmetric movement in both front and hind limbs (VSf: $r = -0.23$, $P < 0.05$ and VSh: $r = -0.28$, $P < 0.05$).

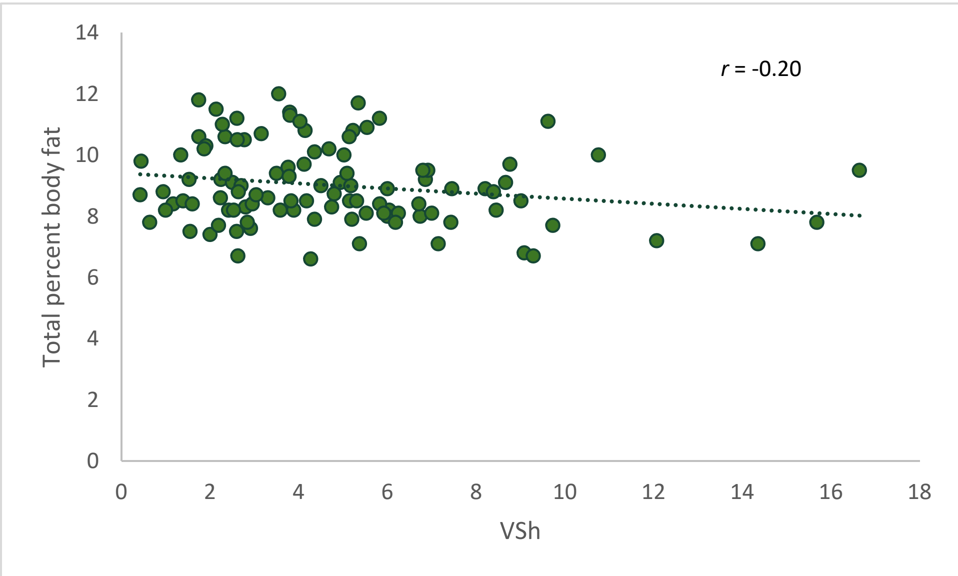

Figure 4. Correlation between percent body fat and VSh (P < 0.05)

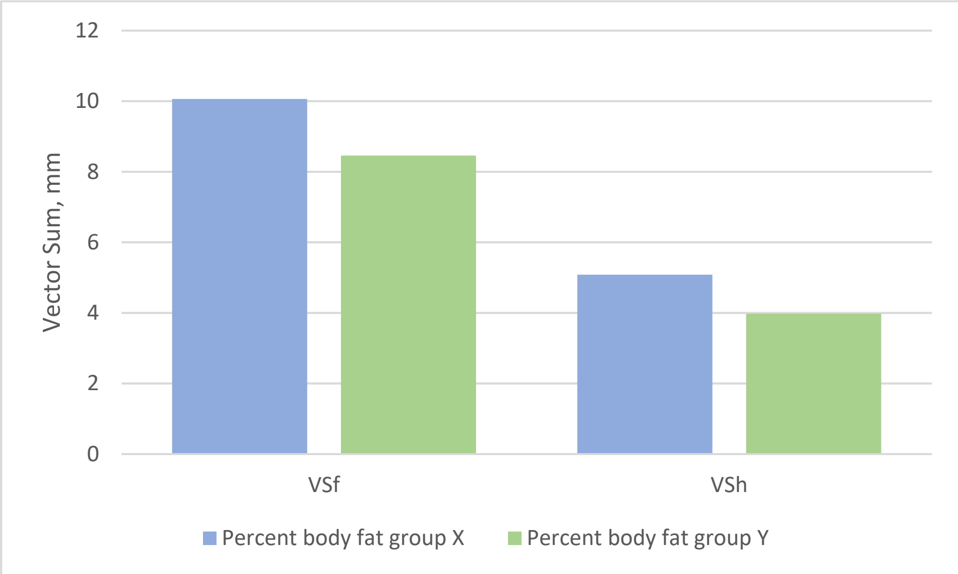

Figure 5. VS in the body fat groups (group X: fat < 10 %, group Y: fat ≥ 10 %), VSf: group X: 9.3 ± 1.0 vs. group Y: 8.4 ± 1.5 (P > 0.05), VSh: group X: 5.3 ± 0.4 vs. group Y: 4.2 ± 0.6 (P > 0.05)

4.2.3. Management effects on motion asymmetries

The number of lessons per week a horse was used ranged from three to 18. It was most common to use the horse for 14 lessons per week (n = 22) followed by ten and 12 lessons per week (n = 10 and n = 8 respectively). No differences in motion asymmetries were found between group a (< 14 lessons/week) and group b (≥ 14 lessons/week, $P > 0.05$).

Horses that spent more time outside (group B > 11h/day) were more asymmetric in front limbs than horses that spent less time outside (Group A: VSf: 7.8 ± 1.4 vs. Group B: VSf: 12.5 ± 1.4, $P < 0.05$). There was no significant difference between the two groups of turnout regime considering motion asymmetry of the hind limbs.

4.2.4. Body condition and motion asymmetries' effects on temper

Horses in BCS group one (BCS < 6) were more willing to work than horses in BCS group two (7.9 vs. 6.8 points of a scale of 1-10, $P = 0.004$). There was a difference between riding schools in how willing a horse was to work ($P < 0.0001$). No significant correlation was found between a horse's willingness to work and its motion asymmetry (VSf: $P > 0.05$ or VSh: $P > 0.05$).

Horses in BCS group one were more energetic than horses in BCS group two (7.2 vs. 6.0 of a scale of 1-10, $P = 0.002$). No significant correlation was found between how energetic the horses were and their motion asymmetries (VSf: $P > 0.05$ or VSh: $P > 0.05$).

4.3. Turnout routines

Two out of five riding schools group housed some of or all their horses. The horses that were stabled during night were out for about 6-7 hours per day in three riding schools and for 10 hours in one riding school. In one of the riding schools the horses were not turned out on Saturdays and on Sundays the horses were turned out for two hours.

All riding schools had several groups of horses in different paddocks which ranged from two to ten horses per paddock. It was most common to have more than five horses in one paddock. Two of the riding schools, of which one only included paddocks used for winter, had paddocks ranging in size from one hectare to three hectares. Two of the riding schools did not know the exact size of their paddocks but said that they were more than sufficient.

5. Discussion

The increasing prevalence of overweight and obesity among horses is a potential animal welfare problem. Overweight has in humans been found to increase the risk of osteoarthritis which often causes pain and inhibits movement (Cooper *et al*., 1998; Grotle *et al*., 2008). In horses, this connection is not well documented. However, it has been found that horse owners perceive their horses as sound although asymmetries in the motion pattern could be seen with objective measurements (Pfau *et al*., 2016; Rhodin *et al*., 2017) and that lameness is the most common cause for veterinary insurance claims of riding schools (Egenvall *et al*., 2009). This thesis aimed to analyse if body condition affects motion asymmetry in riding school horses. The results of this study do not indicate that there is a difference in motion asymmetry between horses with higher body condition score or higher percent body fat and horses with lower body condition score or percent body fat. However, body condition score and percent total body fat had a tendency to affect motion asymmetry in hind limbs. Horses with higher BCS had a tendency to be more asymmetric in hind limbs, although the correlation was weak (r = 0.18) while horses with higher percent body fat were less asymmetric in hind limbs, why the results are in conflict (r = -0.2). Pearson *et al*. (2018) found no significant correlation for body condition score (on a scale of 1-9) and lameness (subjectively evaluated using a scale of 0-5). However, they found that lameness was correlated with fat mass (r = 0.32). Body weights of the horses in the current study was not registered and therefore fat mass could not be estimated. If fat mass was estimated in this study, the different sizes of the horses would have affected the range of estimated fat mass.

Rhodin *et al*. (2017) found that 72 % of the 222 horses in their study were considered lame by the thresholds of the Lameness Locator system (asymmetries > 6 mm for head movement and > 3 mm for pelvic motion). In their study they calculated VS only for front limb asymmetry and assigned the asymmetry to the left or right side. They found that mean VSleft was 17.4 and mean VSright was 14.1 which is higher than mean VSf in the current study. Keegan *et al*. (2012) measured lameness in 18 horses of which 17 had chronic forelimb lameness. Of the 18 horses only 14 were found to be lame when evaluating lameness using calculated VS for front limbs. The results of the calculated VS in the study by Keegan *et al*. (2012) were higher than the calculated VS in the current study. In this study, motion asymmetry was only presented as vector sums for front and hind limbs since which side (right or left) or type (impact or push off) of asymmetry was not of importance to answer the aim and focus was paid to the size of the asymmetry. Lameness or smaller asymmetries in the motion pattern can be caused by various reasons, e.g. inflammation, trauma or management. Inflammation or trauma was only excluded in this study by one of the criteria to participate, horses were not to be given any medication within two weeks from the day of measurements. However, horses in this study might have had an undiagnosed inflammation affecting the results. It is also possible that some of the measured asymmetries could have been in the normal range for the individual horse and therefore, not affected by body condition score or percent body fat. In future studies, factors such as these need to be considered in future studies.

The BCS of the horses in the current study (5.7 ± 0.6) is close to the results of a study by Fowler *et al*. (2020). In their study, the horses had a mean BCS of 5.4 ± 0.2 and mean percent body fat of 12.4 % ± 0.5. Yngvesson *et al*. (2019) found similar body condition scores for riding school horses as in the current study. They found that group-housed horses had a BCS of 6.4 ± 1.0 and horses housed in tie-stall/boxes had a BCS of 6.0 ± 1.0. There might have been a risk for wrongly assessed body condition scores in this study due to the assessor's low experience with body condition scoring in horses. The possible error of BCS in this study could affect the results in such a way that the studied population's body condition scores were skewed to be either lower or higher overall. That could have led to that one of the BCS groups was either smaller or bigger than it should have been and therefore, no significant differences were found between the two groups. Although, in the current study horses with a BCS ≤ 5 and a BCS > 5 as well as horses with BCS < 6.5 and horses with a BCS ≥ 6.5 were compared considered motion asymmetry and no differences were found between either of the groups.

Previous studies have shown high agreement between observers when assessing body condition scores of horses (Czycholl *et al*., 2019 & Burn *et al*., 2009). In this study there was, however, only one observer and intra-rater reliability has also been found to be high when assessing BCS of dairy cows (Kristensen *et al*., 2006; Vasseur *et al*., 2013). With a high intra-rater reliability all horses should have been judged in the same way even if the body condition score was underestimated, which is important for the studies of possible correlations with the other variables measured. Even if the body condition scores were wrongly assessed, a thinner horse was given a lower score compared to a fatter horse when doing the measurements and therefore possible differences between horses with lower or higher body condition score could be analysed.

The subcutaneous fat thickness in the current study was found to be lower than the findings of Westervelt *et al*. (1976) and Kane *et al*. (1987) but closer to the findings of Fowler *et al*. (2020). In the study by Fowler *et al*. (2020) they studied Thoroughbred horses (body weight range 519-649) while both Westervelt *et al*. (1976) and Kane *et al*. (1987) studied both ponies and horses (body weight range from 336-559 kg and 281-474 kg respectively). Considering the studied horses results in the current study might have been expected to be more similar to the results of Westervelt *et al*. (1976) and Kane *et al*. (1987). The reason for the difference is unclear but could be due to that the studied horses in the current study were more similar to the horses in the study by Fowler *et al.* (2020) where all the studied horses were Thoroughbreds in contrast to Westervelt *et al*. (1976) and Kane *et al*. (1987) which might have included more ponies than horses in their studies.

In the study by Westervelt *et al*. (1976) two different equations are presented as the relationship between rump fat and percent body fat, one for horses varying in weight and one specifically for Shetland ponies. The equation presented in the trial with the Shetland ponies was tested for all the horses in the current study (both ponies and big horses), however, that resulted in such a low percent body fat which were deemed to be unrealistic. Therefore, the equation presented in the trial with horses varying in weight was used for all horses in the current study to calculate percent body fat using subcutaneous fat thickness measured at location one of the rump. When calculating percent body fat in the current study, the same equations were used for all horses independent of size. This resulted in the same percent body fat for horses of different sizes with the same measured subcutaneous fat thickness. However, smaller horses would have been expected to have a higher percent body fat compared to bigger horses with the same measured subcutaneous fat thickness. In the current study, percent body fat had a weak correlation with measured fat thickness at location one of the rump. Westervelt *et al*. (1976), found a strong correlation between subcutaneous fat thickness measured with ultrasound and carcass measurement ($r = 0.93$, $P < 0.01$). However, Kane *et al*. (1987) found that the apex of the croup has a too thin fat layer to make correct measurements with ultrasound. In their study, measured subcutaneous fat at the apex of the croup did not have a significant correlation with empty body fat ($r = 0.69$, $P > 0.05$). In the current study, subcutaneous fat thickness measured at location two of the rump had a positive correlation with body condition score. Fat thickness measured at location one of the rump did not have a significant correlation with BCS. Therefore, there might have been more beneficial to measure subcutaneous fat thickness lower down from the apex of the croup or only measured at site two in this study.

The reason to why the results are in conflict in the current study is unclear but might be due to the different methods used for measurements. Dugdale *et al*. (2012) criticises body condition scoring for decreasing in accuracy with increasing body condition score ($BCS \geq 7/9$). However, only a few horses had a $BCS \geq 7$ in the current study. In a study by Martin-Gimenez *et al*. (2016) they found that horses with a $BCS \geq 7$ had thicker subcutaneous fat at their shoulder, ribs, tailhead and rump compared to horses with a $BCS < 7$. When assessing body condition the internal fat of the horse is not taken into consideration. This is, however, included in the estimated percent body fat that is calculated from the measured subcutaneous fat thickness. Body condition score has, however, been found to have a strong positive correlation with percent body fat estimated by measured subcutaneous fat thickness at the rump with ultrasound (Henneke *et al*., 1983; Gentry *et al*., 2004). In the current study, BCS and percent body fat had a weak positive correlation and in a study by Fowler *et al*. (2020) they found a weak negative correlation between BCS and percent body fat ($r = -0.024$), however that correlation was not significant.

No distinction was made considered the size of the horse, i.e. pony vs. horse, in this study. However, a negative correlation was found for BCS and heart girth. Hearth girth also had a negative correlation with VS in both front and hind limbs. This implies that ponies had a higher BCS compared to horses in this study and that ponies might be more asymmetric in their motion pattern. Higher BCS in smaller horses was also found in the study by Visser *et al*. (2014). In future studies it might be of interest to consider the size of the horse to see if there are differences between ponies and horses considering body condition score and motion asymmetry.

Riding school did not affect motion asymmetry in front or hind limbs in this study. This is not in agreement with the findings in previous studies where Egenvall *et al*. (2010) and Lönnell *et al*. (2012) found a riding school effect on disorders in the locomotor apparatus. In the study by Yngvesson *et al*. (2019) they found four cases of lameness, where two horses were kept in group housing systems and two were kept in systems with tie-stall/boxes. However, the authors did not study any factors that could have affected the lameness. The questionnaire in this study was used in order to include management factors. The turnout regime affected motion asymmetry, where horses that on average were out for more than 11 hours per day were more asymmetric in front limbs than horses that were out less than 11 hours. This is not in agreement with the results by Odlander (2010) who found that horses that were out for more than ten hours per day had less trauma injuries and fetlock inflammation. In the current study, the frequency of answers was low, resulting in only 59 horses for the analysis of management factors effect on motion asymmetry. The study by Odlander (2010) included a total of 290 horses, making the conclusions in that study more reliable. The question regarding turnout regime was answered collectively for each riding school and not for the individual horses. Therefore, it is not possible to know if the effect of turnout regime was the affecting factor for motion asymmetries. It could have been other factors for the separate riding schools that affected the motion asymmetry in the horses. However, as previously stated, when riding school was included as an effect in the analyses it did not affect motion asymmetry.

Workload as number of lessons per week did not affect motion asymmetry in the current study. Murray *et al*. (2010) found that dressage horses than spent more time exercising or walking during warmup were more likely to be lame, while Pearson *et al*. (2018) found that activity level (scored on a scale of 0-4) and lameness score (on a scale 0-5) was negatively correlated, although not significant (r = -0.2). Management factors in riding schools with high or low claims for veterinary insurance were evaluated in the study by Lönnell *et al*. (2012). However, in their study no significant differences were found in cases of lameness between the different riding schools (high or low insurance claim) considering turnout regime and number of lessons per week a horse was used.

The number of riding schools asked to participate was limited due to distance and there were also limitations due to workload for the participating riding schools. To be able to do the measurements in this study, staff at the riding school needed to be present which unfortunately made it impossible for some riding schools to participate due to lack of available staff. This affected the total number of horses in this study and that the measurements took place over a long time, from February to June. It is also important to consider the bias of the participating riding schools. The riding schools that wanted to participate in this study might have had a particular interest in lameness and body condition which may have given a skewed representation of the national population of riding school horses.

The use of a one to ten-point scale in the questionnaire might not have been the best choice. A visual analogue scale could have been a better option. The visual analogue scale is a straight line (commonly 100 millimetres long) that only has the extremes in each end (Berntson *et al*., 2016). The person answering the questions would not be forced to choose between the numbers of a one to ten-point scale but freely putting a cross on the line in the visual analogue scale. On a visual analogue scale, the answering person would not have to compromise to choose a number if a horse would fit best between numbers, on a numeric scale, when the visual analogue scale only consists of a straight line and can therefore provide a more precise answer (Berntson *et al*., 2016). However, due to time limitation, and the need of practical solution, the one to ten-point scale needed to be used, too be able to answer the questions via a computer.

The current study found that horses with a BCS < 6 were more energetic compared to horses with a BCS ≥ 6. However, it is not possible to know if the horses scored higher for how energetic they were because they were thinner, or if they were thinner because they were more energetic. All questionnaires were answered by different persons and therefore the answers are not standardised. To standardise the questionnaire and the answers regarding the horses' temper, one person would have had to answer all questions for all horses. Motion symmetry was not affected by how energetic the horse was in the current study. One of the riding school managers stated, when answering the questionnaire in this study, that the question about a horses' temper could be interpreted in two different ways. The answering person could interpret the question in such a way that a horse that would be given the maximum point for how energetic the horse is, would not be suitable for the activity of the riding school or a maximum point would be a perfect riding school horse. In a previous student's thesis, it was found that riding school managers preferred horses with a stable temperament, they should be kind and not too energetic (Sjölund, 2015). Ahlqvist & Waerner (2007) found in their thesis that a horse's temperament was the most important factor to consider when buying a riding school horse. Considering the findings of Sjölund (2015) a preferred riding school horse would not be given the maximum point for how energetic the horse is which would be unmanageable for the students. However, more studies need to be done to get a clear understanding of the perfect riding school horse and if there is a difference in desirable temperament of the horse considering the level of the students.

5.1. Conclusion

The purpose with this study was to analyse a possible relationship between motion asymmetry and body condition score in Swedish riding school horses. No significant relationship was found between BCS and motion asymmetry in this study, but horses with higher BCS had a tendency to be more asymmetric in hind limbs. It was also found that horses with higher percent body fat were less asymmetric in hind limbs, making the results conflicting, and that horses with smaller heart girth were more asymmetric in both front and hind limbs. More studies need to be done in this area to see if it is BCS that affects the motion pattern. Future studies should include a larger study material, i.e. riding school horses from a larger geographical area, which was one of the limiting factors in this study, and also more data about the horse's health.

6. Popular scientific summary

6.1. Är tjocka hästar mer ojämna i sin rörelse än slankare hästar?

Övervikt och fetma är något som ökar bland hästar. Studier som undersökt hur stor del av hästpopulationen som är drabbad har visat att runt 30–50 % av hästpopulationen runt om i världen är överviktiga. Med övervikt kommer en ökad risk för att hästen drabbas av olika sjukdomar, där ibland fång och ekvint metabolt syndrom. Men hur är det med rörelseapparatens funktion, blir den påverkad av några extra kilon?

I en nyligen utförd studie har 109 ridskolehästar undersökts för att ta reda på om det finns någon koppling mellan deras hull och ojämnheter i rörelsemönstret. Studien kunde dock inte påvisa något tydligt samband mellan dessa två parametrar. Det fanns dock en tendens till att hästar med högre hullpoäng hade ett mer ojämnt rörelsemönster för bakbenen jämfört med hästar med lägre hullpoäng. Resultaten var dock inkonsekventa. När andelen kroppsfett för varje häst räknats ut gick det även att se en svag negativ korrelation mellan andel kroppsfett och ojämnheter i bakbenens rörelsemönster, vilket innebär att hästar med större andel kroppsfett rörde sig något mindre jämnt än hästar med mindre andel kroppsfett.

Faktorer som kan påverka en ridskolehästs rörelsemönster är ridskolans rutiner och hantering. I den aktuella studien kunde skillnader ses mellan hästar som i medel var ute mer än elva timmar per dygn och de hästar som var ute mindre än elva timmar per dygn. De hästar som var ute mest hade också ett mer ojämnt rörelsemönster för frambenen. Det var dock inte alla ridskolor som svarade på frågorna om deras rutiner, vilket gjorde att antalet hästar för denna analys var låg. I tidigare studier där det ingick ett större antal hästar har motsatsen visats. I den aktuella studien fanns ingen skillnad i hur ojämnt rörelsemönstret var mellan hästar som gick mer eller mindre än 14 lektioner per vecka.

Resultaten i den nyligen utförda studien motsäger varandra i det avseendet att hästar med högre hullpoäng var mer ojämna och att hästar med mer andel kroppsfett var mindre ojämna. Fler studier behövs för att ta reda på om hull och andel kroppsfett påverkar rörelsemönstret hos hästar.

Att övervikt skulle kunna orsaka problem med rörelsemönstret är något som setts hos människor och hund. För människan är övervikt en riskfaktor för bland annat höftleds- och knäartros. Hos hund har det visats att övervikt är en riskfaktor för höftledsartros. Något sådant samband finns dock inte dokumenterat hos häst. Tidigare studier har dock sett att hälta är det vanligaste hälsorelaterade problemet hos ridskolehästar och att övervikt bland dessa är vanligt.

Den skala som användes för att hullbedömda hästarna i den nyligen utförda studien går mellan ett till nio, där ett innebär att hästen är extremt utmärglad och nio innebär att hästen är extremt fet. För att kunna räkna ut hästarnas procentuella mängd kroppsfett mättes tjockleken på deras underhudsfett med ultraljud på rumpan. Därefter kunde kroppsfett beräknas med hjälp av tidigare framtagna ekvationer. Rörelsemönstret för varje häst analyserades med ett system som använder tre olika sensorer som fästes på hästen. Rörelserna mättes i trav vid hand på rakt spår på mjukt underlag.

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Acknowledgements

I would like to give a special thanks to my supervisor Sara Ringmark who has helped and guided me through the process with this thesis. She has given me valuable tips and tricks and taught me a lot. I am very thankful that she wanted to supervise this thesis and give me the opportunity to do this study.

I would also like to thank all the staff at the riding schools I got to visit. Without them this study would not have been possible. I had a wonderful time at the riding schools with a lot of laughter and interesting discussions.

Appendix 1

Generella frågor om ridskolans rutiner:

Hur många timmar per dag är era hästar ute?

Hur många hästar är det per hage?

Hur stora är hagarna?

Frågor om varje häst:

Dessa tre frågorna upprepades för varje häst.

Hur arbetsvillig är [hästens namn] vid ridning? 1 = Mycket ovillig & 10 = Mycket villig

1☐ 2☐ 3☐ 4☐ 5☐ 6☐ 7☐ 8☐ 9☐ 10☐

Hur energisk är [hästens namn] vid ridning? 1 = Slö & 10 = Het

1☐ 2☐ 3☐ 4☐ 5☐ 6☐ 7☐ 8☐ 9☐ 10☐

Hur många lektioner per vecka går [hästens namn]?