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Feeding routines and prevalence of overweight horses in Norway

Fôringsrutiner og utbredelse av overvektige hester i Norge

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Preface

This master thesis was written as the final part of the Master of Science in animal nutrition at the Faculty of Biosciences at the Norwegian University of Life Sciences submitted in May, 2023. I wanted to write this master thesis to widen my knowledge on horse nutrition. The idea for this topic came when writing my bachelor thesis *Estimate energy balance in the working horse*, as I found no studies on the prevalence of overweight horses in Norway. This made me curious, and I wanted to research this topic deeper.

The target groups for this thesis are students, researchers, veterinarians, horse owners, Norwegian horse federations and other people with interests for horse nutrition and welfare. This thesis investigated feeding routines and the prevalence of overweight in Norwegian horses. The intention of this thesis was to provide information about the challenges about keeping horses in Norway in relation to feeding and body condition. Additionally, this thesis may be a tool for identifying overweight horses, and factors effecting body condition of horses.

Several people have been supporting and helping me through this thesis. First of all, I would like to thank my supervisors Bjørn Håkon Wormstrand and Jon Anders Næsset, Faculty of Veterinary Medicine, Department of Companion Animal Clinical Sciences, Norwegian University of Life Sciences for support, for guidance and good discussions. I would also like to thank Rasmus Bovbjerg Jensen, Faculty of Biosciences, Norwegian University of Life Sciences, for five years of engaging knowledge allocation and support to learn more about my passion, equine nutrition. I would sincerely like to thank all the horse owners participating in my study, and for letting me into their stables. This study would not be possible without you. Lastly, I would like to thank my father for all guidance, motivation and support to achieve my goals.

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Abstract

Background: Over the latest years feeding recommendations for horses have changed continuously. The minimum recommendations for forage intake have increased, and *ad libitum* feeding is encouraged to ensure welfare and health of horses. However, a higher forage intake might result in higher energy intake for the horse. When body condition scoring horses, the prevalence of obesity ranges from 21 to 62% in Scandinavia, Great Britain and the USA. Obesity in horses may lead to health problems and supress animal welfare. Little is known about the body condition score (BCS) of horses in Norway, feeding routines and the percentage of imported horse feeds in Norway.

Aim: The aim of this study was to investigate feeding routines and the prevalence of overweight horses (BCS>6) in Norway.

Materials and methods: In this thesis, a cross-sectional study of 424 horses was conducted. The horses were body condition scored (Kohnke, 1992) and body weight was measured on a weight scale (n=398/424). The horses (n=424) consisted of 144 horses studied at the Equine Hospital at NMBU and 280 horses at private stables in the field. Information about the horses' gender, age, breed, use, and health status was collected. The total number of horses studied consisted of 219 geldings, 158 mares and 37 stallions, with ages ranging from 6 months to 29 years. In addition, 266 out of the 424 horses' and 18 owners of horses who was not body condition scored answered a questionnaire about feeding routines of their horses.

Results: Ninety percent of the horses in the present study were fed Norwegian produced forage. Horses fed imported forage had a lower BCS than horses fed self-produced forage, and 90% of horses fed imported forage were competition trotters. In addition to forage, 68% of the horses were fed concentrate from Norwegian manufacturers only. The origin of concentrate did not affect the BCS, neither the type of forage fed. The prevalence of overweight horses in Norway, with a BCS over 6, was 47%. There were no underweight horses (BCS under 4) in the present study. Gender, age, breed, activity, health, and use affected the horses BCS. Horses with teeth or jaw injuries had the biggest effect on BCS, followed by the horses' breed.

Conclusion: In conclusion, most of the horse feed in Norway is Norwegian produced or from Norwegian manufacturers, and the prevalence of overweight horses investigated in the present study was 47%.

Sammendrag

Bakgrunn: De siste årene har fôringsanbefalinger for hest endret seg kontinuerlig. Anbefalinger for minimumsopptak av grovfôr har økt og fritilgang på grovfôr er anbefalt for å øke dyrevelferd og helse hos hesten, selv om et høyere fôrinntak kan føre til et høyere energiinntak for hesten. Ved hjelp av hold vurdering ble det i studier fra Skandinavia, Storbritannia og USA funnet en prevalens av fedme hos hest på 21 til 61 %. Fedme hos hest kan føre til helseproblemer, og redusere dyrevelferden. Lite er kjent om hesters hold (body condition score - BCS), fôringsrutiner og prosentandelen av importert fôr for hester i Norge.

Formålet: Formålet med denne studien var å undersøke fôringsrutiner og utbredelsen av overvektige hester (BCS>6) i Norge.

Materialer og metoder: I denne studien ble det gjennomført en tverrsnittstudie av 424 hester. Hestene ble holdvurdert (Kohnke, 1992) og kroppsvekten ble målt på en vekt (n=398/424). Hestene (n=424) besto av 144 individer som ble undersøkt ved Dyresykehuset Hest, Norges miljø og biovitenskaplige universitet, og 280 hester ble undersøkt i private staller i felt. Informasjon om hestenes kjønn, alder, rase, bruk og helsestatus ble registrert. Totalt antall hester var 219 vallaker, 158 hopper, og 37 hingster, med en alder som varierte fra 6 måneder til 29 år. I tillegg svarte 248 av de 424 hesteeierne og i tillegg 18 hesteeiere med hester uten hold vurdering på en spørreundersøkelse om fôrings rutiner for deres hester.

Resultater: Nitti prosent av de undersøkte hestene i denne studien ble fôret med norsk produsert grovfôr. Hester fôret med importert grovfôr hadde en lavere BCS enn hester fôret hjemmeprodusert grovfôr, men 90% av hestene fôret med importert grovfôr var konkurransetravere. Sekstiåtte prosent av hestene ble i tillegg til grovfôret fôret kun med kraftfôr fra norske produsenter. Kraftfôrets opprinnelse hadde ikke effekt på BCS, heller ikke typen av grovfôr. Utbredelsen av overvektige hester i Norge, med en BCS over 6, var 47%. Det var ingen undervektige hester (BCS under 4) i denne studien. Kjønn, alder, rase, aktivitet, helse og bruk påvirket hestenes BCS. Hester som hadde tann- eller kjeverelaterte skader hadde størst påvirkning på BCS, etterfulgt av hestenes rase.

Konklusjon: Det meste av fôret til norske hester er norsk produsert eller fra norske produsenter, og utbredelsen av overvekt hos hester undersøkt i denne studien var på 47%.

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1. Introduction

The way we keep horses in Norway has changed continuously over the last 50 years, with a transition from horses being kept as working animals to horses held for sport and recreational use (The Ministry of Agriculture and Food, 2018). This has led to a change in the way we manage and feed them. In recent years, international feeding recommendations for horses has changed, especially with regard to feeding requirements of forage. The recommended minimum requirements for forage intake have increased, and *ad libitum* feeding is encouraged to ensure welfare and health for horses (Harris et al., 2016). A higher forage intake will result in higher energy intake if the diet is not adjusted to the changes.

High body condition score (BCS) and obesity is a rising problem among the equine population (Dugdale et al., 2011). Several studies have investigated BCS in horses and a prevalence of obesity ranging from 21 to 62% has been found in Scandinavia, Great Britain, and the USA (Thatcher et al., 2008; Harker et al., 2011; Ireland et al., 2013; Jensen et al., 2016; Müller and Lindberg, 2020). Just 2 to 6%, in some of the same populations, have been classified as underweight (Thatcher et al., 2008; Wyse et al., 2008; Jensen et al., 2016). Obecity in horses may lead to diseases, and may reduce the welfare if the horse. Equine adiposity has been related to several clinical conditions such as insulin dysregulation, equine metabolic sydrome, adipose tissue dysfunction and low-grade inflammation (Geor, 2008; Reynolds et al., 2019; Fonseca et al., 2020; Harris et al., 2020; Zak et al., 2020; Daradics et al., 2021). There is also reason to belive that obesity in horses increase the risk of arthrosis (Jaqueth et al., 2018).

The Norwegian climate (rain and temperature) and typography is favourable for forage production, making it possible to grow energy rich forage (Harstad, 2016). The Norwegian climate is the main reason why two thirds of the agricultural land in Norway is used for forage production. The increased intake of energy rich forage may lead to a positive energy balance and an increase in BCS in horses. In general, horses can be clasified as overweight when the BCS is over 6, and obese with a BCS over 7 on an 1-9 scale (Kohnke, 1992). The Norwegian climate leading to energy rich forage and population of cold-blooded and primitive horse breeds might make it challenging to follow international recommendations for horse feeding in Norway.

Even though international studies have found a high prevalence of obesity, little is known about the BCS and overweight of horses in Norway. To the authors knowledge there has been no studies investigating BCS and prevalence of obesity in the Norwegian horse population. There are also no recent studies that investigate feeding routines of horses in Norway. Many different concentrates from several different manufacturers, both national and international, are available on the Norwegian market. However, little is known about the share of imported feed for horses in Norway, or the impact on BCS. It is therefore relevant to investigate the BCS and how feeding routines and horse characteristics effect the BCS of horses in Norway.

1.1 The aim, objectives and hypotheses

The aim of this study was to investigate feeding rutines and the prevalence of overweight horses (BCS>6) in Norway.

The objectives of this study were:

- To investigate the proportion of Norwegian produced forage and concentrate from Norwegian manufacturers fed horses in the Norwegian horse population used for different purposes and the consequences for their body condition.
- To compare the body condition of healthy and active horses in the Norwegian horse populations used for different purposes and horses visiting the Equine Hospital at NMBU for treatments.

The hypotheses are:

1) Norwegian horses are mainly fed Norwegian produced and manufactured feeds.
2) Origin and type of feed have no effect on BCS.
3) Overweight is prevalent in Norwegian horses.
4) Breed, activity, health, and use affects the BCS in horses.
5) BCS can be described by a model including gender, age, breed, use and health status.

1.1.2 Delimitation

To answer the hypothesis in this thesis a questionnaire was used to investigate feeding routines. The author has body condition scored horses in the field and at the Equine Section, Department of Companion Animal Sciences, Faculty of Veterinary Medicine, Norwegian University of Life Sciences, Ås, Norway, which in this thesis will be referred to as Equine Hospital at NMBU. Horses with a wide variation of different ages, breeds, use and health status have been included, with the exception of lactating mares and unweaned foals which were excluded.

2. Theoretical Background

2.1 Feeds in Norway

The horse population in Norway has been estimated to be approximately 125 000, and that 72% of these are hobby horses or used for recreational purposes (Vik and Farstad, 2012). As much as 89% of these horses were fed Norwegian produced forage, and 79% was locally produced (Vik and Farstad, 2012).

In Norway only 3% of the total land area is cultivated due to unfavourable conditions for agriculture in most parts of the country, although 45% of Norway's land area is suitable for grazing (Lundekvam et al., 2003). In 2019, approximately 57% of feed for farm animals was home produced (Landbruksdirektoratet, 2021). About 42% of the available feed was store bought concentrate. Less than 1% of the feed was imported forage (Figure 1). The last ten years 80-90% of Norwegian produced grain has been used for animal feed (Landbruksdirektoratet, 2021).

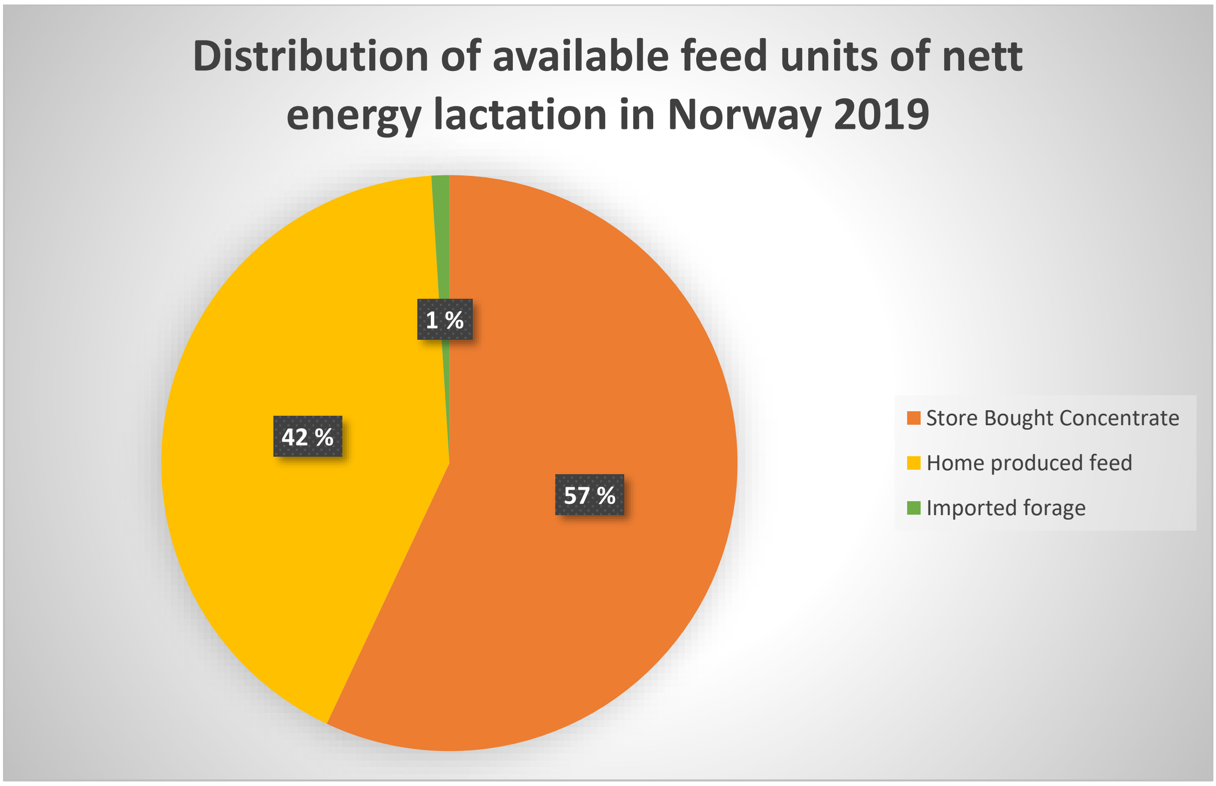

Figure 1. Distribution of the available feed store bought concentrate, home produced feed and imported forage for domestic animals in Norway 2019. Data based on Landbruksdirektoratet (2021).

Grains are the main ingredient in concentrate feed for Norwegian domestic animals, and most of the grain in concentrate from Norwegian manufacturers is produced in Norway (Landbruksdirektoratet, 2021). The grains produced for concentrate in Norway are mainly oats and barley, while the sources of fat and minerals included in the concentrate are mainly imported. Also, it is common to import protein to add in concentrates to increase the protein value. This because Norway does not produce enough oil crops, peas, and beans, and therefore is dependent on import (Nysted et al., 2022). The main protein sources imported are soya and rapeseed. Norwegian horses' main energy source is forage, and the forage is mostly produced in Norway. According to the rapport *Fôrråvarer til husdyr* (Animalia, 2023) is 83% of the Norwegian horse's total diets of Norwegian produced raw materials. In the report from Animalia (2023) it is stated that only 33% of raw materials in Norwegian manufactured horse concentrate is produced in Norway.

2.1.1 Forage

Forage is feed with a high fibre content, and with low levels of energy and protein. Forage can be grazed or fed after harvesting, either fresh or in a preserved form which is most common (Lindberg, 2013). Forage is often categorized as grass, silage, haylage, hay and straw, and is eaten by grazing livestock as well as horses. Silage is defined as forage stored airtight with dry matter (DM) content below 50% (Harris et al., 2016). Haylage is defined as forage stored airtight and with DM content between 50-85%, while hay is defined as forage preserved with a DM content above 85%.

Forage fed horses often consists of multiple gras species and herbs. Timothy and meadow fescue are common species in gras mixes for Norwegian equids. Horses are, as a non-ruminant grazing herbivore, adapted to eat and digest a forage-based diet (Harris et al., 2016). They are hindgut fermenters, i.e. the fermentation take place in both cecum and colon. Hence, the horse's digestive system is developed for grazing, meaning it is well adapted to a feeding pattern with almost continuous intake of small feed amounts (Ellis, 2010). A horse on pasture will forage for around 10 to 15 hours per day (Ellis, 2010).

During the 2012 meeting of the European Workshop on Equine Nutrition, a group of scientists gathered to write a long-needed consensus paper regarding preserved forage fed horses. This resulted in eight recommendations based on a review of scientific studies and the authors' own expert opinion (Harris et al., 2016). The following recommendations are presented because of their relevance to feeding routines, which is relevant to the present study:

- The basis of a diet should consist of forage (fresh or preserved) ideally offered *ad libitum* or distributed throughout the day to avoid longer periods without forage opportunity (>4 to 5 h). Although for older horses with difficulties chewing, soaked mash with high fibre products would be beneficial.
- All horses need sufficient quantities of forage presented in a form that supports species-specific feed intake behaviour preferably for a minimum of 8 h and preferably 10/24 h.
- The lower limit of forage intake should not be lower than 1.5% DM of the horse's bodyweight, with an absolute minimum of 1.25% DM of the horse's bodyweight.

2.1.2 Concentrate

Historically, the energy demand of working horses was too high compared to the relative short time the horse spent eating (Harris et al., 2016). Therefore, if the horse was fed only forage their energy requirements would not have been met. This was especially the case where grazing opportunities were limited. It was also a challenge to distribute and transport bulky forage, which also might have been of poor quality. Therefore, grains such as oats and barley, beans and roots were fed the horses in addition to forage. The tradition of feeding the horse energy dense feedstuffs (concentrates) have continued until today, and is especially a common practice for competition horses, even though the quality of forage has significantly improved (Lindberg, 2013).

The stomach of the horse is relatively small (8-10 l in a 500 kg horse), which means that the gastric storage capacity is lower than other animals species of similar size (Kohnke, 1992). The relativity small stomach is one of the factors causing feed to pass rapidly through to the small intestine, and the short pre-digestion of feed leads to limited digestion of starch. Concentrates often has a larger percentage of starch, compared to forage (Gleerup, 2020). It is recommended that horses are given a maximum of 100 g of starch per 100 kg BW of the horse per feeding, and a maximum total of 200 g of starch per 100 kg horse per day (Hoffman, 2013). Hence, a 550 kg horse should not receive more than 3 kg of concentrate pr. day, if it is approximately 37% starch in the concentrate (Gleerup, 2020).

2.1.3 Energy in horse feed

Equids need energy for all basic functions of life. Energy is obtained from micronutrients in the feed, i.e. carbohydrates, fat, and proteins. The nutritional composition in feed and the digestibility varies, which has an impact on the digestible energy content of the feed (Table 1). Harvest time has a major influence on energy content of forage. As the plant grows and develops the fibre percentage of the feed will increase, and at the same time the protein and sugar content, and most importantly, the digestibility, will decrease (Müller, 2012). This leads to a decrease in available energy for the horse. The nutrient content is closely linked to the plant species and morphology of the plant (Harries et al., 2016). Legumes for example, usually have a higher protein and calcium content compared to grasses (Harries et al., 2016).

Table 1. Chemical compounds (NDF, Crude protein and Sugar, g/kg DM), and the gross energy content (Gross energy, MJ/kg DM), for timothy haylage cut at four different morphological plant stadiums (Stem elongation, Flowering, Seeding and Late seeding). Data based on Ragnarsson and Lindberg (2008).

	Stem elongation	Flowering	Seeding	Late seeding
NDF	503	593	639	615
Crude protein	175	132	102	93
Sugar	62	62	28	26
Gross energy	19.3	19.3	19.4	19.2

2.1.4 Feeding routines in other countries

A comparative study of feeding routines in major horse nations was done at University of Edinburgh through a questionnaire with 4 548 responders from Sweden, USA, England and Germany (Wilhelmsson, 2017, cited in Gleerup, 2019). In addition, a similar study was done in Denmark with 4 114 responders. Results from these studies are summarized in Table 2.

Sweden had the highest percentage (65%) of forage with analysis, compared to USA (29%), Denmark (21%), England (18%) and Germany (12%) (Wilhelmsson, 2017, as cited in Gleerup, 2019; Gleerup, 2019) (Table 2). In addition to a high level of use of forage with analysis, 34% of Swedish horse owners used feed optimising programs to calculate their horses' diets. In the other countries, fewer horse owners had an analysis of forage available, and 10% or less used feed optimising programs to calculate their horses' diets.

Table 2. Statements and percentages from owner based questionnaires with over 8 600 responders from Denmark, Sweden, USA, England and Germany. Data based on studies by Wilhelmsson (2017) as cited in Gleerup (2019), and Gleerup (2019).

	Denmark	Sweden	USA	England	Germany
Use forage with analysis	21%	65%	29%	18%	12%
Use feed optimising programs	10%	34%	7%	4%	7%
Feeds *ad libitum* forage	27%	29%	54%	51%	39%
Under 6 kg forarge pr. day	16%	3%	8%	15%	8%
More than 3 kg concentrate	16%	5%	15%	9%	22%

When it comes to feeding horses *ad libitum* with forage, the Nordic countries had the lowest percentage (Denmark 27%, and Sweden 29%), while England (51%), and USA (54%), had the highest percentages (Table 2). Sweden has the smallest percentage of horses receiving less than 6 kg forage per day (3%). The highest percentage was in England (15%) and Denmark (16%). With regard to horses fed more than 3 kg concentrate, Germany had the highest percentage with 22%, Denmark (16%) and USA (16%) ended up in the middle, while in England (9%) and Sweden (5%) fewest horses were fed more than 3 kg concentrate pr day.

2.2 Prevalence of under and over condition in horses

Obesity is a large and growing problem in western culture, this also includes obesity in horses. When investigating mature Icelandic horses in Denmark only around 6% had a BCS under 4 on an 1-9 scale, while 24% had a BCS 7-9 (Jensen et al., 2016). Furthermore, 62% of riding school horses studied in Sweden had a BCS greater than 6 (Yngvesson et al., 2019). Among horses over 20 years studied in Sweden, 21% were defined as overweight (BCS 4) or fat (BCS 5) on a 0-5 scale (Müller and Lindberg, 2020). Thirty one percent of 797 horses were reported by owners as fat (5) or very fat (6) on an 1-6 scale in a BCS survey in Great Britain (Ireland et al., 2013). At the end of the winter, 27% of hobby horses investigated in UK had a BCS of 7-9 on a 1-9 scale (Giles et al., 2014). Of 300 light breed horses in Virginia, USA, 51% were over conditioned or obese (BCS over 6, on a 1-9 scale) and only 2% had a BCS under 4. (Thatcher et al., 2008). When assessing BCS in 319 pleasure riding horses in South-West Scotland, 45% was body condition scored as fat or very fat (on an 1-6 BCS scale), while only 2% was defined as in poor condition (Wyse et al., 2008). Owner reported scores from UK scored 20.6% of 158 horses as overweight (Stephenson et al., 2011). For leisure horses competing at an unaffiliated championship in the UK, 62% had a BCS 6 or over, and were categorized as overweight, fat or obese, 21 % had BCS 7 or higher (BCS scale 1-9) (Harker et al., 2011).

2.3 Consequences of different body condition

2.3.1 Health risks linked to body condition

Excess adipose tissue in equines can lead to health challenges for the horse, because of its endocrine and metabolic properties (Carter and Dugdale, 2013). Equine adiposity has been related to multiple clinical conditions such as insulin dysregulation (Geor, 2008; Reynolds et al., 2019; Fonseca et al., 2020), equine metabolic syndrome (Geor, 2008; Harris et al., 2020), adipose tissue dysfunction (Reynolds et al., 2019; Daradics et al., 2021), and low-grade inflammation (Zak et al., 2020). Overweight horses are also more vulnerable to develop laminitis, and obesity also reduces the chance of survival if laminitis occurs (Frank et al., 2010; Lane et al., 2017). It is suggested that obesity in horses cause accumulation of adipose tissue around important organs like kidneys and the heart, which may reduce the organ's function (Burrows et al., 2017). The added weight carriage from obesity may be straining on structures within the lower limb such as joints, the suspensory ligament and the navicular bursa and related structures (Patt-Phillis and Munjizun, 2023). It is proven that overweight canines are more prone to develop arthritis, partly due to increased loading of the joints over time (Bockstahler et al., 2009). Likewise, there is reason to believe that adiposity increases the risk of arthrosis in horses. In fact, when investigating 1528 horses and ponies in Maryland, USA, arthritis was the most frequent (31.8%) condition within over-conditioned horses (Jaqueth et al., 2018). Wyse et al. (2008) also related high BCS to the development of osteoarthritis. Consequently, keeping horses in a moderate condition and in energy balance may prolong their athletic careers, life quality, and life itself.

Low BCS have been associated with negative health and welfare concerns for the horse. Low BCS can reflect malnutrition, and lack of important micro and macro nutrients may influence not only the horse's energy status, but also important body functions. It is important to note that some adipose tissue is central for a horse's welfare and health. Adipose tissue is a valuable energy store, and storage for fat-soluble vitamins (Carter and Dugdale, 2013). Fat helps isolating the body, protects organs, and fat tissue is also important for it's contribution to glucose homeostasis.

2.3.2 Reproduction and body condition

Too low or too high BCS of horses are linked to low fertility. Mares with a BCS <4.5 had a lower pregnancy rate than horses with a higher BCS (Henneke et al., 1984). High BCS (>7) may also cause reproductive challenges for mares, with higher rates of anovulatory follicles, prolonged luteal phases and longer inter-oestrous intervals (Vick et al., 2006). Obesity appears to keep mares in a continuous cycle during the winter months, preventing the mares from entering anoestrus (Fitzgerald et al., 2002). Not much research has been done regarding fertility in stallions in relation to body condition, but there is cause to believe that a stallion kept under- or over-conditioned will increase the risk of infertility (Lawrence, 2013). Because the reproduction season for a stallion might imply physical strenuous work it is normal for a stallion to lose some weight during this period. Therefore, a stallion with tendencies of dropping below the moderate BCS (<4) should begin the season with a BCS above 6 (Lawrence, 2013).

2.3.3 Athletic performance and body condition

Adiposity results in a higher workload in horses due to the excess weight. It has been suggested that one body condition score point on an 1-9 scale corresponds to approximately 20-25 kg of fat (Patt-Phillis and Munjizun, 2023). This means that a horse with a body condition score of 7-9 might have up to 50-100 kg of added weight compared to a horse with the moderate BCS of 5.

Body condition scores that are either too high or too low are shown to have negative effects on athletic performance. Lawrence et al. (1992) found that the horses completing in an endurance race (241 km) and finishing in the top 7 had a significantly lower BCS than the horses placed later in the race (BCS 4.4 vs. 4.8 on an 1-9 scale). However, too low body score may also cause poor athletic performance. Horses that were disqualified for metabolic reasons in a 160 km race had a lower BCS than the horses finishing the race (BCS <3.5 vs. 4.5 on an 1-9 scale) (Garlinghouse et al., 1999). All horses with a BCS between 5 and 5.5 finished the same 160 km race and had the highest competition rates, while horses with a BCS <3.0 did not complete the race (Garlinghouse and Burrill, 1999; Garlinghouse et al., 1999).

A decrease in athletic performance is also observed in horses with a high BCS due to the increased work effort of carrying extra weight (Lawrence et al., 1992). The insulating effects of fat tissue combined with reduced surface area to bodyweight in overweight horses may lead to heat stress. Webb et al. (1990) found that horses with a BCS of 7.5 (of 9) had increased difficulties with disposing of body heat in hot or humid environments. This was because the horses' primary source of heat loss is evaporation when blood flow distributes heat to the skin surface, and produce sweat which evaporates (McCutcheon et al., 1999). When a horse is in work, muscle contractions lose up to 60% of metabolized energy as heat and not to mechanical work (Hodgson et al., 1994).

Thornton and Persson (1986) equipped racehorses with 10% additional weight, which resulted in a 15% higher oxygen consumption under a treadmill exercise test. Also, in Thoroughbred horses race time significantly increased when the horses put on more than 10 kg of body weight in the fall (Cho et al., 2008). There also seems to be an influence of weight (additional fat) on race performance in Standardbred horses, where horses with a lower body fat percentage reached a higher $VO2_{max}$, compared to horses with a higher fat percentage (Kearns et al., 2002). Leleu and Cotrel (2006) found that standardbred horses with a higher body fat content were slower than horses with less body fat.

2.3.4 Ideal body condition

The original body condition score study of Henneke et al. (1983) concluded that the BCS of 5 (on a 1-9 Table) would be the most optimal, where BSC 4-6 (moderate thin to moderate fleshy) is within the recommendations. The chapters above (2.6.1 Health risks linked to body condition score and 2.6.3 Athletic Performance) describe a decrease in athletic performance and an increased health risk at the upper and lower end of the BCS scale. Because of this it is recommended to categorise horses with a BCS < 4 as underweight, BCS 4-6 as moderate, BCS > 6 as overweight, and BCS > 7 as obese (Kohnke, 1992). It should be an aim to keep a horse in a BCS between 4 and 6. The ideal body condition and the consequences of underweight or overweight may vary with the use and breed of the horse, but the suggested recommendations are a good, general guideline to follow for optimal health and performance.

2.4 Assessment of body weight and body condition

Assessment of the body condition and body weight (BW) of horses are tools to keep track of individual condition changes. Changes or stability in the horses' body condition and/or weight are informative when it comes to the nutritional status and feeding planning. A stable BCS is an indicator of a stable energy balance. A positive or negative energy balance will give weight change and changes in adipose tissue, and hence, the body condition will change. A horse's BW can be assessed by use of direct or indirect measurements.

2.4.1 Direct measurement of body weight

The most precise method to measure the BW of horses is to use a calibrated horse weight scale, which gives a true, direct measurement. Correct calibration and levelling of the weight is essential to provide an accurate weight of the horse. If the BW is used for comparison of biological feeding parameters, the recording of weight should be done with the same weight and at the same time of day with regard to when the horse is fed and exercised. This is because the BW fluctuates up to 5 % after 18-20 hours starvation due to the water and feed intake, hydration status, urination, and defecation (Webb and Weaver, 1979). This means that the BW can fluctuate with 25 kg for a 500 kg horse. Most horses do not stay 20 hours without food, but this demonstrates how the weight may differ with regard to the animal's daily activity.

2.4.2 Indirect measurements of body weight

Mainly due to practical reasons, the BW of horses is most often estimated using morphometric body measurements. Indirect measurements, such as using weight tapes or tape measuring and formulas, are easy and portable methods to estimate BW, but is less accurate than direct measurements. Over the last half century, different formulas, methods and measurements for indirect weight estimation have been suggested. An indirect measurement formula may use only the measurement of the horse's girth circumference, and these formulas were developed about eighty years ago (Marcenac and Aublet 1964, cited in Carter and Dugdale, 2013). Other formulas use both girth circumference and body length assuming that the body can be compared to the volume of a cylinder (Milner and Hewitt 1969). Further, more complex formulas have been developed. As an example, a formula for BW estimation was published by Carroll and Huntington (1988), including girth circumference, neck circumference, hight and length. Indirect measurements of weight are easy to use anywhere and require little equipment. However, these methods may be inaccurate, especially for horses with extreme BW, body composition and conformation (Carter and Dugdale, 2013).

2.4.3 Measurements of adipose tissue

Body weight alone without morphometric measurements, is not helpful for assessing relative body condition or adiposity. Morphometric measurements are used to estimate relative adiposity. This method is used to compare relative adiposity among or for individual horses and can help tracking changes in adiposity in a horse over time. When using this method, the body circumference is compared to the body size, based on the assumption that the increase in circumference is due to a growth in fat mass. This theory is supported by a study where 32 quarter horses were investigated (Henneke et al., 1983). The study found that the ratio of girth circumference to withers hight was moderately correlated with the body condition score (BCS) (r^2=0.51) and body fat percentage (r^2=0.44). The morphometric measurements with added BW were converted into a weight scale, to describe the BW relative to the horses' size.

2.4.4 Ultrasonic measurement of subcutaneous fat

Ultrasonic measurement of subcutaneous fat depth of the rump of the horse is used to estimate the body fat percentage of the horse (Carter and Dugdale, 2013). This is possible because of the difference in density between muscle and adipose tissue. If multiple ultrasonic scanning's are performed, it is possible to track changes in fat depth over time. This is a method less influenced by bias than for example body condition scoring (described under) as it can describe small changes in subcutaneous fat depth and quantify the regional distribution of fat tissue. However, for a more general use, there are also obvious downsides to ultrasonic measurements of subcutaneous fat depth because of the need of an ultrasound instrument. Also, this method does not measure visceral or intramuscular fat depots, ultrasonography. The ultrasound does only measure subcutaneous fat. Therefore, the total body fat percentage calculations might be inaccurate due to the methods generalizing fatness from a single fat deposit.

2.4.5 Body fat percentage

Total body water is used to determine the total of fat-free and fat mass in the horse. This provides the opportunity to calculate body fat percentage. The most common way to calculate total body water in horses is by deuterium oxide dilution. Deuterium oxide is administered through a nasogastric tube or intravenously, and blood samples are collected before administration and after 2 to 7 hours. In principle, the isotope deuterium oxide equilibrists into all body water space, but not into lipid compartments. This makes it possible to calculate total body water according to the isotope administered compared to the concentration in plasma. Knowing that in adipose tissue the triglyceride content is anhydrous and given the assumption that fat-free tissue contains 73.2% water, it is possible to calculate the fat-free body mass and therefor also the fat mass (Wang et al., 2000). It is also necessary to have a weight scale for accurate measurement for the calculations of mass.

2.4.6 Body condition scores

Body condition scoring (BCS) is a subjective assessment of adiposity and is the most used method for categorising the horse's fat deposits. Performed by a trained examiner, the body condition scoring would be a repeatable assessment of adiposity as shown by Carroll and Huntington (1988). Palpation and visual inspection are used to assess the horses' subcutaneous fat, with focus on specific regions. Each region is graded on a numerical scale according to specific criteria. A horse with excess fat deposits, due to a positive energy balance over time can lead to a high BCS. Contrary, a horse in negative energy balance over time can use its fat storage as energy source and therefore get a lower BCS. Body condition scoring is easy to perform and can be integrated to all body areas of the horse. It is a reliable tool to classify horses into underweight, normal, overweight or obese categories. Also, cut off values to imply risks of disease are accessible.

There are, however, some challenges with body condition scoring systems. Body condition scoring only assesses subcutaneous fat, therefore it gives no reliable information on adipose tissue around organs. Because of large measurement increments, it is difficult to determine small differences, even though some studies give half body condition scoring points. The perception of adiposity could also be influenced by coat length, gut fill, muscle mass, pregnancy, etc.

There are three main body condition scoring systems, Henneke et al. (1983) 1-9 scale including different adaptions, Carroll and Huntington (1988) 0-5 scale (an adaption of Webb and Weaver (1979) 1-6 scale) and Carter et al. (2009) cresty neck score 0-5 scale.

2.5 The original body condition scoring 1-9 scale

To have a standardized, consistent, and comparable system that accurate can compare stored body fat in horses Henneke et al. (1983) developed a body condition scoring system. This system used a scale providing body condition scores (BCS) from 1 to 9. A horse with score 1 is an individual being extremely emaciated and score 9 is given to horses that are extremely obese (Appendix 1). Horses given a BCS ≤ 3 are to be considered thin, while horses given a BCS ≥ 7 are to be considered obese (Figure 2). Horses are often divided into three grouped based on their BCS, under conditioned (BCS 1-3), normal conditioned (BCS 4-6) and over-conditioned (BCS 7-9). Six regions on the horse body are assessed. These are the neck, withers, lumbar spinous processes (loin), tailhead, ribs and the area behind the shoulder (Figure 2). These areas were chosen because they are considered indicative of changes in adipose tissue in horses. The description and arguments for each region of the horse scored is given in full text, and the horse receives only one total BCS.

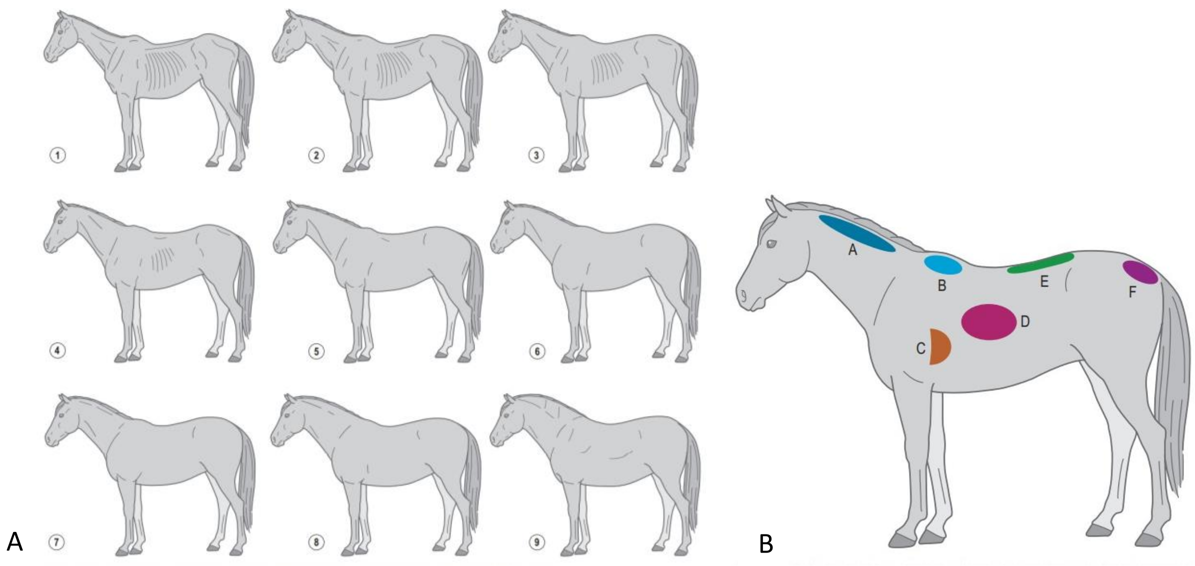

Figure 2. A: Illustrations of individual body condition scores as described by Henneke et al. (1983). Figure A obtained from Carter and Dugdale (2013) p. 398. B: Location of subcutaneous adipose depots over the six bodily areas assessed by body condition according to Henneke et al. (1983). A: neck; B: withers; C: behind the shoulder; D: ribs; E: loin; F: tailhead. Figure B obtained from Carter and Dugdale (2013) p. 396.

2.5.1 Adaptations of the original 1-9 scale

Henneke BCS system was developed on pre-parturient Quarter horse broodmares, and it is discussed whether the system is best adaptable for Quarter horses, Thoroughbreds and Arabians at adult size (Carter and Dugdale, 2013) because these lighter breeds in many ways share the same body type and fat deposits. Therefore, different adaptions of Henneke et al. (1983) were made to fit other breeds of horses, not only the Quarter horse. Kienzle and Schramme (2004) modified the BCS to fit the Warmblood breeds (Appendix 1), and other adaptions to the original was made to suit Thoroughbred geldings (Suagee et al., 2008). Alterations done by Kohnke (1992) have been used in multiple studies on a broader range of different breeds, such as Arabian endurance racehorses (Garlinghouse and Burrill, 1999), Thoroughbred horses (Fowler et al., 2020), Icelandic and Warmblood horses (Jensen et al., 2016, Jensen et al., 2019) and in ponies (Dugdale et al., 2011).

2.5.1.1 Adaptations by Kohnke (1992)

When Australian veterinary John Kohnke wrote a book about feeding and nutrition for owners of all major horse types, he presented adaptations to Henneke et al. (1983) body condition scoring system. Kohnke's system was developed to be easy to follow for all, not only professionals, and meant to be applicable to all horse breeds. The six regions (neck, withers, loin, tailhead, ribs and shoulders) are individually scored and averaged to give the condition score. Kohnke's description of the method is to first inspect the region visually and thereafter palpate for fat for every region. All criteria for scores per region are simply described (Table 3).

Table 3. Characteristics of individual body condition scores for all horses as described by Kohnke (1992).

BCS	Condition	Neck	Withers	Loin	Tailhead	Ribs	Shoulder
1	**Very poor**	Individual bone structure visible	Bones easily visible. No fat	Spine bones visible. Ends feel pointed	Tailhead & hip bones very visible	Ribs v. visible & skin furrows between ribs	Bone structure v. visible
	Animal extremely emaciated; no fatty tissue can be felt						
2	**Very thin**	Bones just visible. Animal emaciated.	Withers obvious, very minimal fat covering	Slight fat covering over vertical & flat spine projections. Ends feel rounded.	Tailhead, hip bones obvious	Rib prominent, slight depression between ribs	Bone structure can be outlined
3	**Thin**	Thin, flat muscle covering	Withers accentuated with some fat cover	Fat build-up halfway on vertical spines, but easily discernible. Flat spinal bones not felt	Tailhead prominent. Hip bones appear rounded but visible. Pin bones covered	Slight fat covering over ribs. Rib outline obvious	Shoulder accentuated, some fat
4	**Moderate thin**	Neck some fat, not obviously thin	Withers not obviously thin, smooth edges	Slight ridge alone back	Fat can be felt	Faint outline visible	Shoulder not obviously thin
5	**Moderate**	Neck blends smoothly into body	Withers rounded over top	Back level	Fat around tailhead beginning to feel spongy	Ribs can't be seen but can be easily felt	Shoulder blends smoothly into body
6	**Moderate fleshy**	Fat can be felt	Fat can be felt	May have slight inward crease	Fat around tailhead feels soft	Fat over ribs feels spongy	Fat layer can be felt
7	**Fleshy**	Visible fat deposits along neck	Fat covering withers is firm	May have slight inward crease down back	Fat around tailhead is soft and rounded off	Individual ribs can still be felt	Fat build up behind shoulder
8	**Fat**	Noticeable thickening of neck	Area along withers filled with fat	Crease down back evident	Tailhead fat v. soft and flabby	Difficult to feel ribs	Area behind shoulder filled in flush with body
	Fat deposits along inner buttocks						
9	**Extremely fat**	Bulging fat	Bulging fat	Obvious deep crease down back	Bulging fat around tailhead	Patchy fat over ribs	Bulging fat
	Fat along inner buttocks may run together. Flank filled in flush						

2.5.1.2 Adaptations by Kienzle and Schramme (2004)

The adaptions done to fit the warm-blooded breeds, investigates slightly different regions of the horse compared to the original Henneke et al. (1983) (Appendix 1) (Kienzle and Schramme, 2004). The withers as used as a region in Henneke et al. (1983) is replaced with hips. Hips and the buttocks are described as markers in the ordinal Henneke et al. (1983), but not as separate individual scoring region, such as in the Kienzle and Schramme (2004) adaption. The adaptation done by Kienzle and Schramme (2004), has more detailed descriptive, specific, and numerical criteria for each score per region compared the original. Also, this adaption uses more anatomical landmarks, like the palpability of specific ribs and quantitative measurements of crest neck fat.

2.5.1.3 Adaptations by Suagee et al. (2008)

Suagee et al. (2008) did adaptions to Henneke et al. (1983) to fit their study on Thoroughbred horses. However, this adaption does not vary greatly from the original. The same regions are investigated (neck, withers, shoulder, rib, loin and tailhead), but in a different order than the original (Appendix 1). It can be discussed if the order can affect the result, Kohnke (1992) specifies the order in his adaptative description. Also, the description of characteristics for each point for each region in the adaptations by Suagee et al. (2008) is more detailed, compared the original Henneke et al. (1983). This makes it easier to replicate, because of the specific anatomical markers.

2.5.2 Body condition scoring 0-5 scale

Another type of body condition scoring system is using a 0-5 scale. On the 0-5 scale body condition scoring 0 is very poor, 2 moderate, 5 is very fat (Appendix 1). This body condition scoring scale was first described by Leighton-Hardman (1980), and later adapted by Carroll and Huntington (1988), which is the most used 0-5 scoring system. The 0-5 scale is a simpler version than the 1-9 body condition scoring systems. Carroll and Huntington (1988) investigated and scored three regions (neck, back and ribs scored together, and pelvis), where points vary from 0-5. The smaller scale provides fewer scoring options and may lead to lower accuracy. If the pelvis score differs by 1 or more points from the back or neck point, the pelvis score is adjusted by 0.5 points to obtain the overall BCS. This might indicate a less precise BCS than the 1-9 scale. However, this 0-5 system could be as useful depending on what the goal of the study or investigation. As with Henneke et al. (1983) there are several adaptations of this 0-5 system (Webb and Weaver, 1979; Carroll and Huntington, 1988; Wyse et al., 2008).

2.5.3 Cresty neck scoring 0-5 scale

Carter et al. (2009) developed what they describe as a more objective, yet easily obtained measurement of adiposity. It was stated that fat deposits along the neck (chesty neck), has been associated with altered metabolic state giving an increased risk of laminitis. They therefore developed a standardized scale to identify and categorize neck crest accumulation of adipose tissue of the horse and ponies, independent of overall adiposity. When applying the cresty neck score in addition to body condition scoring system, the cresty neck score can be compared to the BCS of the horse. This is why cresty neck scoring might be a good tool for identifying risk groups, in particularly metabolic related illness for horses that are not generally obese (Carter and Dugdale, 2013). Visualisation and palpation of the horse's crest of the neck is done and given a score between 0 and 5 (Appendix 1) (Figure 3).

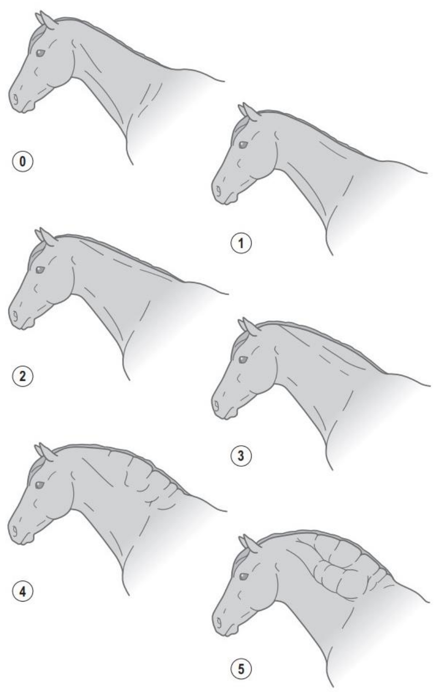

Figure 3. Illustration of individual cresty neck scores as described by Carter et al. (2008), obtained from Carter and Dugdale (2013) p. 401.

There are many ways to quantify BW of the horse, and the weight scale is the most accurate method. Although, weight says little about the horse's body condition or adiposity, this can be determined through different systems. Due to being easy to follow and an understandable scoring system developed for all horses, is probably why the Kohnke (1992) adaption is widely used in studies, and therefore also used in the present study.

3. Material and methods

3.1 Study design and horses

The present study was designed as a cross-sectional study. The studied horses were from the Equine Hospital at NMBU in Southern Norway, and from different stables in Viken (n=18) and Trøndelag (n=10). Horses at NMBU were studied from mid-September to mid-December 2022. This period consisted of 23 test days where the same person, the author, body condition scored all the horses for a consistent and standardized data collection throughout the study. The horses included at NMBU were horses visiting the clinic for short examinations such as control appointments or shoeing, and horses stabled at the hospital for longer periods. Lactating mares and unweaned foals were not included in the study.

In addition, the 28 independent stables were visited from mid-November 2022 to early January 2023. The author's network was used to recruit horses to the field study. All private stable owners and horse owners were contacted by phone or in writing before the horses were studied. Between 3 to 17 horses were examined at each stable.

A total of 424 horses were body condition scored consisting of 144 horses at NMBU and 280 horses in the private stables in the field (Table 5). Information about horses' gender, age, breed, use and health status, and weight were collected as illustrated in the sections below. The total number of horses studied consisted of 219 geldings, 158 mares and 37 stallions, with ages from 6 months to 29 years.

Table 4. Overview of the number of studied horses at the Equine Hospital at NMBU and in private stables (Field), sorted accorded to gender (Geldings, Mares, Stallions) studied from September 2022 to January 2023.

Location	Gelding	Mare	Stallion
Field	154	106	20
NMBU	65	62	17
Total	**219**	**168**	**37**

3.1.1 Grouping horses according to age

Horses were divided into seven age groups based on physiological development, 6 mnth-3 years (n=34), 4-5 years (n=76), 6-11 years (n=88), 11-15 years (n=112), 16-20 years (n=74), horses older than 20 years (n=25), and horses with unknown age (n=15) (Figure 4). The 15 horses with unknown age in the present study were excluded when investigating the influence of age on BCS. The mean age was 11 years (±6.0 years). When sorting the individuals in age groups, the largest age group, for those studied at NMBU and in the field, were between 11 and 15 years old (26%).

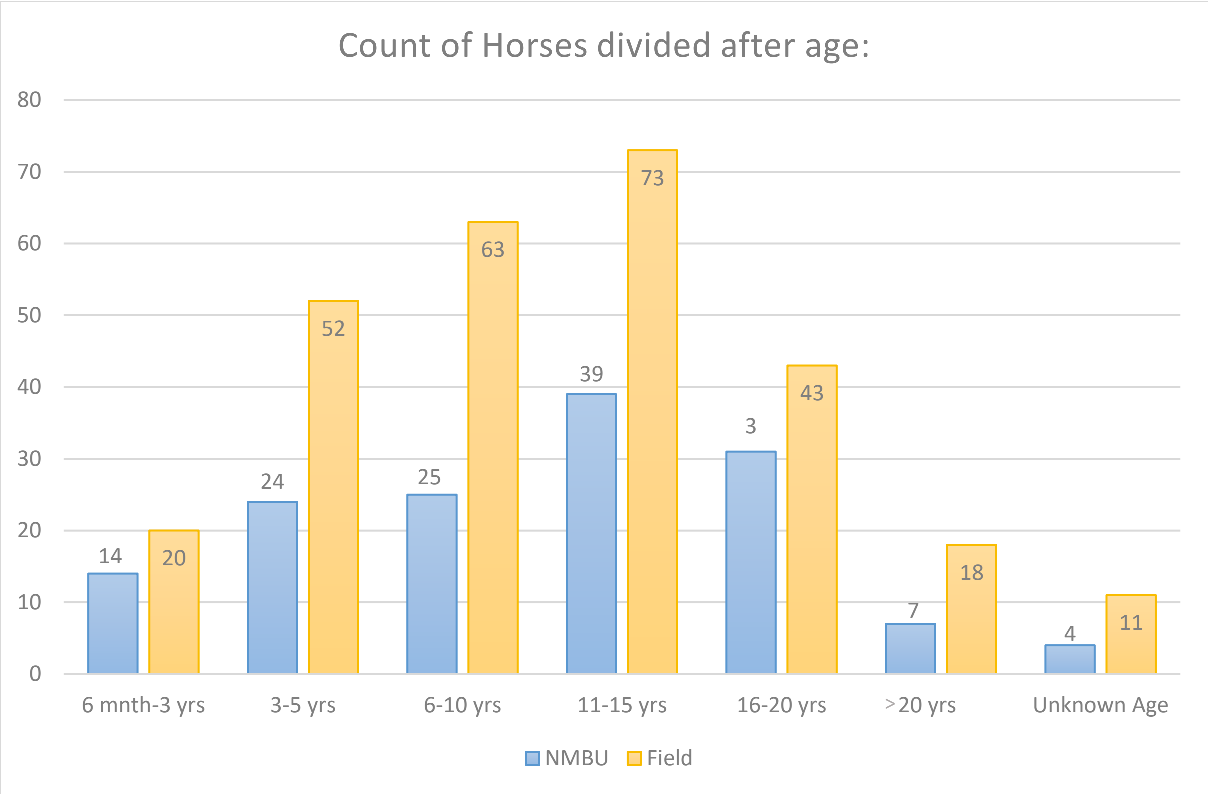

Figure 4. The age distribution of horses at NMBU and in the field studied for body condition score from September 2022 to January 2023.

3.1.2 Grouping horses according to breed

All horses were divided into two major groups, Warm-blooded breeds (n=314) or Cold-blooded breeds (n=110) (Table 6). Breeds categorised as Warm-blooded breeds were Warmblood riding horses, Standardbreds, Sports ponies and Other warm-blooded horses.

Breeds categorised as cold-blooded breeds were Icelandic horses, Cold-blooded trotters, Norwegian fjord horse, Dølahest and Other cold-blooded horse breeds.

All the different breeds at NMBU and in the field were included in the study, this was done to study variations among horse breeds. Warmblood riding horses (n=194), Standardbred (n=58), Sports ponies (n=39), Icelandic horses (n=30), Cold-blooded trotters (n=29), Norwegian fjord horse (n=13), Dølahest (n=12), and other horse breeds (n=49) were investigated (Table 6). Horses of other smaller groups of breeds were divided into the two groups, other warm-blooded breeds or other cold-blooded breeds.

Other warm-blooded breeds consisted of American curly, Arabian horses, Thoroughbred, American saddle breed and Quarter horses. Other cold-blooded horse breeds consisted of Haflinger, Andalusian (PRE), Shetland pony, Welsh cob, Gypsy Cob, Nordlandshest/Lyngshest, Friesians and Gotland Russ.

Table 5. Overview of the number of Warmblood riding horses (WBRH), Standardbred (STB), Sports ponies (SP), Other warm-blooded horses (Other warm), Icelandic horses (ICEH), Cold-blooded trotters (CBT), Norwegian fjord horse (NFH), Dølahest (DH) and Other cold-blooded horse breeds (Other Cold) studied at the Equine Hospital at NMBU and in private stables (Field) from September 2022 to January 2023.

Breed	Total N	NMBU N	Field N
WBRH	194	59	135
STB	58	15	43
SP	39	13	26
Other Warm	23	11	12
Total warm	314	98	216
ICEH	30	15	15
CBT	29	11	18
NFH	13	5	8
DH	12	8	4
Other Cold	26	7	19
Total Cold	110	46	64
Grand Total	**424**	**144**	**280**

3.1.3 Grouping horses according to use and health status

3.1.3.1 Activity status

Horses were divided into broad groups based on health status and activity level. This was done to investigate if injured horses had a different BCS than horses perceived as healthy by the owner (Table 7). Horses were categorised as injured (n=72), active (n=204), not active (n=120), or digestive (n=28) (Table 8).

Table 6. Criteria for active status for horse's body condition scored at NMBU and in the field (n=424) from September 2022 to January 2023. Groups were divided into categories based on active status: Injured, active, not active, or digestive.

Group	
Injured	Longer period and shorter time/Acute
Active	Horses competing or training for competition in disciplines jumping, dressage, Icelandic gait competition or trotting
Not active	Horses not competing or training for competition, hobby horses, breeding and school horses
Digestive	Horses with digestive injuries, teeth or jaw related injuries or horses with colic related disease

Table 7. The number (count) of horses in the discipline or functional groups teeth, colic, short time, period, trotting W, jumping, dressage, Icelandic gait competition (ice), trotting C hobby, school, and breeding studied at NMBU and in the field from September 2022 to January 2023.

Activity status	Category	Count of BCS:
Digestive	**Teeth**	**11**
	NMBU	11
	Colic	**17**
	NMBU	17
Injured	**Short time**	**33**
	NMBU	33
	Period	**39**
	NMBU	39
Active	**Trotting W**	**41**
	Field	36
	NMBU	5
	Jumping	**98**
	Field	88
	NMBU	10
	Dressage	**46**
	Field	35
	NMBU	11
	Ice	**5**
	Field	4
	NMBU	1
	Trotting C	**14**
	Field	8
	NMBU	6
Not Active	**Hobby**	**94**
	Field	84
	NMBU	10
	School	**22**
	Field	22
	NMBU	0
	Breeding	**4**
	Field	3
	NMBU	1
	Grand Total	**424**

3.1.3.2 Use and health status

All horses of all the uses and health statuses were studied to achieve a representative overview of the horse population at the studied locations. Horses investigated varied from horses competing in high level dressage, show jumping and trotting competitions to recreational horses stabled in loose housing system in herds (Table 8).

The owners or person responsible defined the horse's use and discipline; hence, no minimum level of competition results was required for horses to be classified as dressage, show jumping, trotting or Icelandic gait competition. The requirement was that horse was competing or training for competition in the specific discipline.

Horses were visiting NMBU for a variety of reasons and were sorted into groups based on the cause for the visit (Table 9). Horses scored at NMBU were placed in only one group based on the type of injury, sickness, functionality, health or use. Horses that had been out of normal use for a longer period were grouped together. Horses with acute and new injuries were also grouped. Horses with acute or new injuries were sorted according to the use stated in the questionnaire about feeding routines. If the use was not stated horses were grouped as "short time". Horses with injuries influencing feed intake or digestion were grouped, either as horses with teeth and jaw related injuries or sickness, or horses with colic related sickness. These horses were grouped together, because one may anticipate that their health condition may quickly influence (reduce) the horses BCS.

Table 8. Criteria for Use and health status for horses visiting NMBU September 2022 to December 2022. Groups are divided into categories based on functionality, injuries and time of injuries. Categories are: Teeth, colic period, short time, and use.

Group	Cause
Teeth	Horses that are in the clinic because of teeth or jaw related injuries
Colic	Horses that have colic, colic surgeries or are in observation after a colic
Period	Horses that have been out of normal use. Example controls of lameness, CT-scanning, x-ray, ultrasound, cancer, complications after surgery, abscess and horses included in an equine metabolic syndrome study
Short time	Scheduled operations as osteochondrosis dissecans removal or castration, wound, nosebleed (still working horse)
Use	Horses admitted for short, planed visits and where the horses daily use (discipline) is known to the author were grouped together with horses with the same daily use instead of in short time grope. Reasons for the visit were: control before sale, shoeing and horses in normal activity when visiting NMBU

When pooling all horses studied, most of the horses, at NMBU and in the field, were classified as show jumping horses (n=98) and recreational horses used for hobby (n=94), followed by dressage horses (n=46) and Standardbred horses trotting (n=41) (Table 7). There were 39 horses with injuries or sickness lasting over a period, 33 horses with injuries of shorter duration, 17 horses that had colic, 14 horses competing or training for cold-blooded trotting. The smallest groups were breeding (n=4), Icelandic gait competition (n=5) and horses with teeth and jaw injuries (n=11) (Table 8).

3.1.3.3 Warm-blooded horses competing in show jumping, dressage and trotting

To study differences among warm-blooded horses competing in different disciplines, these horses were divided into groups where the criteria were Warmblood riding horses competing or training for competition in show jumping (n=83), Warmblood riding horses competing or training for competition in dressage (n=37) and Standardbred competing or training for competition in trotting (n=41).

3.1.3.4 Gender of use and health status

All three genders were represented inn all studied use and health groups, except for stallions which was not represented in the group of school horses and horses for teeth and jaw treatments at NMBU. Geldings were naturally not represented in the group of breeding horses, and mares were not represented in the group of Icelandic horse used for competitions (Figure 5). The proportion and number of individuals of different genders varied among the disciplines and groups (Figure 5). In the largest groups of individuals, there were most geldings among horsed used for dressage (67.3%), hobby (59.6%), and show jumping (59.2%).

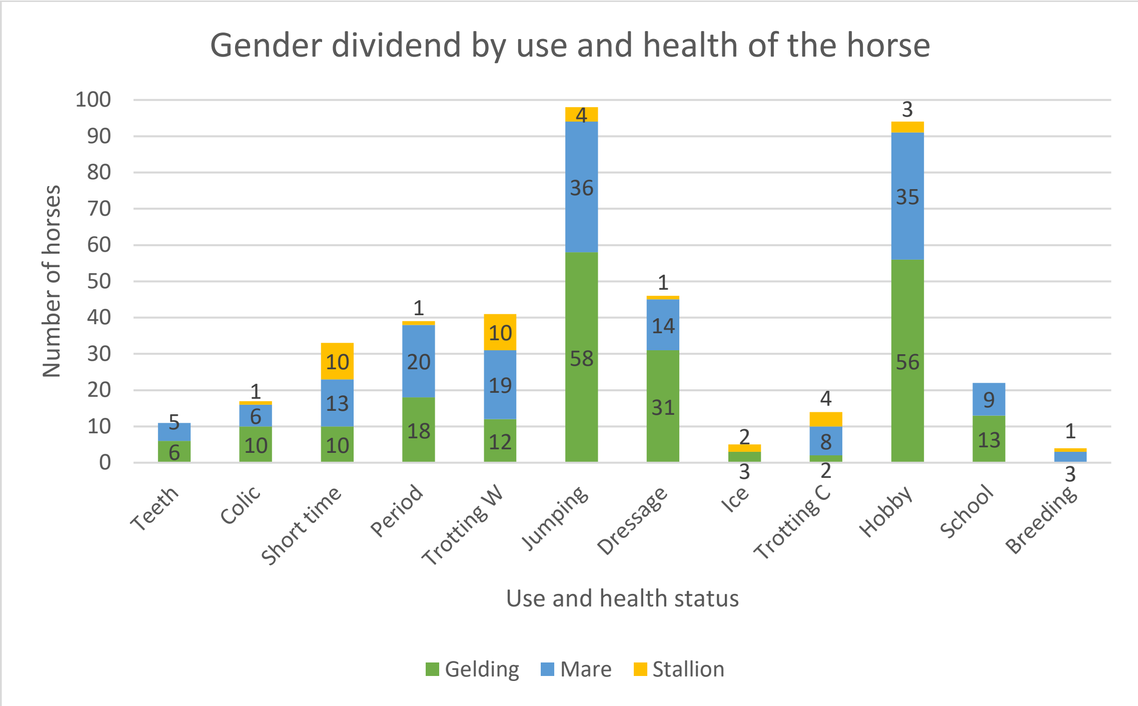

Figure 5. The gender distribution by use and health status of horses at NMBU and in the field studied for body condition score from September 2022 to January 2023.

3.1.3.5 Breeds of use and health status

The breeds consisted of a mixture of different disciplines and functional groups, except for the groups which where breed-specific i.e., Icelandic gait competition (Ice), trotting for Cold-blooded trotters (trotting C) and trotting for Standardbreds (trotting W) (Figure 6). The Warmblood riding horses were largely represented in show jumping (n=83), dressage (n=37) and in hobby horses (n=27).

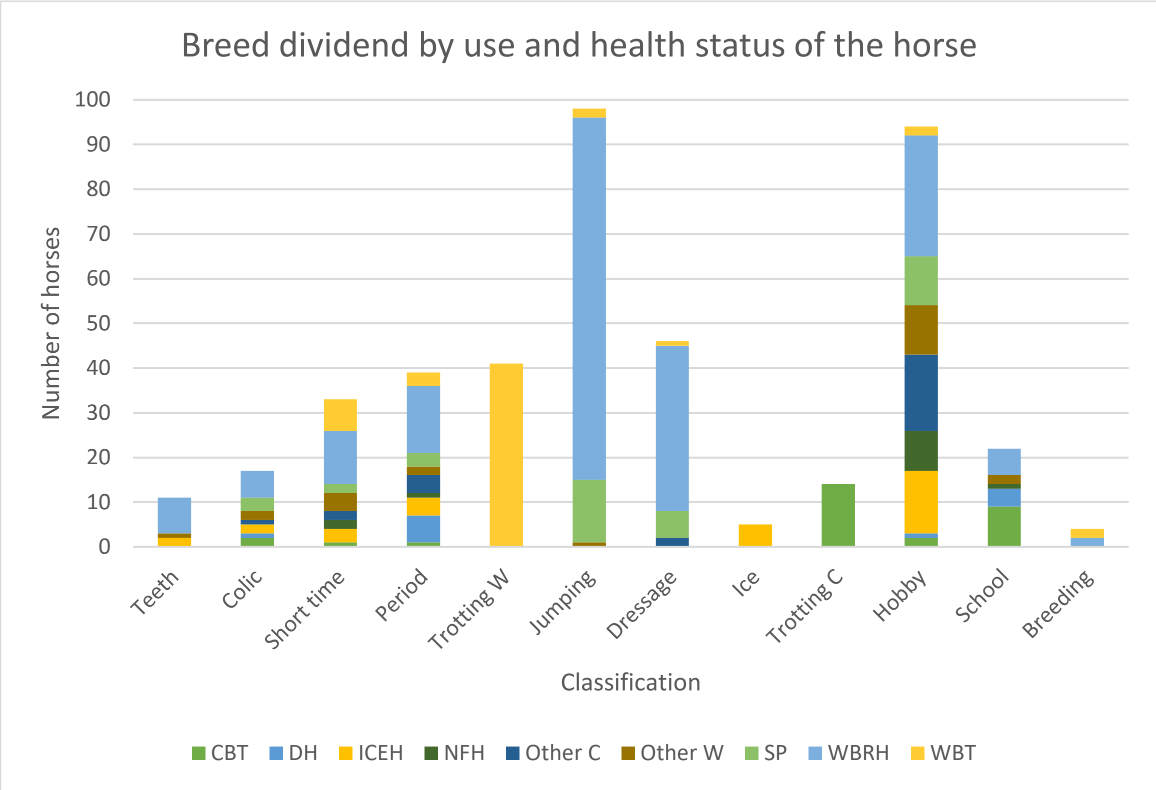

Figure 6. Number of horses of different breeds in use and health status Cold-blooded trotters (CBT), Dølahest (DH) Icelandic horses (ICEH) Norwegian fjord horse (NFH), Other cold-blooded horses (Other C), Other warm-blooded horses (Other W), Warmblood riding horses (WBRH), Sports ponies (SP), Warmblood riding horses (WBRH), and Standardbred (STB) studied at the Equine Hospital at NMBU and in private stables (Field) from September 2022 to January 2023.

3.1.4 Body weight and body condition score

To get a more accurate prediction of the influence of the BW on BCS the horses were divided into groups. The group criteria were horses within the same discipline and breed. Additionally, the horses needed to be between 5 and 15 years of age. The age interval was chosen because at age 5 the horses have generally reached their adult size. Fifteen years of age was chosen as upper limit because horses often still are active and have most likely not been influenced by old age. The groups were set to include minimum 14 horses.

3.1.5 Questionnaire horses

Out of the 266 questionnaires answered for the horses' body condition, 135 horses were geldings, 106 horses were mares, and 25 horses were stallions. The horses varied in age from 6 months to 29 years, mean 11 years ±6.0 years. Horse breeds included in the questionnaires were Warmblood riding horses (n=113), Standardbred (n=41), Sports ponies (n=20), warm-blooded other breeds (n=17), Icelandic horses (n=23), Cold-blooded trotters (n=22), Norwegian fjord horse (n=10), Dølahest (n=6) and other cold-blooded horse breads (n=14) (Table 10). Other warm-blooded horse breeds consisted of American curly, Arabian horses, thoroughbred, American saddle breed, Quarter horses. Other cold-blooded horse breeds consisted of Haflinger, Andalusian horse (PRE), Shetland pony, Welsh cob, Gypsy Cob, Nordlandshest/Lyngshest, Fresian and Gotland Russ.

Table 9. Horses breed, use and health status according to questionnaires at NMBU and in the field (n=266) from September 2022 to January 2023. Number of horses in the different use and health status and the number of the various breeds withing each group (Cold-blooded trotters (CBT), Dølahest (DH) Icelandic horses (ICEH) Norwegian fjord horse (NFH), Other cold-blooded horses (Other C), Other warm-blooded horses (Other W), Warmblood riding horses (WBRH), Sports ponies (SP), Warmblood riding horses (WBRH), Standardbred (STB) and the total are given.

	Teeth	**Colic**	**Period**	**Trotting W**	**Jumping**	**Dressage**	**Ice**	**Trotting C**	**Hobby**	**School**	**Breeding**	**Total**
CBT								11	1	9		**22**
DH			2							4		**6**
ICEH	1		4				5		12			**23**
NFH									8	1		**10**
Other C			1						11			**14**
Other W	1	2	1		1				8	2		**17**
SP					7	4			9			**20**
WBRH	3	1	3		58	22			17	5	1	**113**
STB			1	35	1				2		1	**41**
Total	**5**	**3**	**12**	**35**	**67**	**26**	**5**	**11**	**68**	**21**	**2**	**266**

The largest groups of horses were hobby horses (n=68) and show jumping horses (n=67), followed by trotting warm-blooded horses (n=35) (Table 10). The smallest groups were breeding horses (n=2), horses with colic related injuries (n= 3), Icelandic gait competition (n=5) and horses with teeth and jaw related injuries (n=5).

3.2 Measurements

The BCS was assessed using the body condition score according to Kohnke (1992) (see chapter 2.5.1.1. and Table 3). The BCS was calculated after separately assessing six different regions of the horse, where each region was given a separate score between one and nine, half points was allowed. The average of the six scores were calculated to determine an overall BCS for the horse. The regions inspected on one side were neck, withers, loin, tailhead, ribs and shoulder (see Figure 2B).

The horse's body weight (BW) was measured using a weight scale (n=398/424). The horses at NMBU were weighted using a stationary weight scale (ICS685g, Mettler Toledo®, Ohio, USA), while the horses investigated in the field were weighted on a portable weight scale (Horse weigh® "Tokyo" EziWeigh; Tru-Test, Wales, UK), with an accuracy of ±1% according to the manufacturer. All BWs were rounded to nearest kg. The weight scale was placed on a hard, flat and horizontal surface to ensure accurate readings.

3.3 Questionnaire of feeding routines

The horse owners were asked to answer a feeding practice survey consisting of 11 questions (Table 4). Based on this, the horse's feeding regime were studied and the percentage of Norwegian produced forage and feed in the horse's ration analysed. All responsible persons for horses visiting the NMBU in the period from September to December got the opportunity to answer the questionnaire, also if the horse was not body condition scored (n=18/266). At NMBU a total of 52 feeding practise questionnaires were obtained, and for 34 (65%) of these, the horse's body condition was scored. Of the 280 horses investigated in the field, the feeding practise questionnaire was answered for 214 (76%) of the body condition scored horses. In total, 266 questionnaires about feeding practise were answered.

The questions asked were designed to be compatible with similar, previous studies in Norway (Vik and Farstad, 2012) and Denmark (Gleerup, 2020). The participants got a check-off form, where boxes were checked off for the appropriate answers. Check-off boxes were used for easy grouping and compressing of information. More than one answer could be checked off pr. question, to achieve the most accurate information. Concentrate amount was quantified in number of litres or kilograms. When the answer for forage and feeding amount were given in intervals (e. g. 13-15 kg forage), the mean value (e. g. 14 kg) was used in calculations and further analysis.

Table 10. Questions asked in the questionnaire used in the present study at NMBU and in the field from September 2022 to January 2023 to gain overview over feeding routines in Norway.

1.	What is the horse's type of use?
2.	If it is a competition horse, what is the horse's discipline?
3.	Are you responsible for feeding and/or planning of the horses feed?
4.	Which type of forage do you feed, and (if known) what is the dry matter content?
5.	How many kilograms forage does the horse get each day?
6.	How many forage feedings does the horse have each day?
7.	Is the forage home produced or is it bought, does the forage have a feed analysis?
8.	Is your horse given additional feed to the forage?
9.	Is your horse fed concentrate from a Norwegian manufacturer, which one?
10.	How much concentrate does the horse receive in a day?
11.	How is the horse's diet decided/calculated?

3.4 Calculations, statistical analysis, and modelling

3.4.1 Calculations

To study dry matter intake (DMI), the DMI was calculated for horses fed forage that was analysed and where the amount of forage and dry matter (DM) were known. Dry matter intake per day was calculated by first calculating the DMI-forage using formula 1:

Formula 1:

Forage in dry matter kilograms = Kilograms forage X Dry matter percentage

Information on the DM was not given for all the concentrate fed horses. For these horses the DMI from concentrate was calculated by using a dry matter constant of 85% (formula 2), which is commonly used as a constant dry matter percentage for stable storage of concentrate over time to avoid the concentrate to be spoiled (Miladinovic, 2021).

Formula 2:

Concentrate in dry matter kilograms = Kilograms concentrate X 85%

Most concentrate amounts were given in litres, which was calculated to kg by using a constant of 0.7 kg/L, the most common relationship between weight (kg) per litre of concentrate fed horses in the present study. Further, the DMI per day was calculated by adding DMI forage and concentrate.

3.4.2 Statistical analysis

The following statistical analysis were calculated in R-statistics software program (R core team, 2022, Vienna, Austria; version 4.2.1) with a significance level set to $p<0.05$.

The effects of location (2 levels), gender (3 levels), age (6 levels), warm- or coldblooded breeds (2 levels), breeds (9 levels), activity status (4 levels) and use and health status (12 levels) on BCS were determined by One Way Anova. To determine different effects on BCS between levels within gender, age, warm- or coldblooded breeds, breeds, activity status and use and health status a Tucky HSD test with a confidence interval of 95%, were performed.

The effects of origin of forage (6 levels), forage type (4 levels) and origin of concentrate (3 levels) on BCS were determined by One Way Anova. The effects of forage amount, dry matter intake and concentrate amount on BCS were determined by a linear models. To determine different effects on BCS between levels of forage origin a Tucky HSD test with a confidence interval of 95% were performed.

Correlations between dry matter intake and BCS, concentrate and BCS, age and BCS, and BW and BCS were calculated using CORREL-formula in Excel (2007, version: 202212). Positive and negative correlations were categorised after its the correlation coefficient as weakly (<0.5), moderately (0.5-0.7) or highly correlated (0.7-0.9).

Other calculations of mean, standard deviation, percentage, prevalence, and figures were calculated or produced using Excel (2007, version: 202212). Data were visualised using Box plots from R-statistics or in tables with mean and standard deviations.

3.4.3 Modelling BCS

A linear multivariable regression was used to model various variables effect on BCS including the effects of gender, age, breed, use and health status, calculated in R. Weight was chosen not to be included in the model.

4. Results

4.1 Feeding routines for the studied horse population

Seventy percent of the responders (n=186) had responsibility for both feeding/feed preparation and planning of the horses feeding ration (Figure 7). Of the remaining, 11% (n=29) had responsibility for only feeding/feed preparation and 19% (n=51) had only responsibility for feed ration planning.

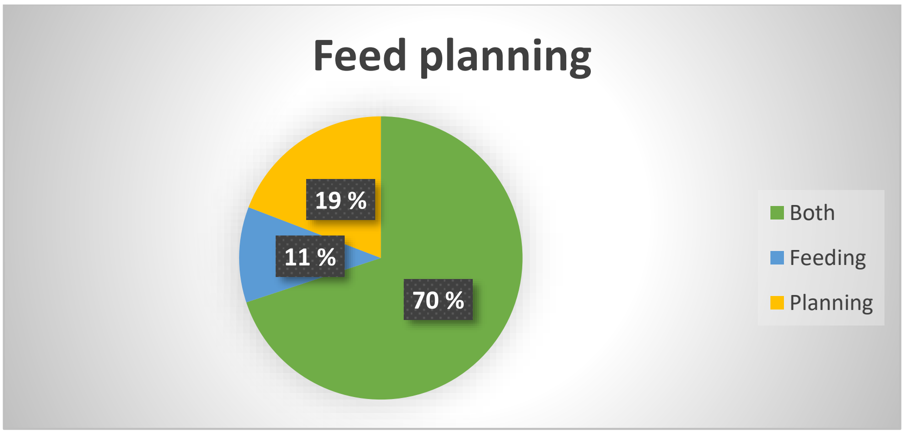

Figure 7. Pie chart illustrating the feed planning and the proportion of horses where the owner was responsible for feeding (n=29), ration planning (n=51) or both feeding and feed planning (n=186) for the body condition scored horses at NMBU and in the field (n=266) from September 2022 to January 2023.

4.1.1 Forage origin

Out of the 266 horses, 49% (n=130) were fed forage self-produced at the farm where the horses were stabled (Figure 8). A lesser number of horses, 36% (n=95) were fed a forage produced and bought in Norway, while 9% (n=24) were fed a forage produced and bought outside Norway. The remaining horses were fed a mix of forage produced in Norway and abroad (1%, n=3), self-produced and bought in Norway (5%, n=13), or self-produced and produced abroad (0.4%, n=1).

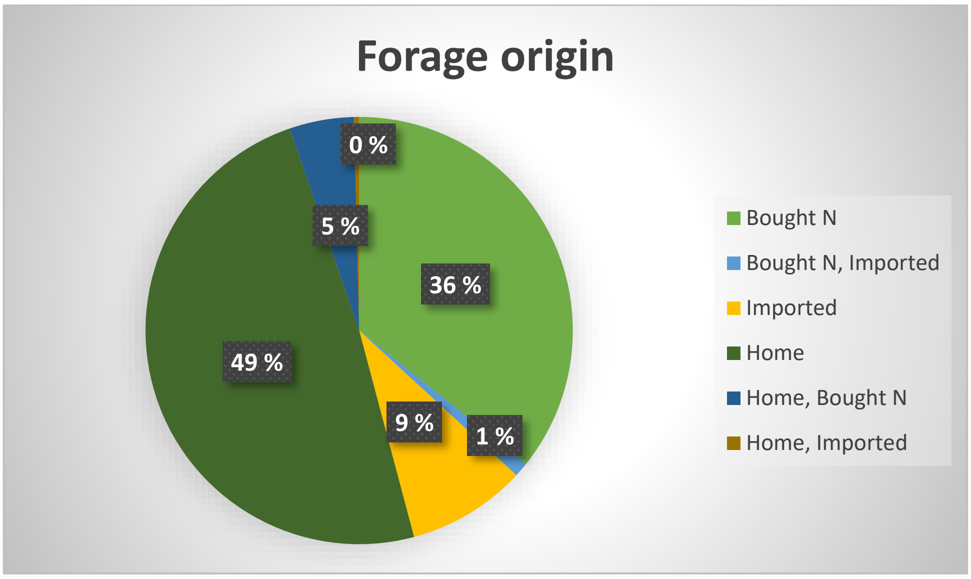

Figure 8. Pie chart illustrating the distribution of the origin of forage fed horses body condition scored at NMBU and in the field (n=266) from September 2022 to January 2023. Forage was divided in the origin categories: Produced and bought in Norway (Bought N), a mixture of forage produced and bought in Norway and forage imported (Bought N, imported), forage produced abroad and imported (imported), self-produced forage from the farm where the horse lived (Home), a mixture of forage self- produced and produced and bought form Norway (Home, Bought N), and a mixture of forage self-produced and forage imported (Home, Imported).

The origin of the forage (self-produced in Norway, abroad or combinations of these) influenced the BCS ($p<0.05$). Horses fed a forage produced locally on the farm (self-produced) had a higher BCS (6.09±0.66) than horses fed imported forage (5.61±0.65, $p<0.05$). The rest of the paired comparisons were similar.

Out of the horses fed imported forage, 90% were competing in trotting (70%, n=14, Standardbred and 20%, n=4, Cold-blooded trotters). The rest of the group consisted of one Warm-blooded riding horse competing in show jumping and one sports pony used as a hobby horse.

4.1.2 Forage type

Most horses were fed haylage (66%, n=175), followed by hay (31%, n=82) (Figure 9). Some owners (3%, n=8) feed their horses with a combination of forage consisting of a mixture of hay and haylage. One person fed the horse a mixture haylage and silage. There was no difference in body condition score (BCS) between horses fed hay, haylage, a mix of hay and haylage, and horses fed silage.

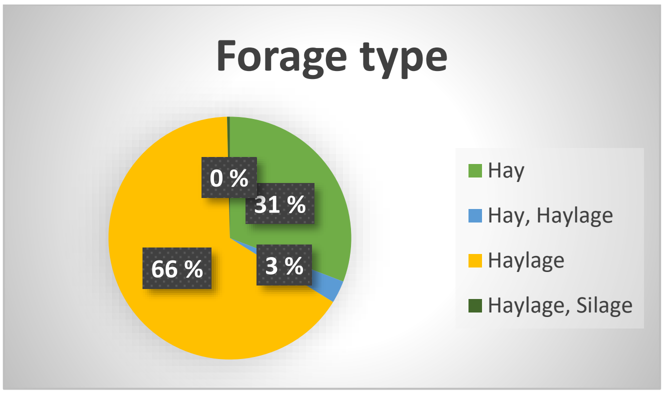

Figure 9. Pie chart illustrating the distribution of forage type fed horses body condition scored at NMBU and in the field (n=266) from September 2022 to January 2023. Forage type was divided in the categories: Hay, haylage, a mixture of hay and silage, and a mixture of haylage and silage.

4.1.3 Forage amount (kg)

Out of the 266 horses, 23% (n=61) of the horses were fed *ad libitum*, 2% (n=4) were fed more than 15 kg forage per day, and 28% (n=77) were fed 12-15 kg (Figure 10). Sixteen percent (n=42) of the horses were fed 6-8 kg forage per day, and 2% (n=5) were fed 3-5 kg. Amount (kg) of forage given to the horse had no effect on BCS.

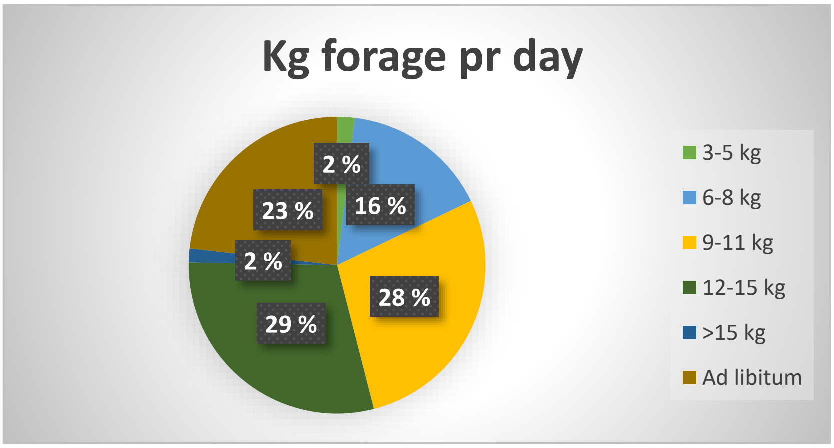

Figure 10. Pie chart illustrating the distribution of kilograms forage feed horses per day of horse's body condition scored at NMBU and in the field (n=266) from September 2022 to January 2023.

4.1.4 Forage analysis

To assist in the planning of forage feeding, 75% (n=200) of the horses were fed analysed forage, while 12% (n=32) did not use analysed forage, and 13% (n=34) was uncertain if the forage of the horse was analysed (Figure 11). Of the forage that was imported, 92% (n=22) was analysed. Out of the self-produced forage 79% (n=103) was analysed, while 74% (n=70) of the Norwegian produced and bought forage was analysed.

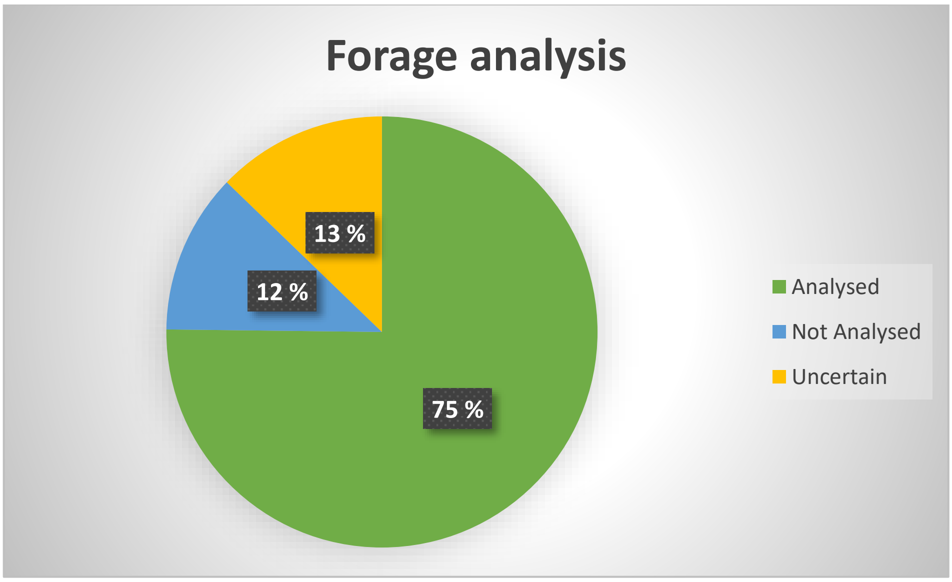

Figure 11. Pie chart illustrating the distribution of forage analyses for forage fed horses body condition scored at NMBU and in the field (n=266) from September 2022 to January 2023. Forage analysis was divided in the categories: Analysed forage (Analysed), forage that was not analysed (Not Analysed), and horses fed forage that was uncertain if it was analysed (Uncertain).

4.1.5 Dry matter intake

For 121 horses, not including horses fed *ad libitum*, the dry matter concentration of the forage was known, and the dry matter intake (DMI) pr day calculated. For the 121 horses DMI was 2.0±0.5 kg pr 100 kg of the horse's total weight. Dry matter intake influenced BCS ($p<0.05$), and the dry matter intake had weak negative (-0.37) correlation on body condition score (Figure 12).

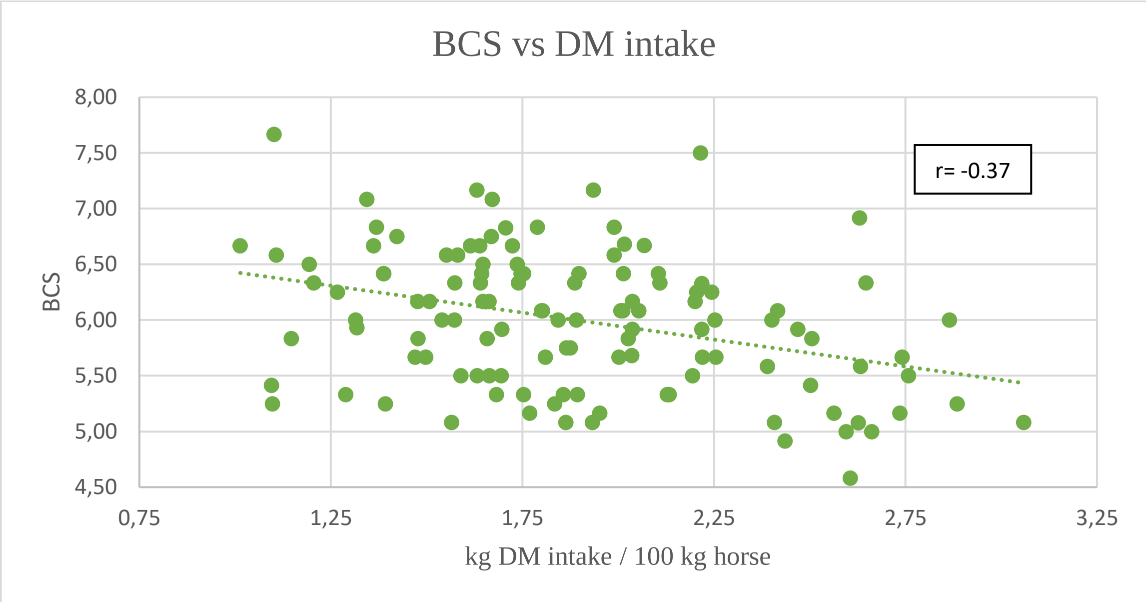

Figure 12. Scatter plot illustrating the relationship between body condition score (BCS) and dry matter intake pr each 100 kg of the horse studied at NMBU and in the field from September 2022 to January 2023. Dotted line illustrates the tendency line with correlation coefficient r= -0.37.

4.1.6 Concentrates

The majority of concentrate fed the studied horses was from Norwegian manufacturers (68%, n=181), while 22% (n=59) horses were fed foreign manufactured concentrate only, and 8% (n=20) horses were fed with a mixture of Norwegian and foreign manufactured concentrate. Only 2% (n=6) of the horses were not fed concentrate, only forage. The origin of the concentrate did not affect the BCS ($p>0.05$). However, the amount (litre) of concentrate given influenced the BCS ($p<0.001$, excluding trotters w and trotters c). There was a weak negative correlation between amount (litre) of concentrate fed and BCS (r=-0.30) (Figure 13).

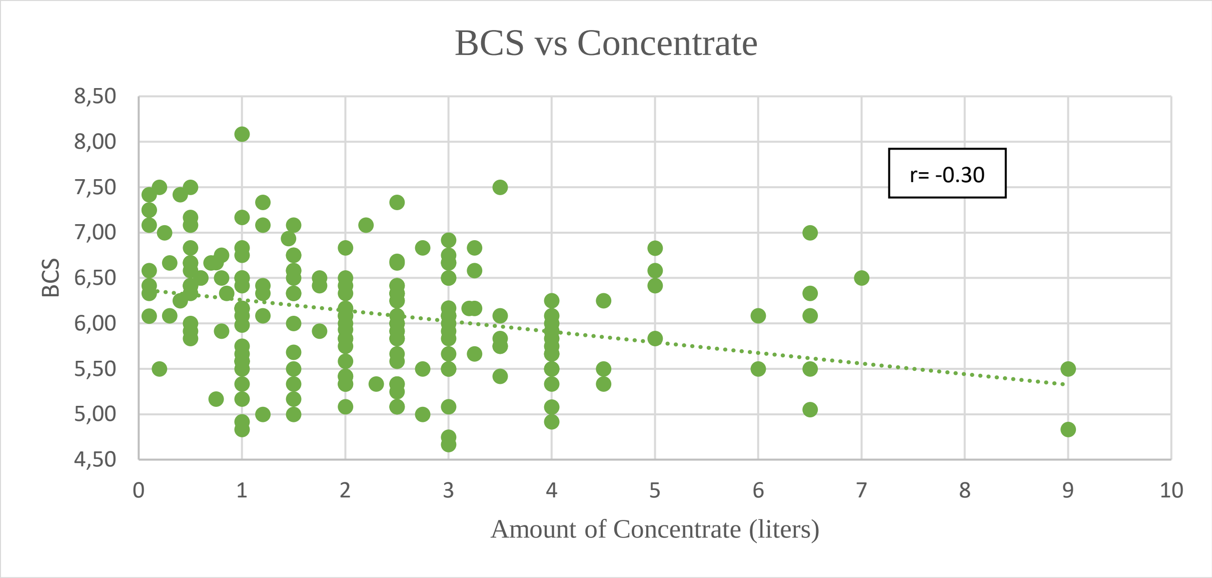

Figure 13. Scatter plot illustrating the relationship between body condition score (BCS) and amount of concentrate (litres) feed horses in addition to forage of the horse studied at NMBU and in the field from September 2022 to January 2023. Dotted line illustrates the tendency line with correlation coefficient r= -0.30.

4.1.7 Calculation of feeding ration:

When asked how the horse's feeding was planned, the responders were given several options and checking off multiple options was possible. Sixty one percent (n=162) of the horses were fed based on the persons own experience, and 49% (n=131) were fed based on own acquired knowledge from courses, education, earlier horse sickness/illness or other injuries, and 35% of responders had answered both options. In summary, 75% (n=200) of the horses were fed according to one or the other, or both these two given options (Figure 14). Despite this, only 11% (n=29) of the persons responsible for the feeding used books and literature, and only 7% (n=18) calculated rations with feed optimizing programs.

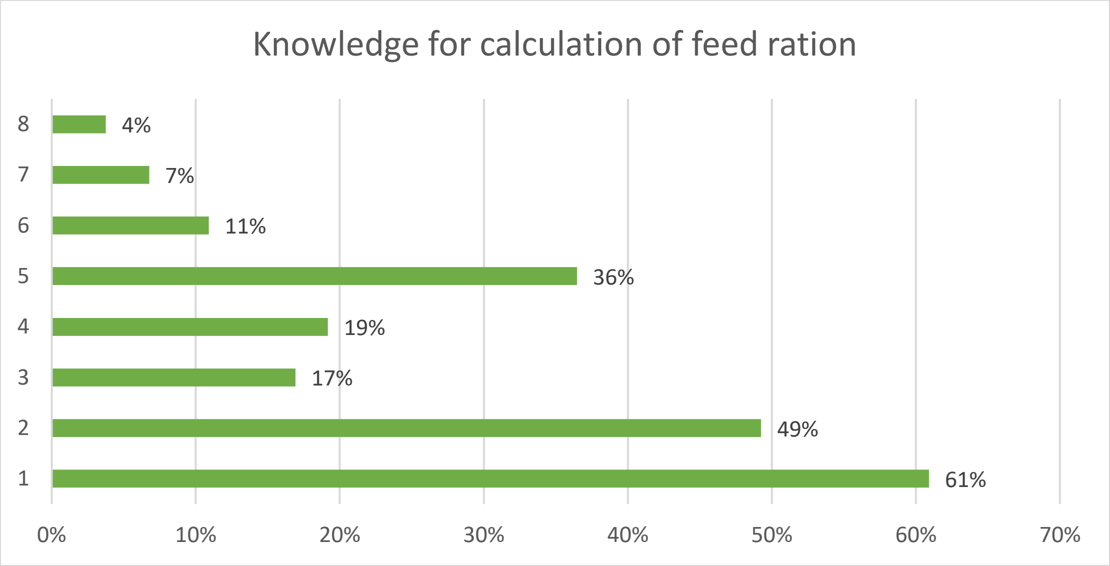

*Figure 14. Answer to the question "*How is the horse's diet decided/calculated?" *for horseowners questioned at NMBU and in the field from September 2022 to January 2023. Multiple answers were possible. Alternatives: Own experience from earlier (1), own acquired knowledge (2), instructions from veterinarian (3), others advice (trainer/stable owner) (4), information from feed manufacturer company (5), books and literature (6), feed optimising programs (7), and other (8).*

4.2 Location

The horses were studied at two main locations, at the Equine Hospital at NMBU and in private stables (field). Horses visiting NMBU included both horses with disease impacting the digestion system and horses with injuries/disease unrelated to the digestion system. There was no difference in the body condition score (BCS) between all the horses treated at NMBU and all the horses studied in the field (Figure 15). Hence, data on all horses from the two locations was pooled (N=424) in analysis of factors influencing the BCS of the horses (Table 11).

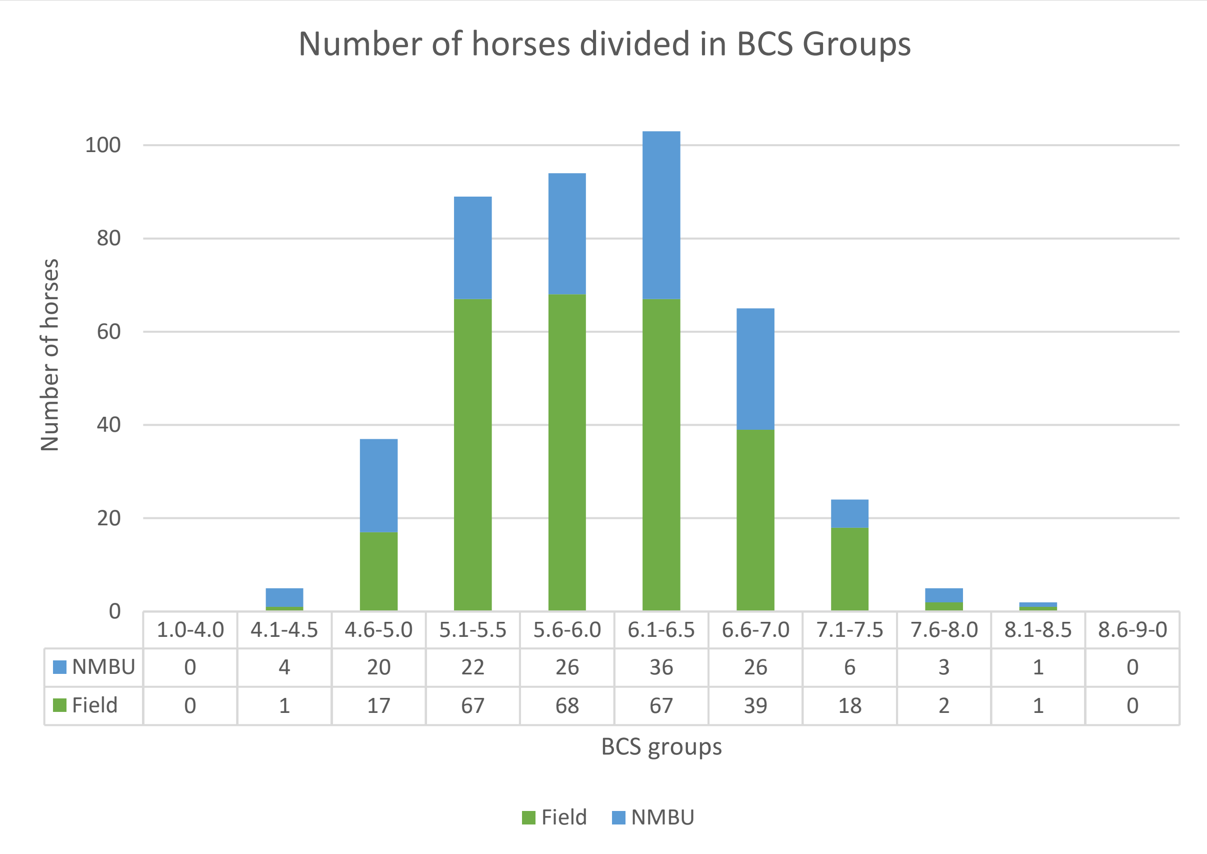

Figure 15. Number of horses in the grouped BCS distribution at NMBU and in the field studied from September 2022 to January 2023.

Table 11. Mean body condition scores for the horses studied at NMBU and in the field from September 2022 to January 2023 dividend into gender, age group, breed, use and health (n=424).

Variable	Group	Count of BCS	Mean BCS (SD)
Gender:			
Mare		168	6.04 (±0.71)
Gelding		219	5.99 (±0.73)
Stallion		37	5.65 (±0.72)
Age group:			
6 mnth-3 years		34	5.40 (±0.58)
3-5 years		76	5.71 (±0.63)
6-10 years		88	6.01 (±0.66)
11-15 years		112	6.18 (±0.70)
16-20 years		74	6.08 (±0.79)
>20 years		25	6.31 (±0.67)
Unknown age		15	5.94 (±0.79
Breed:			
Warm		314	5.80 (±0.66)
STB		58	5.51 (±0.58)
WBRH		194	5.76 (±0.61)
Other W		23	5.76 (±0.65)
SP		39	6.43 (±0.59)
Cold		110	6.50 (±0.67)
CBT		29	6.28 (±0.70)
ICEH		30	6.48 (±0.66)
NFH		13	6.49 (±0.35)
DH		12	6.85 (±0.64)
Other C		26	6.68 (±0.75)
Use and health status			
Digestive		28	5.77 (±0.90)
Teeth		11	5.33 (±1.04)
Colic		17	6.05 (±0.70)
Injured		72	6.03 (±0.88)
Short time		33	5.71 (±0.75)
Period		39	6.30 (±0.90)
Active		204	5.84 (±0.61)
Trotting W		41	5.41 (±0.45)
Jumping		98	5.84 (±0.55)
Dressage		46	6.02 (±0.69)
Ice		5	6.33 (±0.52)
Trotting C		14	6.30 (±0.50)
Not active		120	6.24 (±0.69)
Hobby		94	6.23 (±0.71)
School		22	6.25 (±0.67)
Breeding		4	6.38 (±0.45)

4.3 Gender

The gender of the horses influenced the horses' BCS ($p<0.05$). Stallions had a lower BCS (5.65±0.72) than geldings (5.99±0.73, $p<0.05$) and mares (6.04±0.71, $p<0.01$), while there was no difference in BCS between geldings and mares (Figure 16).

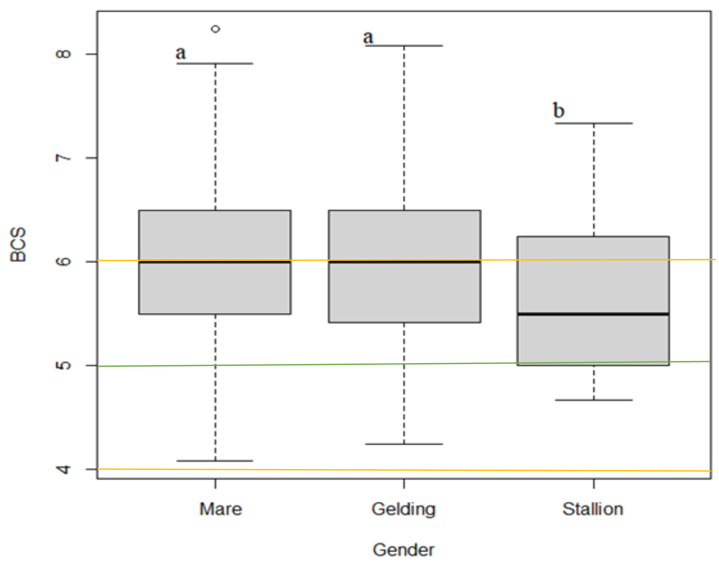

Figure 16. Box plot with mean, quartiles, and outliers (dots) for the body condition score (BCS) by gender (n=168 mares, n=219 geldings, n=37 stallions) studied at NMBU and in the field from September 2022 to January 2023. The same letters indicate that the groups are not significantly different. The green line indicates an ideal BCS (see chapter 2.3.4.), and the orange line indicate the limits for healthy BCS for horses.

Mares and geldings had near equal proportions of the horses with BCS between 4-6 and >6 (Table 12). Among the stallions, however, a higher proportion were between 4-6 (68%) than >6 (32%).

Table 12. The proportion and numbers of mares, geldings, stallions, and all horses with BCS 4-6 and >6 studied at NMBU and in the field from September 2022 to January 2023.

BCS	Mares	Geldings	Stallions	All
4-6	51% (n=85)	53% (n=115)	68% (n=25)	53% (n=225)
>6	49% (n=83)	47% (n=104)	32% (n=12)	47% (n=199)

4.4 Age

The age group of the horses influenced the BCS ($p<0.001$) (Figure 17), and there was a weak positive correlation between age and body condition score ($r=0.29$). Horses in the age group 6 mnth-3 years did not have a different BCS (5.40±0.58) than horses in age group 3-5 (5.71±0.63, $p>0.05$). The BCS of horses in age group 6 mnth-3 years was lower than for horses 6-10 years (6.01±0.66, $p<0.001$), horses 11-15 years (6.18±0.70, $p<0.001$), horses 16-20 years (6.08±0.79, $p<0.001$), and horses older than 20 years (6.31±0.67, $p<0.001$) (Figure 17). Horses 3-5 years had a lower BCS than horses 11-15 years ($p<0.001$), horses 16-20 years ($p<0.05$) and horses older than 20 years ($p<0.01$).

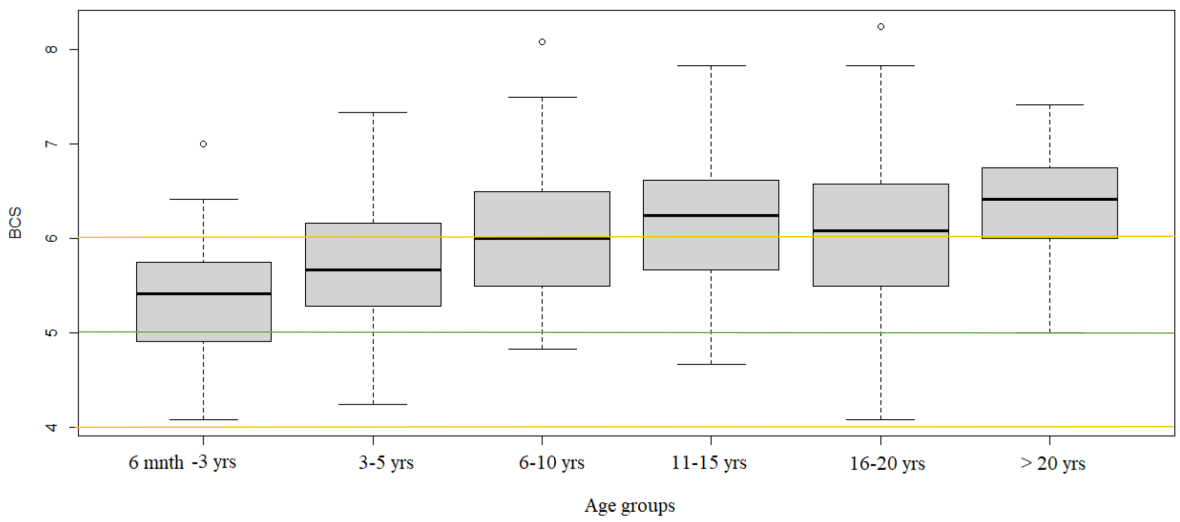

Figure 17. Box plot with mean, quartiles, and outliers (dots) for the body condition score (BCS) by age groups (6 mouths – 3 year, n=34; 3-5 year, n=76; 6-10 year, n=88; 11-15 year, n=112; 16-20 year, n=74; and >20 year, n=25 old horses) studied at NMBU and in the field from September 2022 to January 2023. The green line indicates an ideal BCS (see chapter 2.3.4.), and the orange line indicate the limits for healthy BCS for horses.

4.5 Breed

4.5.1. Warm- and cold-blooded breeds

Based on the origin and breed, the horses were categorized as warm- or cold-blooded (see chapter 3.1.2 Grouping horses according to breed), and the BCS differed between the two groups ($p<0.001$). Warm-blooded horses (5.80 ±0.66) had a lower BCS than cold-blooded horses (6.5±0.67, $p<0.001$) (Figure 18).

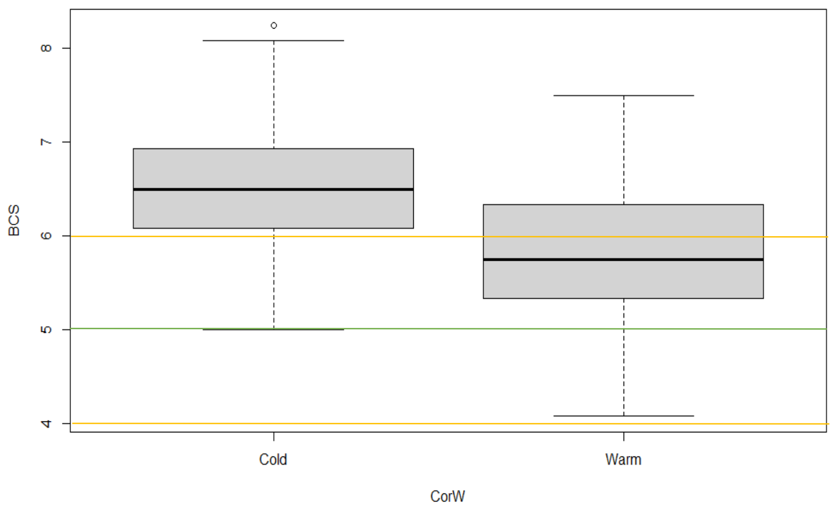

Figure 18. Box plot with mean, quartiles, and outliers (dots) for the body condition score (BCS) for cold-blooded and warm-blooded horses (n=110 cold-blooded horses, n=314 warm-blooded horses) studied at NMBU and in the field from September 2022 to January 2023. The green line indicates an ideal BCS (see chapter 2.3.4.), and the orange line indicate the limits for healthy BCS for horses.

The proportion of horses with BCS 4-6 or >6 differed between warm-blooded and cold-blooded horses (Table 13). Of the warm-blooded horses a higher proportion (65%) had a BCS between 4 and 6, but among cold-blooded horses a higher proportion had a BCS >6 (80%).

Table 13. The proportion and numbers of warm-blooded breeds, and cold-blooded breeds with BCS 4-6, and >6 studied at NMBU and in the field from September 2022 to January 2023.

BCS	Warm-blooded	Cold-blooded
4-6	65% (n=203)	20% (n=22)
>6	35% (n=111)	80% (n=88)

4.5.2 Different breeds

The studied horses consisted of horses of different breeds, which influenced the horse's body condition score (p<0.001). Horses of the breed Dølahest had the highest body condition score (6.85±0.64), while Standardbred had the lowest BCS (5.51±0.58) (Figure 19). Standardbred, Warm-blooded riding horses and other warm-blooded breeds had a lower individual BCS than all the other remaining breeds (p<0.05). Sports ponies had a higher BCS (6.39±0.53) than Warm-blood riding horses BCS (5.76±0.61, p<0.001), and other warm-blooded breeds BCS (5.76±0.65, p<0.001).

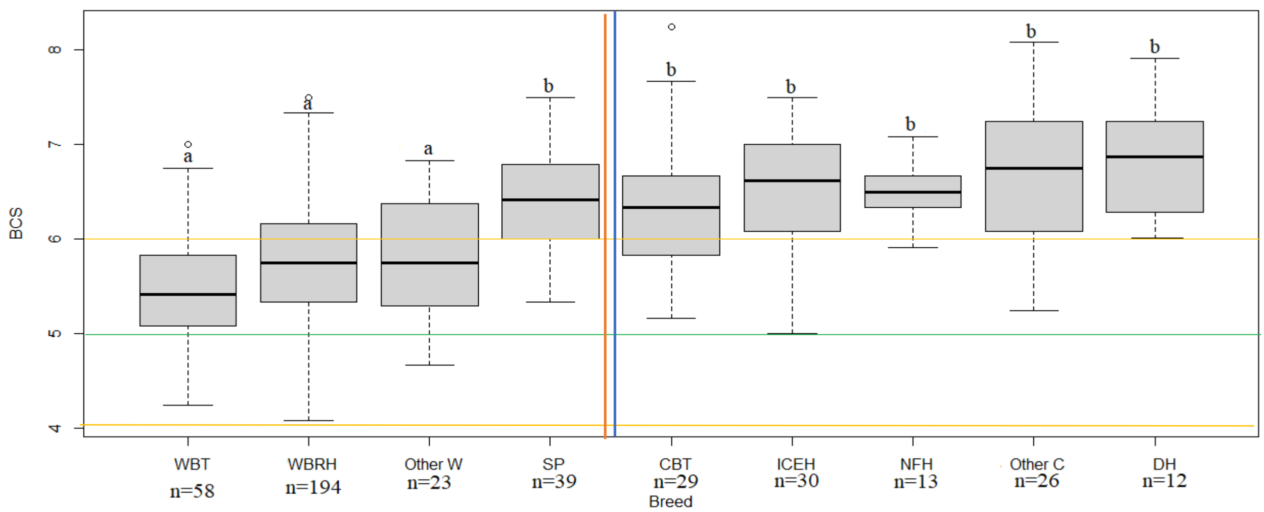

Figure 19. Box plot with mean, quartiles, and outliers (dots) for the body condition score (BCS) for warm-blooded horses competing in Standardbred (STB), Warmblood riding horses (WBRH), Other warm-blooded breeds (Other W), Sports ponies (SP), Cold-blooded trotters (CBT), Icelandic horses (ICEH), Norwegian fjord horses (NFH), other cold-blooded horses (Other C), Dølahest (DH) studied at NMBU and in the field from September 2022 to January 2023. The same letters indicate that the groups are not significantly different. The green line indicates an ideal BCS (see chapter 2.3.4.), and the orange line indicate the limits for healthy BCS for horses. Breeds on the left side of the red horizontal line is categorized as warm-blooded breeds, and breeds hon the right side of the blue horizontal line is categorized as Cold-blooded breeds.

The number and proportions of horses with BCS 4-6 and >6 varied among the breeds (Table 14). Among Standardbred, Warm-blooded riding horses, and Other warm-blooded breeds a higher proportion of the horses were in the interval 4-6, with the largest proportion were found for Standardbred horses. The opposite was found for Sport ponies, Cold-blooded trotters, Icelandic horses, Norwegian fjord horses, other cold-blooded horses, and Dølahest where the largest proportion of the BCS were >6, with the largest proportion were found for Dølahest.

Table 14. The proportion and numbers of Standardbred (STB), Warmblood riding horses (WBRH), Other warm-blooded breeds (Other W), Sports ponies (SP), Cold-blooded trotters (CBT), Icelandic horses (ICEH), Norwegian fjord horses (NFH), other cold-blooded horses (Other C), Dølahest (DH) with BCS 4-6 and >6 studied at NMBU and in the field from September 2022 to January 2023.

BCS	STB	WBRH	Other W	SP	CBT	ICEH	NFH	Other C	DH
4-6	83% (n=48)	67% (n=130)	65% (n=15)	26% (n=10)	31% (n=9)	20% (n=6)	15% (n=2)	15% (n=4)	8% (n=1)
>6	17% (n=10)	33% (n=64)	35% (n=8)	74% (n=29)	69% (n=20)	80% (n=24)	85% (n=11)	85% (n=22)	92% (n=11)

4.6 Activity status

When comparing activity status groups (see chapter 3.1.3.1. Activity status), the activity status of the horses influenced the BCS among all groups ($p<0.001$).

Horses that were injured with an acute (short) or a longer lasting injury (period) did not have a higher BCS (6.03±0.88) than active horses (5.84±0.61, $p>0.05$) (Figure 20). Horses in the digestive disease group had a lower BCS (5.77±0.9) than not active horses ($p<0.01$). Active horses had a lower BCS (5.84±0.61) than not active horses BCS (6.24±0.69, $p<0.001$). The rest of the paired comparisons were similar.

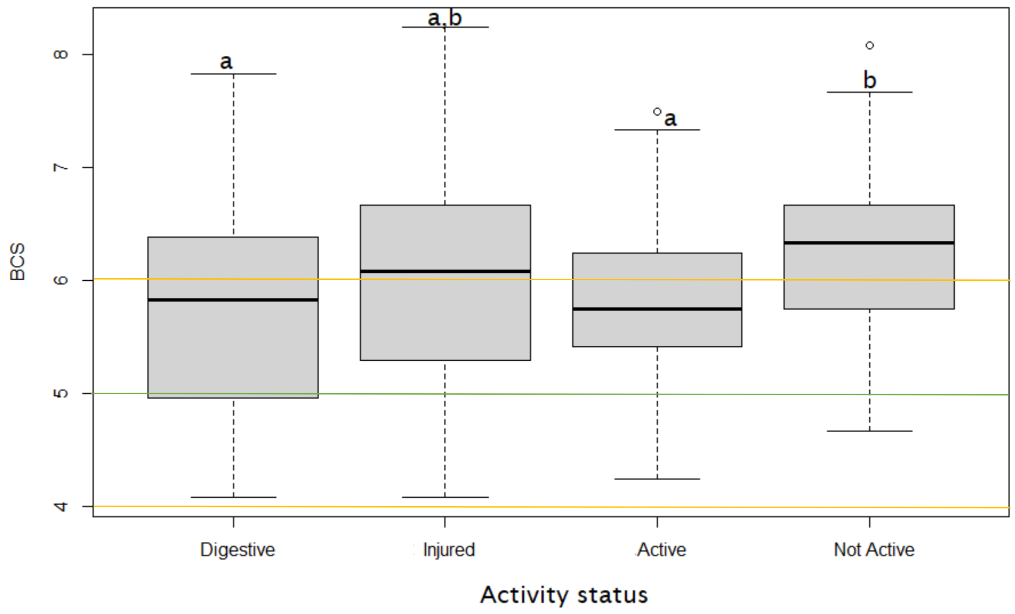

Figure 20. Box plot with mean, quartiles and outliers (dots) of the body condition score (BCS) for horses with activity status, digestive, injured, active and not active studied at NMBU and in the field from September 2022 to January 2023. The same letters indicate that the groups are not significantly different. The green line indicates an ideal BCS (see chapter 2.3.4.), and the orange line indicate the limits for healthy BCS for horses.

4.6.1 Use and health status

Use and health status influenced the BCS ($p<0.001$). Horses that came to NMBU for teeth and jaw treatments had the lowest BCS (5.33 ±1.04), while breeding horses had the highest BCS (6.38±0.45) (Figure 21). Horses with teeth and jaw treatments had a lower BCS than hobby horses (6.23±0.71, $p<0.01$), school horses (6.25±0.67, $p<0.05$), horses competing in trotting (cold-blooded) (6.30±0.50, $p<0.05$), and horses that had been injured for a longer time period (6.30±0.90, $p<0.01$) (Table 11).

Standardbreds competing in trotting had the second lowest BCS (5.41±0.45), after horses with teeth and jaw injuries, and lower than for jumping horses (5.84±0.55, $p<0.05$), dressage horses (6.02±0.69, $p<0.01$), hobby horses ($p<0.001$), school horses ($p<0.001$), trotting cold-blooded horses ($p<0.01$), and horses that had been injured for a longer time period ($p<0.001$). Short time injured or sick horses followed Standardbred horses with regard to BCS (5.71±0.75). This was also lower than for hobby horses ($p<0.01$) and horses that had been injured for a longer time period ($p<0.05$). Competing show jumping horses also had a lower

BCS than hobby horses ($p<0.01$), and horses that had been injured for a longer time period ($p<0.05$).

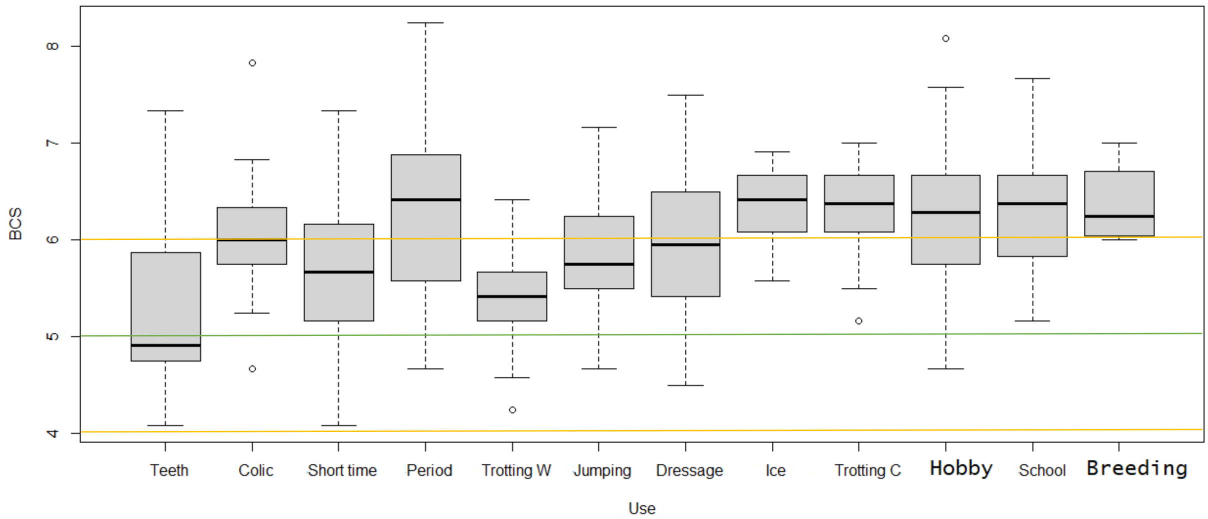

Figure 21. Box plot with mean, quartiles and outliers (dots) of the body condition score (BCS) for horses with different use and health status teeth, colic, period, short time, trotting W, jumping, dressage, ice, trotting C, hobby, school and breeding studied at NMBU and in the field from September 2022 to January 2023. The green line indicates an ideal BCS (see chapter 2.3.4.), and the orange line indicate the limits for healthy BCS for horses.

In the discipline and functional groups, colic and dressage horses had similar proportions of horses with BCS of 4-6 and >6 (Table 15). Among the horses in the groups Warm-blooded trotting and teeth, a higher proportion had BCS of 4-6 (93% trotting w, and 73% teeth) than >6. Cold blooded trotting, Icelandic gait competition, breeding horses, horses that have a longer resting period and school horses had a lower proportion of horses with a BCS between 4-6 (14% trotting c, 20% Icelandic gait competition, 25% breeding, 36% period, and 36% school) than >6.

Table 15. The proportion and numbers of horses with different use and health status teeth, colic, period, short time, trotting W, jumping, dressage, ice, trotting C, hobby, school and breeding with BCS 4-6 and >6 at NMBU and in the field from September 2022 to January 2023.

BCS	Teeth	Colic	Period	Short time	Trotting W	Jumping	Dressage	Ice	Trotting C	Hobby	School	Breeding
4-6	73% (n=8)	59% (n=10)	36% (n=14)	64% (n=21)	93% (n=38)	62% (n=61)	54% (n=25)	20% (n=1)	14% (n=2)	38% (n=36)	36% (n=8)	25% (n=1)
>6	27% (n=3)	41% (n=7)	64% (n=25)	36 % (n=12)	7% (n=3)	38% (n=37)	46% (n=21)	80% (n=4)	86% (n=12)	62% (n=58)	64% (n=14)	75% (n=3)

4.6.2 Warm-blooded horses competing in jumping, dressage and trotting

The active Standardbred competing in trotting had a lower BCS than both Warmblood riding horses competing in show jumping and dressage (both $p<0.001$) (Figure 22).

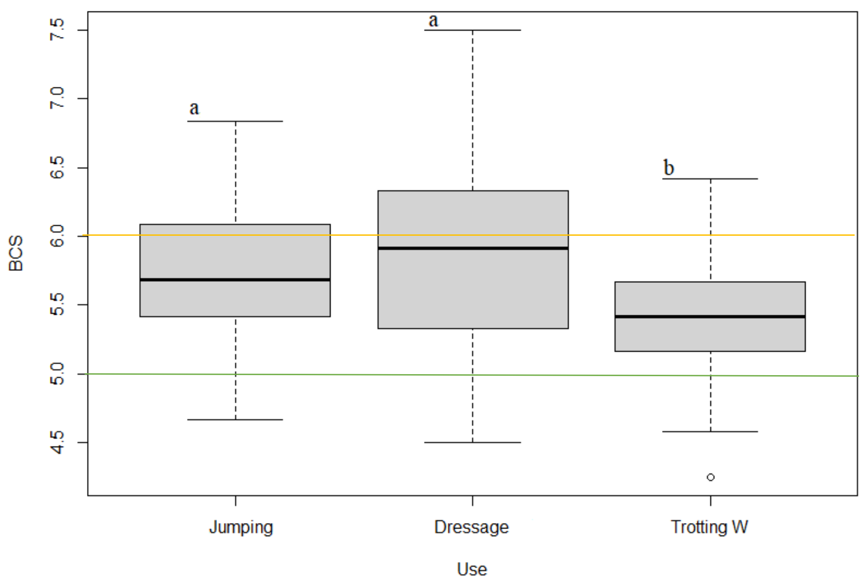

Figure 22. Box plot with mean, quartiles, and outliers (dots) of the body condition score (BCS) for warm-blooded horses competing in jumping, dressage and trotting (n=83 jumping, n=38 dressage, n=41 trotting w) studied at NMBU and in the field from September 2022 to January 2023. The same letters indicate that the groups are not significantly different. The green line indicates an ideal BCS (see chapter 2.3.4.), and the orange line indicate the limits for healthy BCS for horses.

4.7 Body weight and body condition score

Warm-blooded riding hobby horses had a moderate positive correlation between weight and BCS (r=0.53), while Sports ponies competing in jumping had a lower positive correlation between weight and BCS (r=0.32) (Table 16). However, Standardbreds had a weak correlation between weight and BCS (r=0.20). There was no correlation between weight and BCS for Warmblood riding horses competing in dressage (r=-0.06) or Warmblood riding horses competing in jumping (r=0.02).

Table 16. Size groups based on Discipline, Breed, and Age 5-15. Mean, minimum and maximum weight (W) additional to mean, minimum and maximum body condition score and correlation coefficients (Corr) for each group. The breeds consisted of Warmblood riding horses (WBRH), sports ponies (SP), and Standardbred (STB).

Discipline	Breed	N	Mean Weight (kg)	Min Weight (kg)	Max Weight (kg)	Mean BCS	Min BCS	Max BCS	Corr
Dressage	WBRH	28	565	484	654	6.06	5.08	7.5	-0.06
Hobby	WBRH	19	598	488	686	5.75	5.00	6.67	0.53
Jumping	WBRH	65	581	486	704	5.83	4.67	6.83	0.02
Jumping	SP	14	395	258	512	6.43	5.5	7.17	0.32
Trotting W	STB	24	473	385	547	5.48	4.25	6.42	0.20

4.8 Modelling BCS

To summarise the various variables affecting the body condition score of horses studied at NMBU and in the field, a model was fitted to the variables studied.

Based on the assumption that the model horse was a standardized average horse illustrated by a Standardbred mare with a long-lasting injury with a BCS of 5.83, the various variables gender, age group, breed and discipline/functional group had an impact on predicting the BCS (Table 17). This intercept was chosen as a model horse because the breed Standardbred represent a low BCS (5.51±0.58) and horses with a long-lasting injury represents a higher BCS (6.30 ±0.90). This gave a representative intercept (BCS for all 5.98) for all variables of the model standardized horse.

For the various variables effecting BCS, geldings, and stallions had a negative impact on BCS leading to a lower BCS than the intercept. Warmblood riding horses and other warm-blooded breeds also had a negative impact reducing the BCS, while the remaining breeds had a positive effect on the BCS, leading to a higher BCS than the intercept. Horses competing or training for competition in cold-blooded trotting or dressage, or if the horse was a breeding horse would influence the BCS to increase. The rest of the disciplines and functional groups had a decreasing effect on BCS.

The larges decreasing factor for the BCS was horses with teeth (or jaw) injuries -0.973, followed by horses competing or training for competition in Standardbred (-0.520). The largest increasing factor for BCS was the horse being of the breed Dølahest (0.769) or other cold-blooded breeds (0.646).

Table 17. Table over variables affecting Body condition score in horses studied at NMBU and in the field from September 2022 to January 2023 according to the model: BCS ~ gender + age group + breed + use and health status.

Variable	Estimate
Intercept	5.830
Gender:	
Mare	0.000
Gelding	-0.065
Stallion	-0.168
Age group:	
6 mnth-3 years	0.084
3-5 years	0.168
6-10 years	0.252
11-15 years	0.336
16-20 years	0.420
>20 years	0.504
Breed:	
STB	0.000
WBRH	-0.203
Other W	-0.077
SP	0.388
CBT	0.273
ICEH	0.560
NFH	0.588
DH	0.769
Other C	0.646
Use and health status:	
Teeth	-0.973
Colic	-0.252
Short time	-0.370
Period	0.000
Trotting W	-0.520
Jumping	-0.069
Dressage	0.032
Ice	-0.285
Trotting C	0.057
Hobby	-0.096
School	-0.116
Breeding	0.429

5. Discussion:

The main objective of the present study was to provide an overview and compare the body condition of healthy and active Norwegian horse populations used for different purposes and horses visiting the Equine Hospital at NMBU for treatment. To study prevalence of adiposity for horses in Norway, body condition scoring was done on horses visiting NMBU and in private stables using the body condition score suggested by Kohnke (1992). In addition, using a questionnaire combined with the body condition score, the possible consequences of Norwegian and foreign produced forage and feed for the body condition were studied. To the authors knowledge there has not been any similar previous body condition studies done on Norwegian horses. However, the body condition using scoring systems have been investigated in Denmark for Icelandic and warm-blooded riding horses (Jensen et al., 2016, Jensen et al., 2019), and in Sweden for horses in riding schools, horses over 20 years and prevalence of obesity in official animal welfare control data (Yngvesson et al., 2019, Müller and Lindberg, 2020, Hitchens et al., 2016).

5.1 Feeding routines of horses in Norway

Out of the 266 responders, 89% personally planned their horses feed plan. This indicate that most horse owners in the studied group are engaged in how the horses are fed. It can be questioned if all horse owners, also some with a self-made feeding plan, have the satisfactory knowledge level of what to feed, how much and what consequences can be expected of their feeding regime. Hence, it might be room for knowledge improvement if a change in body condition of horses and a change in the feeding routine is recommendable. The horse owners are an important group to target for knowledge dissemination with regard to feeding Norwegian horses.

5.1.1 Origin of feed in relation to BCS

The origin of feed, domestic or imported, influenced the body condition score. Horses fed forage produced outside Norway (n=24) had an 8% lower mean BCS than horses fed forage produced locally (n=130). However, 90% (n=18) of the horses fed foreign produced forage were competing trotting horses. The lower BCS score is thus possibly explained by the high activity level of the horses, not the origin of the forage. It can be argued that buying feed from outside Norway in itself has an effect on the body condition because it often comes with a forage analysis making it easier to optimize and portioning the right amount of feed to the horse. However, 79% of the self-produced forage was also analysed for nutritional content, this is therefore less likely.

An additional theory for higher BCS of the horses fed forage produced locally, could be that they were "fed the forage available". Because of the expenses attached to producing own forage, and for feed in general, local produced forage was fed the horses also if it was not optimal for the horse's energy requirements. Since it is difficult to produce a feed that fits all types of horses, this could explain why some horses got energy exceeding their energy requirements through forage. Therefore, if buying forage, Norwegian produced or foreign, it is easier to choose the forage that fits your horse's needs, optimising the feeding plan of the horse.

There was no difference in the BCS among horses fed concentrate from Norwegian manufacturers, foreign manufacturers or concentrate from a mix of the two (responders n=266). In the investigated group of horses, 30% (n=79) were fed concentrate from foreign manufacturers or a mixture of Norwegian manufacturer's and foreign manufacturer's concentrate. The reason why owners bought concentrates from foreign manufacturers differed. Availability may also be one of the main reasons why the owners choose concentrate from a specific Norwegian manufacturer, as it was the most convenient to get hold of.

5.1.2 Concentrate intake in relation to BCS

Unexpectedly, there was a negative correlation between concentrate intake and BCS (r=-0.3). A higher concentrate intake led to a lower BCS, also when excluding active trotters. The trotters were excluded because they are known to have a high concentrate intake and moderate BCS, due to a high activity level. However, the overall tendency for the rest of the horses were the same as for the trotters. Similar to the present study, Thatcher et al. (2012) found that there was a tendency that horses receiving more concentrate had a lower BCS than horses receiving little or no concentrate when body condition scoring and tracing feed intake for 300 horses in Virginia, USA. They found that horses receiving 0-1.4 kg concentrate/day had a higher BCS than all the other groups, which were consuming more concentrate. This was not as expected, as concentrate often contain high levels of energy. An explanation might be that horses receiving high concentrate intake also had a high activity level. Such as seen in the studied trotters; the amount of concentrate (energy) matched the energy expenditure and the horses were in energy balance, hence not increasing body condition. However, to gain weight horses with low BCS might be given high amounts of concentrate, while the opposite might be the case for horses with a higher BCS. This could explain why horses fed larger amounts of concentrate had a lower BCS. It could also be speculated that horses fed higher amounts of concentrate had a more detailed feeding plan that caused the horse to be in energy balance, compared to horses fed little to no amounts of concentrate.

5.1.3 Norwegian feeding routines in relation to other countries

For more conformity in the studies and easier comparison between countries, the questions presented in the questionnaire in the present study were the same as asked in the Danish study *Er havre davre* (Gleerup, 20219). In the present study horses fed analysed forage had increased with 40% up to 75% since 2012, when compared with Vik and Farstad (2012). Therefore, horse owners today should have a better control over the content in what they feed their horses due to the chemical analysis of the horse's forage. Based on the results in the present study, Norway is the country with the highest percentage of forage analysis (Wilhelmsson, 2017, as cited in Gleerup, 2019, Gleerup, 2019) (Table 2). However, the frequency of forage analysis in the other countries might have increased over the last years, as in Norway, because these studies were from 2017.

When it comes to planning the feeding ration in the present study, only 7% of the 266 horse owners used feed-optimising data programs to calculate their horses feeding ration. This is considerably lower than in Sweden (35%) (Wilhelmsson, 2017, as cited in Gleerup, 2019). It can also be speculated that not all of the 75% of horsesowners with analysed forage used these analyses to optimising their feeding. Most owners (75%) used own knowledge to assemble the feeding plan for their horses. This might be an important explanation for why 47% of the horses investigated in the present study were over conditioned (BCS >6). As Jensen et al. (2016) concluded, this might be the result when the owners are in poor agreement with professionals when determining their horses BCS, and hence, lack of knowledge of nutritional needs leads to overfeeding.

When looking at *ad libitum* forage feeding, Norway has the lowest percentage, among the other Nordic countries studied (Wilhelmsson, 2017, as cited in Gleerup, 2019; Gleerup, 2019). The reason for this might be because of the Nordic winter climate reduce the opportunity for *ad libitum* intake of gras in the fields, resulting in more work and expenses for practical implementation of *ad libitum* feeding of the horse all year around. Only 2% of horses investigated in the present study received less than 6 kg forage per day, this is the smallest percentage together with Sweden (3%) (Wilhelmsson, 2017, as cited in Gleerup, 2019). When it comes to horses fed more than 3 kg concentrate, Norway (16%) is in the middle together with Denmark (16%) and USA (16%). This is probably because it is somewhat more profitable producing forage than grains in Norway because of climate conditions. The Nordic feeding tradition is also going towards a more forage-based diet for horses, which is reflected in the feeding practises investigated in Sweden, Denmark and England (Wilhelmsson, 2017, as cited in Gleerup, 2019; Gleerup, 2019).

5.1.4 Forage for horses rely on locally produced resources

In the present study 47% of the horses had a BCS higher than 6 and could be categorized as being in a state of overweight. These horses are likely being fed more energy than their requirements. Nine percent (n=24 of 266) of the horses were fed foreign produced forage and 22% (n=59 of 266) were fed concentrate only from foreign manufacturers. This suggest that it is possible to reduce the imported share of feed for Norwegian horses, without compromising of the horses' welfare or health. This can be done if reducing the feed intake for horses with a BCS over 6 and distributing the excess feed to replace imported feed, meaning Norway could be near self-sufficient with regard to horse feed, especially forage, from national resources. This might be done without a substantial increase in the production. To be fully self-sufficient it might be necessary to use more local resources which is not utilized today, such as open field grazing and extensive pasture. This is based on the assumption that the future numbers of horses will be the same, the activity levels for the horses are not substantially increased, and hence, no major increase in energy in forage and feed is needed.

5.2 Methods and data collection

Body condition scoring is widely used for monitoring the body condition and identifying adiposity in horses. The consequences of using a subjective method, as the body condition score (BCS), to describe subcutaneous fat coverage in horses has been questioned by Pratt-Phillips and Munjizun (2023). Body condition scoring has however been shown to be a repeatable measurement when it comes to estimating adipose tissue (Carroll and Huntington, 1988).

Different practices have been used when body condition scoring horses in studies. Some studies have used several trained persons for repeatable body scoring of the same individual and then used the mean BCS in analysis (Carter et al., 2009; Thatcher et al., 2008; Thatcher et al., 2012). When using two independent persons to score, kappa between the BCS for individual scorers was 0.65, which indicate a high level of agreement (Thatcher et al., 2012). However, only one person to body score horses are also common in studies (Harker et al., 2011; Giles et al., 2014). In the present study only one person, the author, body condition scored all the horses. The data collector was trained in body condition scoring horses and followed the same criteria throughout the study to ensure conformity in the data collection. It should be kept in mind that scores should be regarded as subjective when comparing prevalence of obesity, and when comparing results among studies where different persons have body condition scored. However, when comparing relative differences among groups within the same study where all horses were scored consistently by the same person, the results are representative for among group variation.

It the present study it was deemed beneficial to use the body condition score adaptation suggested by Kohnke (1992). This was because Kohnke's adaptation includes individual adiposity scoring per region on the horse, compared to the original Henneke et al. (1983) which contains only a total score for the whole horse. In most horses investigated in the present study, BCS varied among the horse's regions and one total score would be difficult to give for the horse. Some horses got as much as 2 scoring points difference between regions, for example BCS 7 for the neck and BCS 5 for the shoulder. This illustrates that using the Kohnke (1992) adaption gives a more specific BCS than the original BCS of Henneke et al. (1983).

Use of individual region scores were especially useful in cases where one score, usually the neck, was higher than the other scores. When body condition scoring stallions, older stallions got a higher than mean average score for the neck. Stallions are also known to have a thicker and more muscular neck than mares and geldings. Physiological differences might therefore have led to a higher mean BCS for the stallions than what the adiposity tissue of the horse represents. A high neck score was also found in horses that had lost a lot of weight. For several of these horses individual scores for the neck were 2 scoring point higher than the remaining five adiposity regions. This indicates that fat reserves in the neck might be difficult to access and mobilise metabolically. This also suggest that cresty neck scoring (Carter et al., 2009) might be a better measurement for investigating body condition of horses as a risk factor for metabolic sickness as Equine metabolic syndrome (EMS) and laminitis. Although obesity is detected in the best part of horses with EMS and laminitis, some horses have a moderate body condition with a regional adiposity such as a cresty neck (Carter et al., 2009). This may be explained by horse owners taking action and helping the horse to lose weight, but the insulin resistance may already have occurred, and measurements might have happened to late in the process.

Several large and tall horses of the breed warm-blooded riding horses received a lower score (4-4.5) on withers, although their mean BCS ended above average. The largest deviation from the mean most often was the neck score being the highest, and the lowest score was most often for withers. Horses with either higher scores on necks or lower scores on withers might have influenced the horse's mean BCS. This shows that the horse should be seen as a whole, not just regions regarded individually to score an accurate BCS for the horse. In addition, it would be beneficial when interpreting the results of body condition scoring not only to look at the mean score, but also consider the variation among regions, and keep in mind that some of the results for individual regions, and the mean score, might be due to gender, age or horse breed.

5.3 Seasonal changes in BCS

In the present study horses were body conditioned scored during the winter months (October-January). For some of the individuals of the cold-blooded breeds, the thick winter coats of the horse represented a challenge for the accuracy when determining the scores, especially when differentiating within the moderate BCSs 4 to 6. However, the high BCS >6 was easy to determine with high accuracy independent of coat thickness. Therefore, this did not represent a major challenge when interpreting the overall status of these horses.

Seasonal changes in body condition of feral horses have been documented, going from the lowest BW in the spring after winter conditions to the highest BW in the autumn after gaining an average of 44 kg BW (n=12) (Scheibe and Streich, 2003). Seasonal differences in prevalence of obesity (BCS 7-9) have been documented to vary in domesticated horses as well (Giles et al., 2014). For 96 horses at pasture for a minimum of 6 h per day in England, 27% were obese at the end of the winter which increased to 35% by the end of the summer.

To avoid seasonal changes in BCS in the present study the period for data collection and horse surveys in the field were concentrated to the winter months (mid-November to start of January). Based on Scheibe and Streich (2003) and Giles et al. (2014) it would be reasonable to believe that if the BCS had been done in the spring the prevalence of obesity could have been lower due to seasonal variation. Although, the data collection at NMBU was obtained over a period of 4 months to increase sample size, there was no differences in BCS between horses at NMBU and in the field.

5.4 Prevalence of obesity

This is the first published study to report on BCS and under and over condition in any group of horses in Norway. Out of the 424 horses, 47% (n=199) had a BCS higher than 6 and were classified as overweight, while none of the studied horses had a BCS under 4 which is the suggested threshold for horses in poor condition (see chapter 2.3.4 Ideal body condition).

This may not mean that thin horses did not exist in the private stables studied. In these stables horses were studied after consent of owners/stable owners and horses in poor or obese conditions might not have been brought for examination and included in the study. However, as for private stables, there were no thin or poor horses (BCS<4) studied at NMBU, and there was no difference in the mean BCS between the two studied locations. In comparison to the field sample, the studied horses at NMBU were a random sample of horses. Hence, if thin or poor horses were present in the private stables studied, but not presented for examination, they must have been relatively rare and, hence, not to a major degree influencing the overall results of the present study. Also, it is not likely that many horse owners denied participating in the present study of obesity as the author is familiar with most of the stables studied in the field.

It is important, however, to note that the collected data was not random sample but opportunistic based on availability and opportunity. But the results are suggested to be representative for an overall prevalence due to the large number of horses investigated (n=424).

5.5 Gender in relation to BCS

Stallions had a BCS that were 0.34 points lower than geldings and 0.39 points lower than mares. The lower body condition score of stallions might be because of a higher level of sex hormones and a stallions increased activity during breeding season, which usually ends in august (Lawrence, 2013). On the other hand, stallions did mostly represent competition horses indicating that training of the horse was important for a lower BCS. There were no differences in BCS between mares and geldings. This differs from (Thatcher et al., 2012) who body condition scored 300 light weight breeds during summer in Virginia, USA, and found that female horses had a higher chance of being obese than male horses. The male horses consisted of both geldings (n=151) and stallions (n=9). Stallions did most likely not decrease the mean BCS of males due to constituting only six percent of the population. Although differences in BCS related to gender was found in the present study, the difference may not be biologically relevant.

5.6 Age in relation to BCS

When comparing age groups of the 424 horses body condition scored in the present study, age had an effect on horse's BCS. Younger age groups (6 months – 3 years, and 3-5 years) had a lower (5-14%) mean BCS than older horses (11-15 years, horses 16-20 years and horses older than 20 years). Horses 6 months – 3 years also had a lower (10%) mean BCS than horses 6-10 years. A lower BCS of younger horses has also been found in other studies. When body condition scoring 96 horses in England, young horses (<4 years) were less likely to be obese than older horses (>4 years) (Giles et al., 2014). The present study also found a positive correlation between age and BCS (r=0.29). Similarly, Thatcher et al. (2012) found increasing BCS with increasing age for 300 horses 4-20 years in Virginia, USA. In another observational cohort study in Northern Virginia investigating risk factors for pasture-associated laminitis in 160 pure- and cross-bred Welsh and Dartmoor ponies, a weak correlation (r=0.16) between age and BCS was found (Treiber et al., 2006). The correlation between age and obesity found in the present and earlier studies is probably due to an elevated energy maintenance level in younger horses due to body growth and physiological development (Staniar, 2013).

Müller and Lindberg (2020) investigated 1443 horses over 20 years (20-42 years, median 24 years) of 40 breeds, and found that BCS decreased with increasing age. The findings by Müller and Lindberg (2020) together with the findings in the present study suggest that BCS increases with age, until a turning point suggested to be over 20 years, when the BCS starts decreasing.

5.7 Breed in relation to BCS

The present study found that horses within some of the studied breeds had a higher mean BCS, and possible a higher risk for obesity. Horses were divided into warm-blooded breeds and cold-blooded breeds (see chapter 3.1.2 Grouping horses according to breed). Most of the cold-blooded horse breeds (n=88/110, 80%) had a BCS higher than 6. This is more than twice the percentage (n=111/314, 35%) of warm-blooded horse breeds with a BCS higher than 6. Robin et al. (2015) also found through owner-reported BCS of 792 horses, that the cold-blooded breeds (draught-type, cob-type, Welsh and other native breeds) had increased risk of being obese. In a study investigating BCS in a hobby horse population in UK, native cobs breeds had 13.61 times the odds of obesity compared to lightweight horse breeds (Giles et al., 2014). Most horse breeds categorised as cold-blooded breeds in the present study are native or primitive horse breeds from Norway and other North-European countries. These native or primitive horse breeds have adapted to advance in sparse and/or harsh environments with limited grazing opportunities (Giles et al., 2014). Hence the cold-blooded breeds may have adapted genetically having 'thrifty' genotyped to survive harsh conditions (Treiber et al., 2006). When primitive horse breeds are stabled in a modern stabling environment and fed energy rich feed throughout the year, without longer periods without deprived feed leading to weight loss, the body condition is difficult to keep at a moderate level (BCS 4-6). Hence it is difficult to keep the energy level at maintenance for cold-blooded horses and simultaneously feed them enough dry matter to satisfy forage requirements recommended by Harris et al. (2016). This is especially a challenge if there are limited options of forage qualities available to feed the horse, due to availability or the stable providing forage.

5.8 Activity in relation to BCS

One might assume that differences in activity level experienced by injured or sick horses could affect the horses BCS compared to active healthy horses. The present study found no difference in BCS between injured horses and competition horses. However, horses with digestive related sickness or injures had a lower BCS than the rest of the non-active horses. Horses with teeth and jaw injuries had the lowest mean BCS (5.33), this is probably due to reduced food intake due to pain and issues related to eating. Furthermore, horses stabled at NMBU with colic would receive restricted feeding to prevent further negative development of illness. If this illness period last for longer periods, it might also explain the lower mean BCS, although no horses were in poor condition.

Most previous BCS studies have excluded injured horses form their study. But when Giles et al. (2014) conducted repeatable BCS of horses and did not exclude horses that obtained injuries between scores. They found that horses in North Somerset, England that got injured between the repeated body condition scoring in the summer and winter had over 5 times increased odds ratio of obesity than hoses not injured horses in this period.

The different categories of use and health status of the horses affected the horses body condition expressed by BCS. When excluding horses with teeth and jaw injuries, Standardbred horses competing in trotting, which were assumed to have the highest activity level, also had the lowest mean BCS (5.41). These horses had a lower BCS than all other competition horses. Horses used for show jumping and dressage, also high activity levels (NRC, 2007), had a BCS within the moderate range with BCS 5.84 and 6.02, respectively. But the present study did not find a difference in BCS between the disciplines. Similar, in New Zealand, 158 horses competing in the disciplines dressage, show jumping and eventing, had no difference in BCS between the disciplines (Verhaar et al., 2014). On the other hand, when studying leisure horses competing at an unaffiliated championship in the UK, dressage horses had a higher body BCS than show jumping horses (Harker et al., 2011).

Cold-blooded trotters had the lowest mean BCS (6.28) of the cold-blooded breads (BCS 6.50). This is probably due to the large part (48%) of the cold-blooded trotters investigated competed in trotting, an activity with high work intensity.

A higher work intensity reduces the horses probability of being overweight (Thatcher et al., 2012). The present study found that competition horses also had a lower BCS (mean 5.84) than horses held for hobby use (BCS 6.24). In a study investigating 237 horses in Switzerland, 38% of hobby horses were over-conditioned (a BCS over 3 described as moderate on Carroll and Huntington scoring system 0-5), versus 19% of the competition horses (Dittmann et al., 2020). Similar, when owners reported BCS for 792 horses in Great Britain, hobby horses were more than two times more likely to be obese (BCS ≥4 out of 5 Carroll and Huntington scoring system) than competition horses (Robin et al., 2015). The difference in BCS in the present study could be because of a higher food intake or a lower energy expenditure, or both, for hobby horses compared to horses competing or training for competition. It can also be because of a higher proportion of professional horse management for competition horses.

5.9 Modelling BCS

In the second part of the discussion, the impact of different single factors affecting the body condition of the horses was presented. Some of these factors are constant within a group of individuals, such as gender and breed of the horse. Other factors can and will vary throughout the lifespan of the horse, for instance age and the activity of the horse. These factors have different effects on the body condition, some increasing BCS, while other decreasing BCS. Weight was not included in the model; this was because the model was made for assessment of BCS in the field where weighing the horse is difficult to do due to lack of equipment. Also, weight of the horse as a variable alone did not influence BCS.

The presented model combines and compares the different variables effects on the body condition, the direction of the effect and how these variables interact. There are several factors that may influence the horse's energy requirements in its daily life and how it responds to activities and feed. Combining these factors, such as in the presented model, has to the present authors knowledge not been published before.

The standard horse (intercept) used in the model was chosen to present a random horse with a BCS close to the mean BCS of 5.98 for all horses in the study. By combining variables, the standard horse had a BCS of 5.83. This horse was a mare (BCS 6.04), with a long-time injury (BCS 6.30), and being of the breed warm-blooded trotter (BCS 5.51).

When comparing all variables, gender and age had a small but significant effect on a horses BCS. The model suggest that the breed of the horse is the variable with the largest effect on the horses BCS.

The aim with the model was to present a tool to help determine factors affecting a horse's BCS, and to which extent. However, the model will not give the true BCS for every horse but may guide the interpretations of the BCS for different kind of horses. When including the specific gender, age, breed and use of the horse, the output would be an estimated BCS for what is common for this type of horse (at the studied locations). The model suggests that especially horses of the breeds Dølahest, Norwegian fjord horse, Icelandic horses and other coldblooded breeds are prone to obesity, and that this should be taken into account when feed planning for these horses.

6. Conclusion

In conclusion, Norwegian horses are mainly fed Norwegian produced and manufactured feeds. Most horses in Norway (90%) are fed Norwegian produced forage. Horses fed imported forage had a lower BCS than horses fed self-produced forage, but this was probably explained by the breed and activity status of the horses rather than the origin of the feed. Sixty eight percent of horses were fed concentrate from Norwegian manufacturers only. The origin of concentrate did not have an effect on BCS, independent of the type of forage fed.

In the present study, the prevalence of overweight horses in Norway, with a BCS over 6, is 47%. Breed, activity, health and use affected the horses BCS. Cold-blooded breeds had a higher BCS than warm-blooded breeds, and out of the cold-blooded breeds 80% were overweight (BCS over 6). When looking at health and activity status, sick or injured horses did not have a lower BCS than active horses, but horses with digestive related problems had a lower BCS than the not active horses. Actively competing horses had a lower BCS than not active horses.

Body condition can be described by a model including gender, age, breed and use. The model suggests that breed of the horse had the largest effect on BCS. Except if the horse has teeth or jaw related injuries or problems.

7. Perspectives

Based on the high prevalence of overweight horses documented in the present study, it is reason to believe that there are room for improvement of the health status in the Norwegian horse population by improving the feeding practice. This might be done by dissemination of knowledge of the consequences of excessive feeding, and how to calculate the optimal type, quality and amount of forage and concentrate for the individual horse. This could for example be done by the Norwegian national horse federations like Norwegian Riding Federation, the Norwegian Icelandic Horse Association, the Norwegian Jockey Club, the Norwegian Trotting Association or breeding organisations. A good example of such a campaign is the “stop lameness”- campaign initiated by the Norwegian Riding Federation and Agria insurance which is widely distributed in social medias.

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Appendix 1

Body condition scoring system 1-9 by Henneke et al (1983).

Table 1. Description of the body condition score developed by Henneke et al (1983).

Score	Grade	Description
1	Poor	Animal extremely emaciated. Spinous processes, ribs, tailhead, tuber coxae and ischii projecting prominently. Bone structure of withers, shoulders and neck easily noticeable. No fatty tissue can be felt.
2	Very thin	Animal emaciated. Slight fat covering over base of spinous processes, transverse processes of lumbar vertebrae feel rounded. Spinous processes, ribs, tailhead, tuber coxae and ischii prominent. Withers, shoulders and neck structures faintly discernible
3	Thin	Fat build up about halfway on spinous processes, transverse processes cannot be felt. Slight fat cover over ribs. Spinous processes and ribs easily discernible. Tailhead prominent, but individual vertebrae cannot be visually identified. Tuber coxae appear rounded, but easily discernible. Tuber ischii not distinguishable. Withers, shoulders and neck accentuated.
4	Moderately thin	Negative crease along neck. Faint outline of ribs discernible. Tailhead prominence depends on conformation, fat can be felt around it. Withers, shoulders, and neck not obviously thin.
5	Moderate	Back level. Ribs cannot be visually distinguished but can easily be felt. Fat around the tailhead beginning to feel spongy. Withers appear rounded over spineous processes. Shoulders and neck blend smoothly into body
6	Moderate Fleshy	May have slightly crease down back. Fat over ribs feel spongy. Fat around tailhead feels soft. Fat beginning to be deposited along the side of the withers, behind the shoulders and along the side of the neck
7	Fleshy	May have crease down back, individually ribs can be felt, but noticeable filling between ribs with fat. Fat around tailhead is soft. Fat deposited along withers, behind shoulders and along the neck.
8	Fat	Crease down back. Difficult to feel ribs. Fat around tailhead very soft. Area around tailhead filled with fat. Area around shoulder filled with fat. Noticeable thickening of the neck. Fat deposited along inner thighs.
9	Extremely Fat	Obvious crease down neck. Patchy fat appearing over ribs. Bulging fat around tailhead, along withers, behind shoulders and along the neck. Fat along inner thighs may rub together. Flank filled with fat.

Body Condition score scale 1-9 adapted by Kienzle and Schramme (2004).

Table 2. Description of the body condition score developed by Kienzle and Schramme (2004).

BCS	Neck	Sholder (Ribs behind ellbow)	Back	Ribcage	Hip	Tailhead (Line: pinbone-tail vertebrae)
1	Side area concave, atlas visible, 3.-6. vertebrae palpable, 4.-5. visible, no crest fat, shelf where neck meets shoulder	Scapula completely visible, 6.-8. rib visible, not possible to form skin folds	Spinous/transverse processes and onset of ribs visible, croup concave, skin not movable	6.-18. rib completely visible, skin not movable	Hip bone prominent, pin bone visible, over sacrum concave, anus sunken in	Individual vertebrae definable, line concave
2	Side area concave, atlas and 4.- 5. vertebrae palpable, no crest fat, shelf where neck meets shoulder	Scapula cranial and spina visible, 6.-8. rib palpable, 7.-8. visible, difficult to form skin folds	Spinous/transverse processes visible, onset of ribs palpable, croup concave, skin not movable	7.-18. rib completely visible, skin not movable	Hip bone prominent, pin bone visible, over sacrum straight, anus sunken in	Individual vertebrae definable, line concave
3	Side area slightly concave, vertebra 4.-5. palpable with pressure, no crest fat, shelf where neck meets shoulder	Spina visible, 7.-8. rib palpable, difficult to form skin folds	Spinous/transverse processes visible, skin not movable	Side area of 7.-18. rib visible, skin not movable	Hip bone prominent, cranial edge sharp, pin bone visible, anus slightly sunken in	Side area of vertebra not visible, line concave
4	Side area straight, vertebrae palpable only under strong pressure, crest fat not higher than 4 cm, slight shelf where neck meets shoulder	Spina partially visible, 7. rib covered, 8. rib palpable, possible to form short skin folds with much tension, skin slightly movable	Spinous processes only at withers visible, skin not movable	11.-14. rib visible, 9.-18. rib palpable, skin a little movable	Dorsal hip bone prominent, cranial edge sharp, pin bone faintly discernible	Outline of vertebra faintly discernible, line slight concave
5	Side area slightly convex, crest fat 4-5,5 cm	Spina faintly discernible, soft tissue over 7. rib, 8. rib palpable, possible to form short skin folds with tension, skin slightly movable	Skin a little movable, 14.-18. rib palpable under slight pressure	Ribs shadowy visible , 10.-18. rib palpable, skin movable	Dorsal hip bone slight prominent, cranial edge rounded, pin bone palpable	Vertebra covered, line straight
6	Side area slightly convex, crest fat 5,5-7 cm	Over 7.-8. rib soft tissue, possible to form short skin folds without much tension, skin slightly movable	Skin slight movable, 14.-18. rib palpable only under strong pressure	Ribs not visible, 14.-18. rib palpable, skin slightly movable	Dorsal hip bone faintly discernible, pin bone hardly palpable, inner buttocks touch each other	Compact fat deposit beside tail vertebra 3, line convex
7	Side area slightly convex, crest fat 7-8,5 cm	Over 7.-9. rib soft tissue, possible to form skin folds without tension.	Soft tissue on croup, over 14.-18. rib fat deposit, possible to form thick skin folds	15.-17. rib palpable, skin slightly movable, over 9.-18. rib soft tissue, finger-tips sink in a little, possible to form skin folds with much tension	Hip bone round, palpable	Soft fat deposit beside tail vertebra 3, line distinctively convex
8	Side area slightly convex, crest fat 8,5-10 cm	Over 7.-9. rib soft tissue, possible to form high skin folds without tension	Soft tissue on croup, thick fat deposit over 14. -18. rib, possible to form thick folds	Ribs barely palpable, skin slight movable, over 9.-18. rib soft, finger-tips sink down distinctly, possible to form skin folds	Hip bone covered, palpable	Soft fat deposit beside 1-3. tail vertebra, line distinctively convex
9	Side area convex, crest fat >10 cm	Fat deposit over withers and rib cage, high skin folds	Fat deposit throughout	Ribs not palpable, fat deposit throughout	Hip bone discernible only as a slight curvature	Fat deposit throughout

Body condition score 1-9 scale adapted by Suagee et al. (2008)

Table 3. Characteristics of individual body condition score in thoroughbred geldings as determined in Suagee et al. (2008).

BCS	Neck Area	Wither Area	Shoulder Area	Rib Area	Loin Area	Tailhead Area
Anatomic Description	From the poll to the 3rd cervical vertebrae	From the top of the shoulder blade to the top of the spinous processes of the 3rd, 4th, and 5th vertebrae	Between scapula/ triceps muscle and barrel	The side of the horse; including the 6th through 12th ribs	Lumbar vertebrae	Caudal sacral vertebrae to tuber ischii
4	Small amount of fat deposited on crest of neck with slight depression in front of withers, otherwise flat between the poll and withers	Wither prominence depends on conformation. Shape of spinous processes visible. Fat begins to accumulate around transverse processes.	Point of shoulder easily identified. Top of scapular spine may be visible. Some fat felt but area is concave in appearance.	Central ribs visible (ribs 6-12) with others easily felt.	Some filling around sides but tops of spinous processes easily visible.	Tailhead prominence depends on conformation. Spinous processes of sacral vertebrae visible with little fat fill on sides. When viewed from side, some fat accumulation but concave in appearance.
5	Even deposition of fat along crest of neck, creating a smooth nearly flat line between the poll and the withers.	Fat accumulating from top of shoulder blade to point of withers lending a nearly flat appearance.	Fat fill in shoulder area creates smooth transition from shoulder blade to barrel though slightly concave. Can no longer identify scapular ridge.	Ribs cannot be visually distinguished, but can be easily felt.	Fat fill along spinous processes makes loin area level.	Fat filled along either side of tailhead, spinous processes of sacral vertebrae no longer visible. Fat along tailhead results in flat appearance when viewed from side.
6	Fat cover on crest of the neck slightly increases height of neck (eg, a ‘‘cresty’’ neck beginning to develop).	Fat fill results in flat appearance of withers.	Fat fill appears convex and increasing in size ventrally.	Fat laid down between ribs, making them difficult to distinguish from each other. Can be felt with direct pressure.	Fat beginning to accumulate above spinous processes, creating a slight depression.	Fat fill slightly convex in appearance.
7	Obvious crest with fat fill increasing the width of neck. Fat fill along crest filled in cranially and caudally. Fat laid down in front of shoulder, at point where neck and body meet.	Fat fill convex in appearance.	Fat fill Causes obvious convexity and had increases in size ventrally to encompass the area just behind the point of the elbow.	Noticeable filling between and on top of ribs. Individual ribs can be felt but difficult, even with direct pressure.	Fat accumulated above spinous processes creating an obvious depression on the loin area.	Fat fill above level of bony processes of tail head.

Body condition score 0-5 scoring by Carroll and Huntiongton (1988).

Table 4. Characteristics of individual body condition score 0-5 system for a variety of breeds as developed by Carroll and Huntington (1988).

Score	Description	Neck	Back and Ribs	Pelvis
0	Very poor	Marked 'ewe', neck narrow and slack at base	Skin tight over ribs Spinous processes sharp and easily seen	Angular pelvis-skin tight Deep cavity under tail and either side of croup
1	Poor	Ewe' neck, narrow and slack at base	Ribs easily visible, skin sunken either side of backbone. Spinous processes well defined	Rump sunken, but skin supple. Pelvis and croup well defined. Deep depression under tail
2	Moderate	Narrow but firm	Ribs just visible. Backbone well covered Spinous processes felt	Rump flat either side of backbone. Croup well defined, some fat. Slight cavity under tail
3	Good	No crest (except Stallions), firm neck	Ribs just covered - easily felt No 'gutter' along back. Spinous processes covered, but can be felt	Covered by fat and rounded. No 'gutter'. Pelvis easily felt
4	Fat	Slight crest, wide and firm	Ribs well covered - need firm pressure to feel 'Gutter' along backbone	'Gutter' to root of tail . Pelvis covered by soft fat -felt only with firm pressure
5	Very fat	Marked crest, very wide and firm, folds of fat	Ribs buried -cannot feel Deep 'gutter' Back broad and flat	Deep 'gutter' to root of tail. Skin distended Pelvis buried-can not feel

Cresty Neck Score 0-5 scale developed by Carter et al. (2009).

Table 5. Description of Individual Cresty Neck Scores by Carter et al. (2009).

Score	Description
0	No visual appearance of a crest (tissue apparent above the *ligamentum nuchae*). No palpable crest
1	No visual appearance of a crest, but slight filling felt with palpation
2	Noticeable appearance of a crest, but fat deposited fairly evenly from poll to withers. Crest easily cupped in one hand and bent from side to side
3	Crest enlarged and thickened, so fat is deposited more heavily in middle of the neck than toward poll and withers, giving a mounded appearance. Crest fills cupped hand and begins losing side to side flexibility
4	Crest grossly enlarged and thickened and can no longer be cupped in one hand or easily bent from side to side. Crest may have wrinkles/creases perpendicular to topline
5	Crest is so large it permanently droops to one side

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