Feeding and management practices in the New Zealand Sport Horse industry

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Millicent Ferguson-Wilson

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Supervisors: C.W. Rogers and E.K. Gee

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Abstract

Nutrition is a vital component of sport horse performance, ensuring they have sufficient energy to maintain condition as well as perform the demands of their sport. Nutrition as it concerns specifically to sport horses in New Zealand is a neglected topic of research. The aim of this paper was to describe the feeding practices and supplement use in New Zealand horses competing in the disciplines of dressage, eventing, show jumping, showing, western riding, and within pony club events. Data were collected via an online survey using Qualtrics Survey Software, obtaining a total of 364 valid responses, which could be taken to be an accurate distribution of the national herd, based on discipline and demographics. The overall mean bodyweight of horses in the survey was 540.7 kg, with horses involved in dressage, eventing, and show jumping tending to be heavier than other disciplines, and dressage horses being the heaviest overall. Overall mean ideal body condition score was 5.4, with showing and western horses having a significantly higher ideal BCS, at 5.9. Many (65.5%) of the horses had continuous access to pasture, with little variation between disciplines. Pasture management was typically rotational grazing, with a mean paddock size of 1.0 Ha. Pastures were most commonly ryegrass & clover, as is expected with New Zealand pastures, however many respondents (32.4%) were unsure what pasture type was sown on the grazing property. Horses were usually offered concentrates twice a day, however concentrates were only offered to most pony club horses once per day. Most (90.3%) responders fed hay in addition to the pasture that was grazed, and 80.9% fed concentrates. The mean quantity of concentrates fed per day was 1.9 kg as fed, with no difference between disciplines. The mean digestible energy supply per day was 81.8 MJ (range 0 - 369.5 MJ), with little variation between disciplines. This accounted for approximately 80% of the horse’s daily DE requirement, with the remainder assumed to be consumed from pasture. Many (89%) respondents reported the addition of dietary supplements into their horse’s daily ration. The most popular supplements fed were salt, bone and joint, mineral/vitamin balancer, digestion aid, and toxin binders. Important future research would be to quantify nutrient profile trends for all major nutrients in sport horse diets, and to quantify pasture intake and include it in nutrient profiles.

Chapter 1: Introduction

The sport horse industry in New Zealand is rapidly growing and intensifying, with increased focus on competitive performance, especially as riders seek international recognition. However, little research has been conducted examining the management and nutrition of these horses. This should be prioritised in order to optimise feeding management and maximise the performance of horses.

A sport horse is defined as horses participating in one of the three Olympic equestrian disciplines - dressage, eventing, and show jumping (Creagh et al., 2010). In this survey, this definition has been extended to cover other major disciplines in New Zealand - showing, western, and pony club, to gain understanding of the current feeding and management practices of all competitive horses outside the racing demographic. The New Zealand sport horse industry currently does not have requirements for the registration of horses into a central database, which results in limited documentation of the genetics and makeup of the national herd (Bolwell et al., 2020). The next steps for the industry should include quantifying current management practices, in order to identify or modify best practices that promote the health and performance of sport horses (Bolwell et al., 2020).

The New Zealand agricultural industry has a large reliance on pasture, which is reflected in the equine industry. Pasture is believed to be an important nutrient source for horses in New Zealand, which is in contrast to many Northern Hemisphere equine management systems (Randall et al., 2014). Horses are typically housed in single stalls, and pasture turnout is limited (Werhahn et al., 2012). This system places little attention on the associated health problems of high concentrate diets and limited turnout, which can include gastric ulcers, colic, and an increased risk of laminitis. What is known of the management of horses in New Zealand is that it is very much in contrast to the overseas model. As a result, research into the management and nutrition of horses which is not New Zealand based does not provide accurate data towards the topic as it applies in New Zealand. However, previous Northern Hemisphere studies have identified issues of high starch diets (Burk & Williams, 2008; Geor, 2007), as well as oversupplementation with dietary supplements (Hoffman et al., 2009). It is important to identify whether these issues exist and need to be identified in the New Zealand equine industry.

I. Objective

The aim of this study is to describe the feeding practices and supplement use in New Zealand horses competing in the disciplines of dressage, eventing, show jumping, showing, western riding, and within pony club events, whilst at home in spring, just prior to the beginning of competition season.

II. Hypothesis

It is hypothesised that there would be significant differences in the feeding management between each of the disciplines. It is predicted that there will be little difference in the quantity of concentrate consumption between New Zealand sport horses and overseas, regardless of discipline. It is also predicted that, regardless of discipline, horse diets will reflect at least 50% of the nutritional requirements of horses based on NRC, with adjustment for pasture intake.

Chapter 2: Literature review

The horse is a browsing and grazing monogastric herbivore, spending large quantities of time consuming a variety of forages. Horses are able to efficiently break down plant cell walls and digest forages using a process known as microbial fermentation in the hindgut, similar to the role of the rumen in a ruminant. This microbial fermentation process provides the horse with its major source of energy.

Modern day management systems, for example that of sport horses, normalises the feeding of grain, rich in hydrolysable carbohydrates. Grains provide a more efficiently digested ration than structural carbohydrates and hence provide a rich form of energy to satisfy the performance demands of sport horses. However, this management system can conflict with the function of the horse's gastrointestinal tract and contribute to health concerns due to a lack of forage in their diet.

1. Digestion

1.1 Features of the gastrointestinal tract

Mouth: Horses ingest food using their teeth, lips, and tongue. Molar teeth at the back of their mouth are used for chewing and grinding their food, reducing food particles to a size and form that is more appropriate for digestion, approximately 1.6mm (Merritt & Julliand, 2013).

Food ingestion also stimulates the production of saliva from the parotid gland. Adult horses secrete up to 35-40 litres of saliva per day, with a pH of approximately 9 (Merritt & Julliand, 2013). The composition of equine saliva is mostly water and acts primarily as lubrication for swallowed ingesta and buffering of gastric contents. Saliva does not contain any digestive enzymes (Merritt & Julliand, 2013).

Stomach: Ingesta enters the stomach via the oesophagus. The equine stomach comprises only about 8% of the total gastrointestinal tract. The stomach produces hydrochloric acid, secreted by parietal cells in the fundic mucosa. There is a constant, basal secretion of hydrochloric acid, even when the stomach is empty, which increases in the presence of food. The stomach has an acidic pH, which decreases further when horses are fed high grain, low forage diets (Andrews et al., 2005); which suggests that high forage diets, especially diets rich in lucerne, may protect the stomach from an excessively acidic pH, due to buffering effects of high calcium and protein contents of lucerne (Lybbert, 2007).

The stomach also secretes digestive enzymes pepsin and lipase. The main function of the stomach is to hydrolyse protein and partial digestion of carbohydrates. Starch (non-structural carbohydrates) can be hydrolysed into lactic acid, but very little digestion of structural carbohydrates can occur, due to the absence of cellulytic microorganisms (Merritt & Juliand, 2013).

Small intestine:
The small intestine is divided into 3 main sections: duodenum, jejunum, and ileum. The equine small intestine is approximately 25m long, which is relatively short considering the horse's size. Pancreatic and bile secretion in the horse is continuous, due to the lack of a gall bladder. Pancreatic and intestinal enzymes within the small intestine hydrolyse nonstructural carbohydrates, proteins, and dietary fats - in conjunction with bile salts (Merritt & Juliand, 2013). The end products of this digestion, including glucose, nitrogen, and long-chain fatty acids are absorbed across the intestinal wall into capillaries and satisfies some of the horse's basal energy and nitrogen requirements.

Large intestine:
The large intestine in the horse is highly developed, designed to digest and absorb plant-based structural carbohydrates which the small intestine cannot digest. It contains microorganisms which can break down plant cell walls (Merritt & Juliand, 2013). Volatile fatty acid, electrolyte, and water absorption also occurs across the large intestine.

1.2 Microbial fermentation

Microbes in the large intestine break down structural carbohydrates from plants. Volatile fatty acids (acetate, propionate, and butyrate), in addition to carbon dioxide and methane by-products are produced by the microbial fermentation of carbohydrates. These VFAs are absorbed through the wall of the colon, and are available as a major energy source to the horse (Merrit & Juliand, 2013).

2. Feed Requirements

2.1 Energy

The first limiting nutrient in most animals' diets is energy. This is the nutrient which will first run out in a limited supply. The energy available from food sources in horse diets is described as digestible energy, and is calculated from the gross energy content of the food minus energy present in faeces. It is not the most accurate method due to the presence of

endogenous losses and undigested food, but is the most practical to measure in horses. Energy is typically described in joules (J) or calories (NRC, 2007).

Maintenance energy is the basal amount of energy required by the horse. This is the minimum requirements for animal function, and is influenced by age, body condition, diet, and living conditions (Rogers et al., 2017). For any additional functions above maintenance, that being production, gaining body condition, growing a foal, or lactating, additional energy is required, proportional to what is expended (Rogers et al., 2017). For sport horses, energy for physical activity is often an important consideration, providing sufficient dietary energy for the horse to run, jump, and perform as necessary for its discipline.

The NRC identifies four main categories of activity. Most activities involving sport horses will fit under one or more categories. These are: light (recreational and occasional showing), moderate (school horses and frequent showing), heavy (polo, ranch work, low-level eventing), and very heavy (racing, endurance, elite-level eventing) (NRC, 2007; Williams & Burk, 2010). If insufficient energy is provided for the horse's demands, the result will be the mobilisation of body fat as fuel, and subsequent loss of body condition (Williams & Burk, 2010).

The major source of dietary energy for the horse is carbohydrates, from plant origin (NRC, 2007). Volatile fatty acids, fermented from structural carbohydrates in the hindgut, contribute approximately 50-70% of the horse's energy requirements (Fernandes et al., 2014a). These originate from roughage digestion. Due to the cell wall presence, roughage is unable to be hydrolysed enzymatically in the small intestine, and hence must be microbially fermented in the hindgut (Hoffman, 2013).

Non-structural carbohydrates provide the other major energy source. These are primarily starch-based from grain or cereals (NRC, 2007). They are digested mainly in the small intestine, by enzymatic hydrolysation, and are broken down into simple sugars, usually glucose, which is converted readily into ATP (NRC, 2007; Hoffman, 2013).

Fats are a lesser used source of dietary energy. These are obtained by the addition of oil in a horse's diet. Fats are triacylglycerides, which undergo beta-oxidation to yield ATP (NRC, 2007). They provide 2.25 times more energy per unit weight than glucose, and hence dietary fat can be beneficial to increase the energy density of a horse's diet, as an alternative to a high-starch grain diet (NRC, 2007; Warren & Vineyard, 2013).

2.2 Crude protein

Protein is a necessary component of a horse's diet, providing amino acids which have many vital roles within the body, including structure, enzymes, nutrient transport, and immune system components (Urschel & Lawrence, 2013). Horses also have a requirement for nitrogen in the caecum for microbiota health, this is obtained through the breakdown of protein (Trottier & Tedeschi, 2019).

Horses have a maintenance requirement for crude protein of approximately 788 - 1263 mgCP/kgBW, which equates to approximately 0.69 kgCP/day in a 545kg horse (NRC, 2007; Trottier & Tedeschi, 2019). Lysine, being the first-limiting amino acid, also has dietary requirements outlined by NRC. Maintenance lysine requirements are approximately 36-54 mg/kgBW or 30 g/day for a 545 kg horse (NRC, 2007; Trottier & Tedeschi, 2019). Sport horses will have additional protein requirements, due to muscle development and repair, as well as significant amino acid loss through sweat (Dunstan et al., 2020). Additional protein requirements for exercising horses range from 0.089 gCP/kgBW/day for light exercise to 0.354 gCP/kgBW/day in very heavy exercise (NRC, 2007).

Protein digestion occurs in the small intestine, via proteolytic enzymes and peptidases in the intestinal brush border (Trottier & Tedeschi, 2019). They are broken down into free amino acids, which enter the bloodstream for utilisation, and nitrogen. Pre-caecal protein digestion only contributes to approximately 11% of whole GIT apparent protein digestion, due to the fast passage time through the small intestine; however protein digested microbially in the caecum is unavailable to the body (Trottier & Tedeschi, 2019). The result of this is the necessity to provide high-quality protein, especially to sport horses with increased protein requirements, to maximise the proportion of protein which is pre-caecally digested and hence available to the body. The best feedstuffs to achieve this are grain or low-lignin forages, such as fresh pasture (Trottier et al., 2016). As New Zealand horses typically consume diets high in fresh pasture, protein is not usually a major limiting nutrient in diets.

2.3 Minerals

Minerals are important in diets due to their roles in metabolism and homeostasis. They aid in transformation of energy, but do not produce any energy themselves (Biricik et al., 2005). Minerals are divided into two groups: macro-minerals and trace elements. Macro

minerals are necessary in higher quantities than trace elements (NRC, 2007). Minerals have individual requirements, but are also important in ratios with other minerals, due to their interactions in absorption, metabolism, and excretion (Kinezle & Zorn, 2006). Calcium, phosphorus, magnesium, potassium, sodium, and chloride are considered the most important macrominerals in horse diets (NRC, 2007). Of the trace elements, selenium, copper, manganese, iodine, zinc, iron, fluoride, and cobalt are considered the most important (NRC, 2007). These minerals have daily dietary requirements, outlined by the NRC. These must be met by the diet, either from naturally occurring in forages, included in premixed grains, or added into supplementary feed. Mineral imbalances, either in over-consumption resulting in toxicity or under-consumption resulting in deficiency, can cause serious health problems (Zhao & Muller, 2015). Mineral intakes in accordance with NRC recommendations have been shown to improve animal performance, growth rates, and reduce the prevalence of clinical signs of disease (Grace et al., 2002).

2.4 Vitamins

Vitamins are defined as a group of complex organic compounds, essential for normal metabolism, and act as antioxidants preventing tissue damage by free radicals (Mcdowell, 2001). Vitamins are divided into two classes: fat soluble (A, D, E, and K), and water soluble (B and C) (NRC, 2007). Horses are conditionally able to synthesize vitamins to some capacity, so do not require dietary provisions of some vitamins - mainly K and C (Zeyner & Harris, 2017). The most important vitamins considered for supplementation in horses are A and E. However, most horses managed on sufficient pasture will receive enough of these vitamins without additional supplementation (Hammer, 2010).

2.5 Roughage

Due to horses' evolution as grazers on grasslands, their digestive tract is designed to facilitate forage digestion as opposed to other feed types, such as starch (Hoskin & Gee, 2004). Although NRC (2007) does not recognise a direct requirement for forage in horse diets, it is widely accepted that insufficient forage can result in several common health conditions (NRC, 2007).

Gastric ulcers are associated with excessive starch consumption or low roughage consumption. Horses consuming a high fibre diet have increased saliva production due to increased mastication. Saliva, which is basic, acts as a buffer against an acidic pH in the stomach, associated with high quantities of grain consumption (Hammond et al., 1986; Bell et al, 2007).

Colic, defined as apparent abdominal pain, has many contributing causes. One of the major risk factors is insufficient roughage intake, due to interruption of the natural grazing cycle (10-15h/day). This can lead to microbial perturbations, decreased intestinal pH, and disruption of gut motility, thereby causing the horse to colic (Veneable et al., 2017). Restricted access to pasture/forage has also been linked to increased stereotypic behaviours (Goodwin et al, 2002; NRC, 2007).
NRC (2007) has recommended that horse diets should contain no less than 1% of the horse's bodyweight as forage per day (on a dry matter basis). However in natural settings horses grazing pasture have been recorded to consume a minimum of 1.5% and up to 3% of their BW of pasture DM per day (NRC, 2007).

3. Pasture in NZ

3.1 Pasture availability

New Zealand's temperate climate provides favourable conditions for year-round grass growth. Relatively mild weather conditions compared to other countries also facilitate year-round access to pasture turnout for horses and other farmed livestock (Verhaar et al., 2014; Randall et al., 2014). Due to this, the New Zealand equine industry has a large reliance on pasture as a nutrient source (Randall et al., 2014).

The most common pasture type for grazing livestock in New Zealand is perennial ryegrass (*Lolium perenne*). It is typically sown as a mixture with white clover (*Trifolium repens*), in a ratio of 80-95% perennial ryegrass, 5-20% white clover (Hoskin & Gee, 2004). Pastures for grazing horses need to be resistant to treading and periods of overgrazing (Rogers et al., 2017). Perennial ryegrass is ideal for this purpose, as it is a perennial species, meaning it does not need to be resown every year, and maintains reasonable growth year-round in the New Zealand climate, as well as being resistant to trampling damage (Rogers et al., 2017).
Another vital feature of perennial ryegrass in its suitability for horse pastures, is its relatively high nutritive value. This allows it to provide almost all essential nutrients horses require, with only some additional feed required, depending on seasonal pasture growth rates and energy requirements of stock (Hoskin & Gee, 2004). A table of average nutrient composition can be found below.

Table 1: Estimated nutrient composition of pasture on NZ equine farms (Rogers et al., 2017)

	Spring	Summer	Autumn	Winter
Metabolisable energy (MJ/kg DM)	12.6	9.3	10.7	11.2
Crude protein (% DM)	27	19	21	23
Lipid (% DM)	4	2	3	4
Acid detergent fibre (% DM)	22	28	25	24
Neutral detergent fibre (% DM)	39	56	43	43
Ash (% DM)	11	10	11	11
Soluble CHO (% DM)	11	5	11	11
Organic matter digestibility (% DM)	86	64	75	77

Perennial ryegrass also has a relatively high digestibility at 0.64. This is higher than what has been reported for hay (0.46-0.55), but lower than that of grains (0.86-0.9) (Rogers et al., 2017). When grazing is unrestricted, the feeding value of pasture means it provides adequate nutrient levels for horses on maintenance requirements. In spring, for example, the feeding value may be too high, which can result in obesity if not managed carefully (Hoskin & Gee, 2004). One of the major nutrition issues in grazing pasture is the protein content. This is consistently high (Table 1), and well above the protein requirements for horses even under intense exercise conditions (11.4% CP) (Hoskin & Gee, 2004). Despite the high protein content, perennial ryegrass pasture has a relatively low energy density, which means some high performance sport horses may not receive sufficient energy grazing pasture alone (Hoskin & Gee, 2004). Despite this, perennial ryegrass pasture generally provides sufficient nutrients for most classes of horse. For horses with nutrient requirements greatly above that of maintenance some supplementary feeding may be required, for example sport horses in intense exercise conditions.

Pasture growth and quality is highly seasonal, and generally sets the limit for utilisation by horses (Hirst, 2011; Rogers et al., 2017). Growth and quality is generally at its lowest point during winter, when some form of supplementary feed is usually necessary to meet

nutritional demands, and is best over spring (Hirst, 2011; Rogers et al., 2017). This pattern can be seen in the blue line curve in the diagram below (Figure 1). For most classes of horses, nutritional demands are fairly constant throughout the year, with increases in feed demand in broodmares close to parturition and in lactation. The curve shown in the diagram below (Figure 1), shows that the average pasture cover is in excess of feed demand for most months of the year. However sport horses with high energy requirements due to exercise may have different feed demands than Thoroughbred broodmares, which would change the shape of the graph. The general trend displayed in this graph is that for most of the year, average pasture cover exceeds feed demand, and suggests that feed demand for the average will be able to be met by grazing pasture.

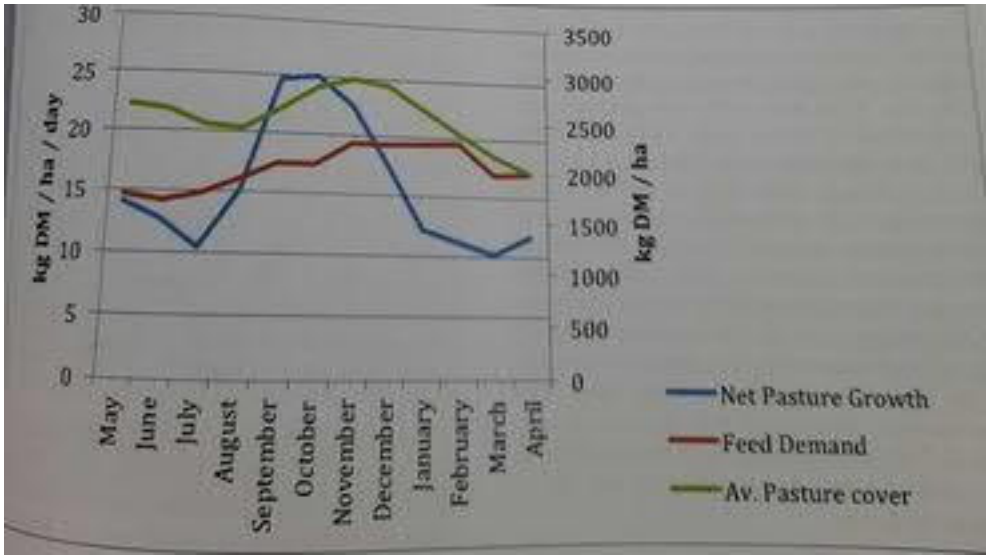


Figure 1: Daily net pasture growth and daily feed demand and monthly average pasture for a typical commercial Thoroughbred stud farm. Retrieved from (Rogers et al., 2017).

3.2 Grazing behaviours

Despite the physical availability of pasture, horses have several grazing behaviours which are likely to impact the true feed availability. There are vast differences between individuals in their grazing behaviours as well as breed differences in feed conversion efficiency, which can pose difficulties in estimating whether dry matter availability will be sufficient for the individual horse (Rogers et al., 2017; Rogers et al., 2018).

Horses are selective browsers, frequently rejecting ingested food from their mouths, which they have determined as unpalatable. The result of this is a high degree of wastage (Hirst, 2011). Horses will preferentially select grasses that are higher in sugars and low in fibre, which have a higher ratio of non-structural:structural carbohydrates, despite their evolution

to consume high fibre forages. This means within pasture systems horses will preferentially consume lush, green pasture over older, dry pasture (Randall et al., 2014; Rogers et al., 2017).
In a study comparing sward height preference, comparing heights; horses were found to prefer taller 17, 11, and 6cm pasture sward heights, though consumption did not vary between pastures (Rogers et al., 2017). This has been proposed as due to an optimal foraging model, where horses will preferentially choose taller sward heights to maximise feed intake per mouthful (Edouard et al., 2009).

A major grazing behaviour displayed by horses is latrine avoidance. Horses will avoid grazing in areas self-designated as defecation sites. This creates major uneven grazing, with heavily grazed lawns, and roughs around defecation sites where pasture grows longer and denser without grazing pressure. Roughs contain a large proportion of the pasture mass, but is considered by horses as inedible, and impedes pasture utilisation (Hoskin & Gee, 2004; Rogers et al., 2017; Rogers et al., 2018). Horses tend to return to the same preferred feeding place until it is overgrazed - lawns diminish, defoliate, and soil erosion occurs (Chin et al., 2019). In a study involving weanling thoroughbreds, when pasture DM fell below 1500 kgDM/ha the horses began to consume areas identified as roughs (Rogers et al., 2017). It is likely that this behaviour will occur in all classes of horse, to some extent, and it can be assumed that increasing grazing pressure could manage the presence of roughs (Fleurance et al., 2016). Cross grazing with other species, such as sheep or cattle, has been suggested to manage roughs, as they do not display the same latrine avoidance behaviour as horses (Rogers et al., 2017).

Horses are good at adjusting their foraging behaviour to adapt to the feed quality and quantity in order to optimise their voluntary feed intake. This involves altering latrine avoidance behaviour and becoming less picky about acceptable plant species, in order to maximise use of forage available in the habitat (Fleurance et al., 2012).

In feral populations, horses spend up to 16 hours per day grazing, covering approximately 16 km each day in social groups, between grazing sites around a central water source (Hampson et al., 2010; Hoskin & Gee, 2004). This behaviour reduces grazing pressure on smaller grazing sites and facilitates latrine avoidance behaviours. In domestic populations, this behaviour is significantly restricted due to the confinement of horses to a smaller space.

3.3 Endophyte

In New Zealand Perennial ryegrass is infected with a symbiotic fungus, producing the endophyte lolitrem B. This is a toxin which is heavily associated with ryegrass staggers in horses (Rogers et al., 2017). Pasture utilisation does not appear to differ between the presence or absence of endophyte within the pasture (Randall et al., 2014). This suggests that horses may not be able to identify the toxin in pasture.

Endophytes are important in grasses, especially the different varieties of ryegrass - annual, perennial, Italian; as well as Tall Fescue. They are important in ensuring persistence of the grass by protection against insect or heat damage. The lolitrem B endophyte offers protection against the argentine stem weevil, a common insect pest in New Zealand (Hoskin & Gee, 2004).

Each pasture variant contains a different strain of endophyte, lolitrem B being the main endophyte of concern to horse health. However, the tall fescue endophyte can have negative impacts on the growth and development of young horses (Hoskin & Gee, 2004). Most modern grasses for horse grazing are modified to not contain lolitrem B endophyte, and instead are infected with novel endophyte, AR1 being most common, which do not cause ryegrass staggers or alternative health conditions to the horse. However still provide protection for the grass against the argentine stem weevil (Hoskin & Gee, 2004). Novel endophytes are also available for Tall Fescue, which are not toxic to horses.

3.4 Paddock size

Ideal paddock size is an understudied topic in New Zealand. In one study involving sport horses, it appeared that paddock sizes were small, at a median of 0.44 Ha, which was believed to be sufficient for a single horse or pair (Verhaar et al., 2014). In comparison, thoroughbred stud farms reported a grazing paddock size of 1.5-2 Ha (Stowers et al., 2009). However, optimal paddock size is dependent on stocking density. Stud farms tend to run larger mobs of horses in a single paddock; whereas sport horses appear to be kept in individual paddocks, with many (46%) being paddocked alone (Verhaar et al., 2014). Although, it is likely that horses will have a shared fence-line with another horse for social contact. Horses evolved living in herds, roaming and browsing forage in large spaces. However modern management systems are likely to heavily restrict this behaviour. To improve the welfare of horses, natural social and grazing behaviours need to be taken into account.

The New Zealand Code of Welfare (2018), which governs the management of horses and other livestock and pet species, does not currently provide provisions for the ideal paddock size for horses. Their only recommendation is that the pasture needs to be "… appropriate to the age, physiological state, level of work and breed of horse" (New Zealand Government, 2018, p.7). New South Wales guidelines, the only code of welfare that could be found that contained paddock size recommendations for horses, stated that paddock size should be approximately 1 Ha, with 0.4 Ha being the minimum for a single horse (New South Wales Government, n.d.). These regulations provide the horse with adequate space for free exercise, as well as the capability of the land mass to provide sufficient forage.

4. Feeding and management systems

4.1 Racehorses in New Zealand

The current management systems of racehorses frequently utilise stabling and high grain diets. The most common management system observed in previous studies was a mixture of stabling with some pasture access (125 of 171 horses), followed by full-time stabling (16/171 horses) (Bell et al., 2007). Only 13 horses in the sample population were found to be managed entirely on turnout. A similar study observed that 97% of thoroughbreds were stabled in a 5m x 5m area for at least 12 hours/day, with 50% of the sample population of horses under the care of 16 North Island trainers, having no access to pasture (Williamson et al., 2007). The most likely reasoning for this is based on the increasing restriction of land availability for racehorse turnout - too many horses to manage and a lack of landmass available, due to urbanisation and housing development (Williamson et al., 2007). It is also likely that the New Zealand racing industry is facing pressure to reflect the intensive management of racehorses overseas (Williamson et al., 2007).

Energy requirements for racehorses are estimated to be over twice that of a horse at maintenance, based on NRC recommendations (Nielson, 2013). This is unable to be met by forage alone, which highlights the importance of alternative energy-rich supplementary feed. Inadequate energy intakes can result in rapid onset of fatigue and reduced performance (Nielson, 2013). High starch diets, such as concentrates or grain, easily meet the high energy requirements of racehorses (Richards et al., 2006). However, excessive starch consumption can predispose horses to gastric ulcers and colic, due to gastrointestinal tract disruption (Nielson, 2013). In racehorses presenting with recurrent exertional rhabdomyolysis (RER), known in the industry as 'tying-up', it is important to

restrict starch intake in order to manage symptoms (Woods et al., 2019). There have been some reports of the feeding of fats and oils as an energy source. These are low in starch and hence do not pose any digestive issues to the horse. They can be included up to 10% of the diet and have been reported to improve glycogen utilisation (Nielson, 2013; Hughes et al., 1995). In recent studies, 62% of Thoroughbred trainers were reported to feed oil or an alternative fat source (Wood et al., 2019).

The typical diet of a New Zealand Thoroughbred racehorse has been reported to be comprised of red clover hay, oats, lucerne chaff, and a commercial premixed grain - NRM sweet feed. The total diet provided approximately 9.36 kgDM/day, with a gross composition of 112.3 MJME/day and 1253 gCP/day (Firth et al., 2004). These values were in accordance with NRC recommendations for horses in intense exercise, which cites 111.3 MJME/day and 1195 gCP/day. A recent New Zealand study found Thoroughbred racehorses were offered a total of 140.92 MJDE/day and 1546.79 gCP/day. Concentrates provided the greatest proportion of nutrients (Wood et al., 2019). In comparison, Standardbred racehorses from the same study were reported to be offered a total of 106.37 MJDE/day and 1011.96 gCP/day, and offered 4.96 kgDM of concentrates each day (Wood et al., 2019). Standardbred racehorses tend to be smaller and thriftier than Thoroughbreds, as well as generally having a higher level of pasture access than Thoroughbreds (Wood et al., 2019). In general, racehorses were in positive energy balance and the diet provides sufficient nutrients to allow these horses to perform as desired without having to mobilise body fat to obtain energy (Firth et al., 2004). NZ studies have reported racehorses receiving an average of 5.5 kg/day (Williamson et al., 2007), and 6.55 kgDM/day (Wood et al., 2019). In contrast, Australian studies have reported 7.3 kg grain fed per day (Richards et al., 2006).

4.2 Management of sport horses

4.2.1 Turnout

The most widespread management system of sport horses is intensive, and is similar to that reported in racehorses. Sport horses are typically housed in single stalls, with limited access to pasture and roughage (Sauer et al., 2019). Turnout is usually restricted due to perception of increased risk of injury and reduced performance (Werhahn et al., 2012). In the off-season from competition (winter and autumn), cold climates with snow or high rainfall can restrict the availability of safe turnout (Werhahn et al., 2012).

In a United Kingdom study, of 2,450 dressage horses, it was found that 27% of the sample population had no access to turnout, 9% were turned out for over 90 hours per week, and only 3% were field-kept 24/7. The majority of the horses were turned out between 15-60 hours per week, which equates to approximately 2-8 hrs/day (Walters et al., 2008). Another study reported mean daily pasture access in the United Kingdom to be between 9 and 13 hrs/day (Burk & Williams, 2008). In New England, USA, the mean turnout time was surveyed as 2hrs/day (Hoffman et al., 2009). Turnout times will vary significantly between regions and countries, based on climate and the trends within that region. The appropriateness of this type of management system on the welfare of horses has been debated (Werhahn et al., 2012).

In New Zealand, the model of sport horse management is vastly different. As New Zealand has a mild, temperate climate, it allows horses to be kept at pasture year-round (Verhaar et al., 2014). Most sport horse owners in New Zealand also keep their horses at their own property, rather than at a livery yard, as is popular overseas (Verhaar et al., 2014). This allows for a more personalised management system that suits the owner and individual horse's needs, rather than having to follow a management system structured by a livery yard. Published preliminary data indicates that the New Zealand management system for sport horses differs from what has been reported in Europe. Most (68%) of New Zealand sport horses were found to be kept at pasture 24/7 (Verhaar et al., 2014); with even top level sport horses having access to turnout for 9-12h/day when not at competitions (Rogers et al., 2017). (Table 2) below (Dijkstra et al., 2016) outlines the time spent at pasture during the competition season and in the winter off-season for dressage and show jumping horses in New Zealand. The data shows the majority of horses being turned out for greater than 12h/day, during both the competition season and winter. It has been proposed that the New Zealand management systems are a combination of ease of management and recognition of the benefit of free exercise on musculoskeletal health and behaviour (Dijkstra et al., 2016).

Descriptor	Show Jumping	Dressage	Total
At pasture >12 h/d			
During competition season	68% (46/67)	89% (26/29)	74% (71/96)
During winter	80% (54/67)	51% (15/29)	72% (69/96)

(Table 2): Table showing turnout prevalence in populations of New Zealand show jumping and dressage horses. Adapted from Dijkstra et al., 2016.

4.2.2 Diet

The primary goal of feeding a sport horse is to provide nutrients in optimal quantities, using feed management programmes that allow a horse to perform to its capabilities. Sport horse diets are typically comprised of forage and one or more concentrates, with nutrient balance taking into account activity level, life stage, and individual variation (Hoffman et al., 2009). Sport horse is a diverse term, encompassing horses of many different disciplines and activity levels. The NRC identifies four main categories of activity: light (recreational and occasional showing), moderate (school horses and frequent showing), heavy (polo, ranch work, low-level eventing), and very heavy (racing, endurance, elite-level eventing) (Williams & Burk, 2010). Horses in the 'very heavy' category typically have nutrient levels 1.5-2x that of maintenance (Leahy et al., 2010). Sport horses will fall into one of these categories, usually moderate-heavy; although the category itself will fluctuate throughout the year based on whether the horse is in competition work or not. Thus, the model for feeding sport horses is varied, and one management system is unlikely to suit all horses, or be appropriate throughout the year.

Forage is the most important component of a sport horse's diet and is obligatory in their diet. However, additional feed sources are often necessary to provide sufficient nutrients (Burk & Williams, 2008; Leahy et al, 2010). Horses should consume at least half their diet as forage, which should account for approximately 1.5% of their bodyweight (Burk & Williams, 2008). When provided with unrestricted pasture, horses are expected to consume 2.5% of their bodyweight, although a substitution effect will occur when concentrates are added to their ration (Verhaar et al., 2014). When horses were provided with a mixed diet, concentrates have been noted to provide up to 52% of the horse's daily

digestible energy requirements, with the remaining 48% being obtained by grazing pasture. This may change depending on pasture availability and composition, as well as the quantity of concentrate provided (Verhaar et al., 2014).

It is anticipated that the majority of forage in New Zealand will be provided as pasture, with some hay feeding when necessary (Huntington & Jenkinson, 2001). Pasture is the best form of forage available, as it provides an excellent source of vitamins and protein, as well as being higher in energy and having a higher digestibility than conserved forages (Rogers et al., 2017). However, when pasture is not available in sufficient quantities, or if consumption must be limited for health reasons or stabling, conserved forage is necessary. Conserved forages are available in many forms. In New Zealand, chaff (chopped hay) is common as a method of bulking grain-based hard feeds. The main forms of chaff are reported to be lucerne and oaten, and typically provided at a rate of 3-400g/day (Huntington & Jenkinson, 2001). Meadow and lucerne hays are most common in stabled performance horses or as a supplement to pasture. Haylage is also becoming common due to difficulties in making high-quality grass hay. Horses are typically provided 2.5kg hay or alternate conserved forage per day in New Zealand (Huntington & Jenkinson, 2001).

Supplementary feeds in the form of concentrates/grains are common. Concentrates provide a highly digestible, high energy, nutrient supply which is formulated to meet performance horse's needs (Geor, 2007). Concentrates are usually marketed as balanced premixes, designed for different classes of horses and fortified with additional minerals and vitamins to meet the general requirements of specific horse classes. In New Zealand, these are usually fed as a hard feed in conjunction with chaff and/or ensiled forages to bulk the feed (Verhaar et al., 2014).

Concentrate consumption in sport horses has been widely studied. Sport horses in New Zealand are typically fed premixed grains at lower quantities than in racehorses, or sport horses overseas. This is likely due to most sport horses having a lower workload and thus lower energy requirement than racehorses, as well as the use of pasture in New Zealand sport horse diets. Average concentrate consumption of sport horses in New Zealand has been reported to be 1.7-1.8 kg/day (Verhaar et al., 2014; Rogers et al., 2017). Whereas in the United States, 3* event riders have been reported to offer an average of 13.7 kg/day, whilst Olympic level event horses in Australia were offered approximately 10 kg/day as-fed (Brunner et al., 2012). Show jumping horses in France were offered approximately 4.9kg of grain, whilst in Switzerland show jumping horses were offered 3.1kg on an as-fed basis

(Pratt-Phillips, 2016). Grain consumption should be restricted to 2.5 kg as-fed in a single meal in order to minimise the risk of gastrointestinal issues, such as ulcers (Geor, 2007). Most horses overseas, according to reports, will exceed this consumption even if split over several meals. It appears that horses in New Zealand will not exceed starch limitations, but current information is necessary.

When starch consumption is exceeded, especially in elite performance horses with high energy requirements, alternate energy sources are recommended to reduce the quantity of grain necessary. The primary method of this is to feed fat in the form of oil (Williams & Burk, 2010). Fats provide a slow release of energy, due to being slowly digested and absorbed in the gastrointestinal tract. They can provide up to 20-25% digestible energy (Geor, 2007). There is also increasing marketing of grains that are low in starch, but remain a high source of energy (Geor, 2007). These may be a better alternative than traditional high-starch grains, but may be more expensive due to increased preparation. The prevalence of these low-starch options in current management systems needs to be explored.

In a survey of United States event horses, it was found they were commonly fed a ration consisting of: limited pasture, hay, commercial grain product, as well as supplementation with salt and one or more commercial supplement product (Burk & Williams, 2008). This ration typically provided nutrients (crude protein alongside minerals potassium, calcium, phosphorus and magnesium) 3-21% greater than the NRC recommendations (Burk & Williams, 2008; Williams & Burk, 2010). Similar studies in Australia have noted that many sport horses were sodium deficient, due to a lack of dietary salt; as well as a surprisingly low digestible energy content of the diet (Huntington & Jenkinson, 2001). This may be due to issues in estimating the workload and energy requirements of horses, or poor assessment of feed quality. This data has not been quantified for New Zealand, so it would be interesting to see if this trend observed in Australia carries over to performance horses in New Zealand, or if there has been any change in the 20 years since the publication of the study.

4.2.3 Supplements

The final component of diet formulation for sport horses is supplements. Supplements are used to boost athletic ability or mitigate a problem. They may include substances with metabolic roles or tissue function, but are not necessarily considered essential nutrients

(Geor, 2007). Mineral and vitamin supplements are available, but these are less common due to the fortification of pre-mixed concentrates with minerals and vitamins. These are popular for horses that do not receive concentrates, or have known mineral deficiencies. Supplements are traditionally available in a powdered form, offered in small quantities in a hard feed. The common supplements provided to sport horses include magnesium, joint supplements, amino acids, biotin, electrolytes, and salt (Verhaar et al., 2014; Pratt-Phillips, 2016). Salt is perhaps the most vital supplement for sport horses. There are significant sodium losses through sweat, which cannot be compensated by a pasture and grain diet, and hence must be provided as a supplement (Jansson & Dahlborn, 1999). Sodium is offered by salt (sodium chloride) addition into hard feed or as a mineral block in the paddock. Salt is only present at rates of approximately 3g/kg in most commercial feeds. A horse's maintenance requirement for salt is approximately 20mg/kgBW/day, increasing with sweat losses to approximately 100g/day under moderate exercise conditions (Brunner et al., 2012). This highlights the necessity for salt supplementation in the diet.

There is very little information available regarding supplement use in horse populations, although most studies agree widespread, high usage across populations. The most common reasoning for supplement provision has been indicated as 'because the owner believed the horse required it', with very little scientific backing to the efficacy (Swirsley et al., 2017). In New Zealand, previous findings in sport horse populations indicate 87% of owners feeding a median of 2 (IQR 2-4) dietary supplements per day (Verhaar et al., 2014). In a survey of New Zealand endurance riders, 98% reported feeding additional supplements, with a median of 3 (IQR 2-4). Common supplements were reported to be electrolytes, mineral mixes, joint supplements, vitamin E, selenium, and magnesium (Bolwell et al., 2015).
In a New England study, 84% of the survey population reported feeding at least one form of dietary supplement, with a median of 3 and up to 10 (Hoffman et al., 2009). A more recent US survey also identified that 84% of a non-specified demographic of horse owners provided supplements (Swirsley et al., 2017). This indicates a high prevalence, though it does not appear to have increased over time.

The high proportion of supplement use was cited as performance enhancing or for health benefits, but the efficacy and safety of the practice remains unproven (Hoffman et al., 2009). Horses fed some type of nutritional supplement in the study were twice as likely as unsupplemented horses to have excessive dietary levels of at least one nutrient,

increasing the likelihood of an improperly balanced ration. This provides evidence towards oversupplementation (Hoffman et al., 2009). More information on the common types of supplements used in sport horse populations and their prevalence would be beneficial in understanding supplement use in New Zealand, and an indication of if oversupplementation may be an issue worth investigating.

Chapter 3: Materials and methods

1. Data collection

Data collection occurred in the form of a survey. An online survey was created using Qualtrics Survey Software. The survey was spread to potential respondents on social media pages of sport horse groups in New Zealand, as well as a link posted on the author's personal page, and spread by industry participants known to the author. This enabled the survey to reach respondents that were considered representative of the New Zealand competitive sport horse population. The survey was targeted at competitive sport horse owners across a multitude of popular equestrian disciplines within New Zealand - dressage, show jumping, eventing, showing, western, and recreation/ pony club. The survey was anonymous, with no data collected which could identify the horse or owner, for respondent privacy.

The survey consisted of 36 questions, mostly crafted in a closed format, with options for open-text responses where necessary. The questions addressed five primary topics - basic horse identification, body condition and weight, workload, turnout and pasture condition, and feeding management. The survey was considered low risk and approved by the Massey University Human Ethics committee.

One of the survey questions asks for the horse's current and ideal body condition scores. For this question, body condition scoring was based on the Henneke et al. (1983) method, which uses a 1-9 scoring system. A diagram was provided for reference, as seen below (Figure 2).

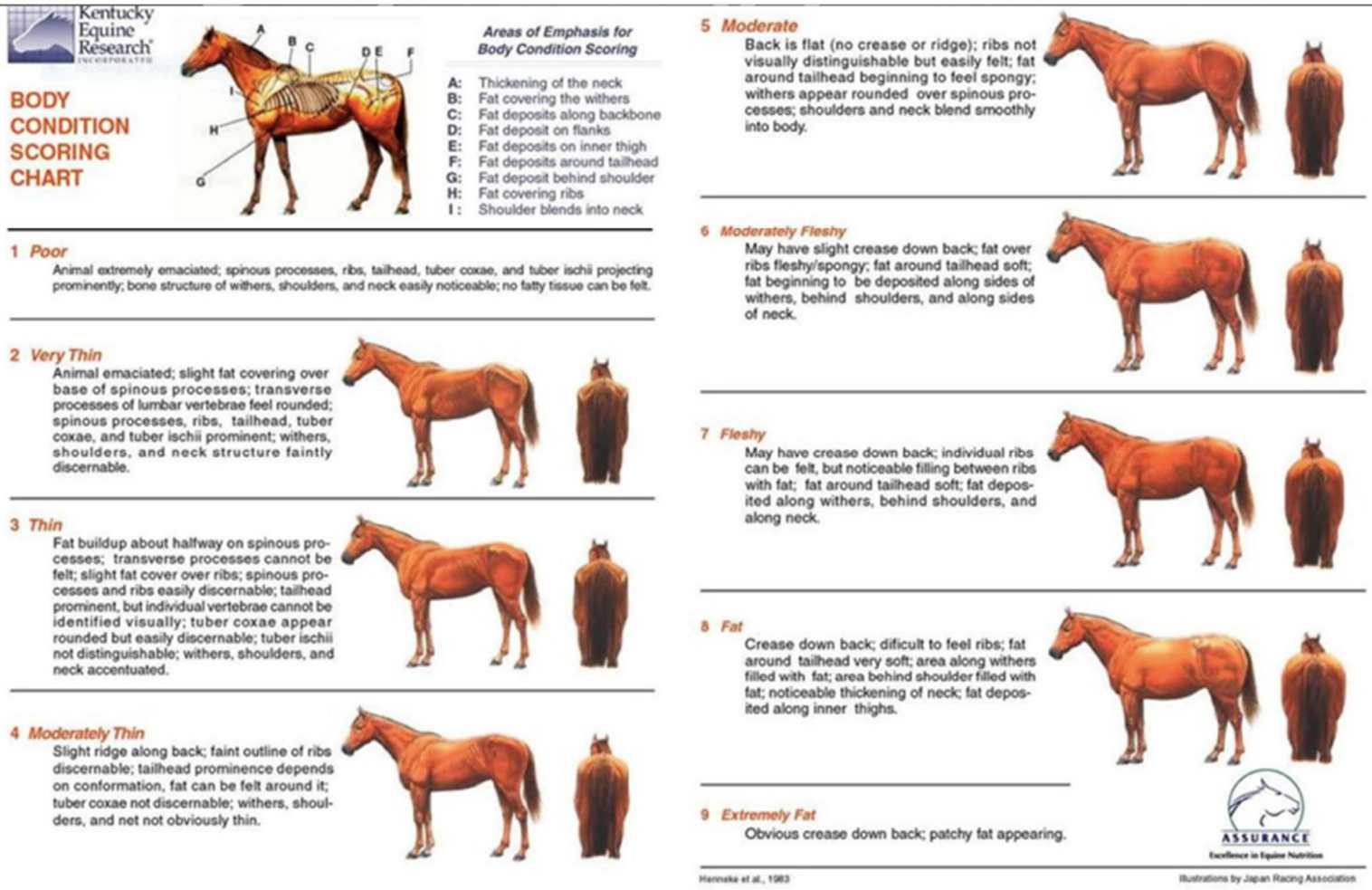
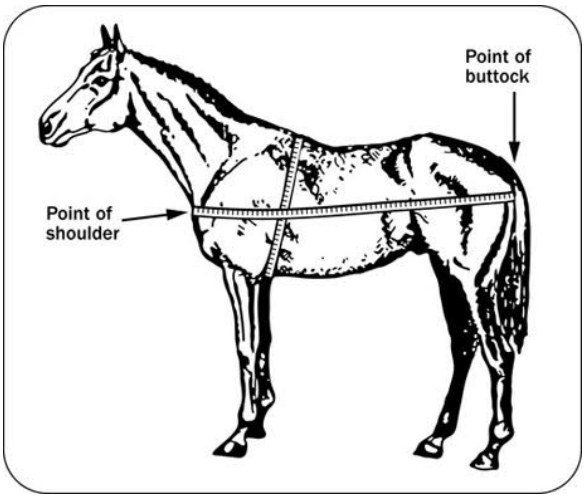


Figure 2: Body condition scoring diagram. (Henneke et al., 1983).

The survey also asked for an accurate estimation of the horse's bodyweight. If bodyweight was not known, then the option was given to provide the horse's girth length and body length, based on the diagram provided. These values can be used to calculate bodyweight, from the following formula:

Weight (kg) = [(girth measurement in cm)^2 x (length measurement in cm)] ÷ 11,900

This formula is derived from Carroll & Huntington (1988). A diagram (Figure 3) was provided as an example of necessary measurements.



(Figure 3): Diagram showing measurements to calculate a horse's bodyweight. Retrieved from Carroll & Huntington, 1988.

2. <u>Beta testing</u>

Prior to release to the public, the survey was beta tested on four competitive horse owners based at either Massey University Equestrian Centre in Palmerston North or Waterfall Equestrian in Wanaka. Participants had no prior knowledge of the survey, and their results were excluded from the data analysis. Following beta testing, only minor survey modifications were necessary based on responder recommendations.

3. <u>Data analysis</u>

Complete datasets underwent further analysis to determine digestible energy supply and demand from known feed quantities.

Digestible energy requirement is derived from the animal's bodyweight and workload. Exercise per week and discipline from survey responses were used to determine workload, based on NRC recommendations. The following table (Table 3) was used as a guide to categorise each subject's workload.

TABLE 1-10 Example Weekly Workloads of Horses in the Light, Moderate, Heavy, and Very Heavy Exercise Categories

Exercise Category	Mean Heart Rate[a]	Description[b]	Types of Events[c]
Light	80 beats/min	1–3 hours per week; 40% walk, 50% trot, 10% canter	Recreational riding Beginning of training programs Show horses (occasional)
Moderate	90 beats/min	3–5 hours per week; 30% walk, 55% trot, 10% canter, 5% low jumping, cutting, other skill work	School horses Recreational riding Beginning of training/breaking Show horses (frequent) Polo Ranch work
Heavy	110 beats/min	4–5 hours per week; 20% walk, 50% trot, 15% canter, 15% gallop, jumping, other skill work	Ranch work Polo Show horses (frequent, strenuous events) Low-medium level eventing Race training (middle stages)
Very Heavy	110–150 beats/min	Various; ranges from 1 hour per week speed work to 6–12 hours per week slow work	Racing (Quarter horse, Thoroughbred, Standard-bred, Endurance) Elite 3-day event

[a]Mean heart rate over the entire exercise bout.
[b]These are general descriptions based on weekly totals of work and do not include all combinations of work intensities and duration. The hours of work performed per week in any particular category could be much more than the estimate given, if the work intensity was much lower. For example, horses in the light category could be exercised for more than 3 hours per week if the work intensity was much lower (see Table 1-9); and horses in the moderate category could be exercised for more than 5 hours per week if the work intensity were lower than the mean heart rate given.
[c]For additional discussion of the sources of variation in energy requirements, see explanation in the text.

Table 3: Table used to determine workload and exercise category for the horses in the survey (NRC, 2007).

Exercise category was then used to calculate each horse's energy requirement, based on the following formulas:

Light work: DE (Mcal/d) = (0.0333 x BW) x 1.20

Moderate work: DE (Mcal/d) = (0.0333 x BW) x 1.40

Heavy work: DE (Mcal/day) = (0.0333 x BW) x 1.60

Very Heavy work: DE (Mcal/day) = (0.0333 x BW) x 1.90

To convert these values to megajoules (MJ), each was multiplied by a factor of 4.184. This put both energy demand and supply into the same units for easier comparison.

To calculate digestible energy content of provided feed, known feed quantities were first converted to kilograms. The following assumptions, based on Verhaar (2010) and trial measurements obtained by the author, were used.

- All feed provided was consumed - i.e. no wastage
- One slice of hay weighs approximately 2.25 kg
- A standard bale of hay = approximately 25 kg
- The volume of a standard feed scoop is 2L, as is an ice cream container

- A double handful = the equivalent of a single scoop
- A single handful = 1/2 scoop
- One scoop contains:
  - 250g of chaff or similar
  - 900g grain
  - 800g flaked feed - eg unsoaked beet, barley etc

Type and quantity of each feed were used to determine DE consumption. MJDE as fed for 1kg of feed was multiplied by kilograms fed to determine total consumption. These were summed to give a total DE consumption for each horse, which could then be compared against DE demand.

DE values of feed were derived from manufacturer websites which provided nutritional breakdowns, and from previous NZ values. Where possible, DE was converted from a dry matter to an as fed basis, using the dry matter content of the feed. This gave a more accurate reflection of the energy consumed by the horse. For soaked feeds, DE was taken on a dry matter basis, as measurements of quantity were taken before the addition of water into the feed.

4. Statistical Analysis

The dataset was compiled for analysis on Apple Numbers. All statistical tests were performed, with significance reported at $p<0.05$ using R-studio statistical software. Parametric data were examined for differences between groups using a general linear model, whilst non-parametric data were examined using a Kruskal-Wallis test one-way analysis of variance. Significant differences between groups were further analysed using a Tukey HSD test to identify pairwise differences between means of groups. Categorical data were examined using Chi Squared tests. Data are presented as mean ± standard deviation unless otherwise stated.

Chapter 4: Results

1. Demographics

The survey yielded a total of 364 valid responses. Of which, 302 were 100% completed.

Table 4: Breakdown of responses by discipline

	Dressage	Eventing	Show jumping	Showing	Western	Recreation/ PC
No. horses	64	55	86	19	18	78
Response rate *	17.6%	15.1%	23.6%	5.2%	4.9%	21.4%

* 7 respondents did not specify the horse's main discipline

Table 5: Description of sample population by discipline

	Dressage	Eventing	Show jumping	Showing	Western	Recreation /PC	
Horse gender							**Total**
Gelding	46	40	47	13	7	47	200
Mare	15	15	36	5	9	30	110
Stallion	1	0	0	0	1	0	2
Horse breed							**Total**
Sport horse	12	14	19	3	1	8	57
TB	9	29	20	5	0	20	83
Warmblood	24	0	30	3	0	4	61
Stationbred	5	7	13	2	0	27	54
QH type	2	1	0	0	15	4	22
Draft	0	2	0	1	1	1	5
Other	9	2	1	4	0	13	29

Table 6: Mean age, weight, and height of horses by discipline

	Dressage	Eventing	Show jumping	Showing	Western	Recreation/ PC
Age (years)	10.4 ± 3.8 (N = 44)	10.2 ± 3.7 (N = 38)	10.3 ± 3.0 (N = 60)	8.4 ± 4.1 (N = 8)	12.7 ± 6.1 (N = 10)	11.7 ± 5.3 (N = 57)
Weight (kg)	565.4 ± 92.6 (N = 41)	540.0 ± 70.5 (N = 42)	555.0 ± 66.6 (N = 52)	510.2 ± 135.0 (N = 14)	502.2 ± 43.2 (N = 9)	512 ± 79.5 (N = 47)
Height (cm)	163.3 ± 8.7 (N = 62)	161.0 ± 6.5 (N = 54)	161.8 ± 7.5 (N = 82)	161.2 ± 8.9 (N = 18)	154.1 ± 5.5 (N = 16)	157 ± 7.5 (N = 76)

Geldings were the predominant gender across all disciplines (64%), although mares appear more prevalent in western riding (7 geldings, 9 mares). Show jumping and recreation also showed a high proportion of mares. Thoroughbreds were the most popular breed overall (27%). They were the most common breed in eventing (n=29), and were also popular for show jumping (n=20) and recreation (n=20). Warmbloods were most commonly used for dressage (n=24), and were also popular in show jumping (n=30), with minimal use outside these disciplines. Quarter horses and their related breeds - paints and appaloosas - were most common in western (n=15). Sport horses were common in the three primary disciplines - dressage (n=12), eventing (n=14), and show jumping (n=19). The popular breeds across most disciplines were varied, with a large range in breeds. Only western riding displayed a strong preference for a single breed - Quarter horses.Overall mean age of the horses in the survey was 10.4 ± 3.8. There was no significant differences in mean age between the disciplines.

Overall mean bodyweight of the horses was 540.7 ± 86.5 kg. There was a significant difference observed between mean bodyweights between disciplines (p-value = 0.00734). p-value age = 0.116, which is greater than significance level at 0.05, indicating no statistical difference in the mean age of horses across disciplines. This was driven by a difference in mean bodyweights between dressage and recreation/ pony club (p-value = 0.008). Dressage horses trended towards heavier bodyweights than those involved in recreation or pony club. Most respondents (n = 220, 60%) knew their horse's bodyweight. Of these, 110 respondents knew bodyweight by scales, 64 by most accurate estimation, and 46 by weigh tape. Of the other respondents who did not know their horse's bodyweight (n = 140), 10 attempted to determine bodyweight by calculation. Of these, only 2 respondents produced a valid output.

Horse bodyweight was positively correlated with breed (p = 2.16e-10). For analysis, 'other' breeds were split into its main components - Arabian, ponies (Riding ponies and welsh

being the most common pony breeds), and other hack breeds. Ponies were significantly lighter than all breeds aside from Arabians. Warmblood horses tended to be heavier than quarter horses (p = 0.01) and Arabians (p = 0.03).

Overall mean height of horses was 161.2 ± 7.3 cm. No significant differences were observed between mean heights of horses between the disciplines.

The graph below (Figure 4) shows bodyweight compared with height, displaying a positive linear relationship between bodyweight and height.

Figure 4: Scatterplot showing horse bodyweight by height

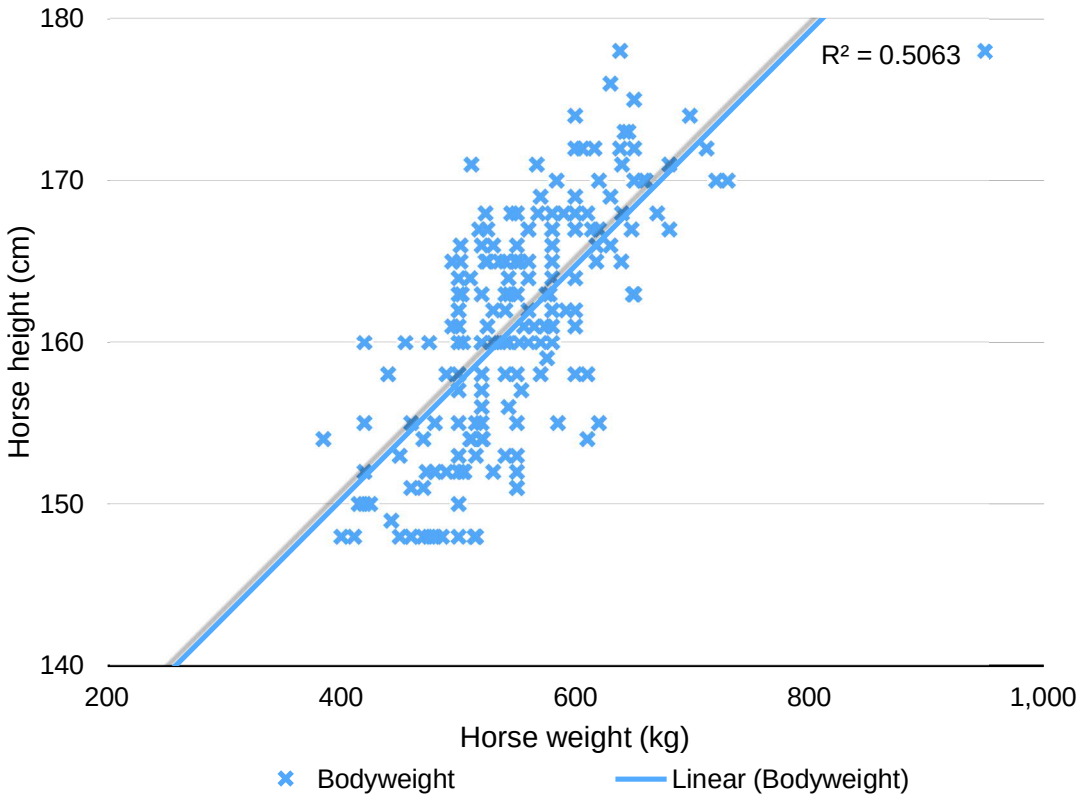


Table 7: Body condition score by discipline

	Dressage	Eventing	Show jumping	Showing	Western	Recreation /PC	
BCS change							**Total**
Maintaining	53	42	72	12	13	63	255
Gaining	7	10	9	3	4	10	43
Losing	0	2	1	3	0	3	9
BCS mean							
Current	5.6 ± 0.8 (N = 62)	5.0 ± 0.7 (N = 55)	5.4 ± 0.8 (N = 83)	5.1 ± 1.3 (N = 18)	5.8 ± 1.1 (N = 17)	5.6 ± 1.1 (N = 76)	5.4 ± 0.9
Ideal	5.4 ± 0.6 (N = 62)	5.2 ± 0.6 (N = 55)	5.4 ± 0.6 (N = 83)	5.9 ± 0.6 (N = 18)	5.9 ± 1.0 (N = 17)	5.3 ± 0.6 (N = 76)	5.4 ± 0.6

The majority of horses in the survey were reported to be maintaining their body condition score (81%). There was no significant interaction between body condition score change and discipline.

Both the current and ideal overall mean body condition scores were 5.4. A significant difference was observed in both current ($p=0.002$) and ideal ($p<0.001$) body condition scores between disciplines. For current condition score, this was driven by differences between eventing and dressage ($p=0.02$), recreation (0.01), and western ($p=0.03$). Both showing and western riders idealised higher condition scores than the current (BCS 5.9 ± 0.6 and 5.9 ± 1.0 respectively). This resulted in the mean ideal body condition scores being higher between showing and western with dressage ($p = 0.01$ and $p = 0.04$), eventing ($p<0.001$ and $p<0.001$), show jumping ($p = 0.006$ and $p = 0.03$), and recreation/pony club ($p = 0.002$ and $p = 0.001$).

Table 8: Competition frequency and workload of horses

	Dressage	Eventing	Show jumping	Showing	Western	Recreation/ PC
Competition frequency						
Not at all	3	1	0	0	2	14
A couple times	7	1	2	2	1	20
Monthly	20	18	15	7	8	20
Fortnightly	29	26	47	8	3	19
Weekly	3	9	19	1	3	4
Workload						
Exercise sessions	4.9 ± 0.9 (N = 62)	4.7 ± 1.1 (N = 55)	5.1 ± 0.9 (N = 83)	4.4 ± 1.2 (N = 18)	3.9 ± 1.8 (N = 17)	3.7 ± 1.3 (N = 75)
Length	45.2 ± 12.0 (N = 62)	46.9 ± 16.1 (N = 55)	40.6 ± 10.7 (N = 82)	40.8 ± 13.4 (N = 18)	52.9 ± 16.9 (N = 17)	47.8 ± 19.2 (N = 75)

The most common competition frequency was fortnightly, followed by monthly. A number of horses, especially in show jumping, would compete every week during show season. Horses in recreation and pony club discipline competed less frequently than horses in other disciplines. Discipline and competition frequency were correlated ($p<0.001$), with most dressage, eventing, and show jumping horses competing fortnightly; western horses most commonly competed monthly, showing horses competed most often monthly or fortnightly; and recreation/pony club horses a couple times a season or monthly.

Most horses had 4-5 exercise sessions per week. A significant difference was found in mean number of exercise sessions between the disciplines ($p<0.001$). Differences were observed between recreation and dressage ($p<0.001$, eventing ($p<0.001$) and show jumping ($p<0.001$); as well as between western and dressage ($p= 0.002$) and show jumping ($p=0.001$). This is driven by lower mean exercise sessions for western and recreation/pony club.

Exercise session lengths, regardless of discipline, were approximately 45 minutes. Show jumping and showing horses appear to have shorter exercise durations, and western and recreation horses were worked for longer durations. A significant difference was observed

in session length between disciplines (p=0.005). Positive differences were found between show jumping and recreation (p=0.03) and western (p=0.02), with recreation and western horses tending to have longer exercise sessions than show jumping horses.

2. <u>Pasture access</u>

The surveyed horses were assessed on their pasture access. The finding was that 65.5% (n=209) of all horses were turned out for 24 hours a day. 13.2% (n=42) of horses received less than 12 hours turnout, ranging between 0 and 11 hours, and were boxed or yarded for the remainder of the day. 21.3% were turned out for 12 hours or greater, up to 22 hours. There was no statistical interaction between turnout and discipline.

The most common paddock management scenario was found to be rotational grazing at 47.4% (n=147), followed by set stocking (n=83, 26.8%) and strip/break fencing (n=80, 25.8%). There was no statistical interaction between pasture management and discipline.

When asked what pasture type was sown in their horse's paddock, 32.4% (n=104) of respondents answered they were unsure. A ryegrass & clover pasture was the most prevalent type, at 29.9% (n=96), followed by a mixed sward (29.6%, n=95). Mixed sward pastures were frequently described as a horse mix, or a combination of grasses and legumes.

Mean sward height of grazed pasture was 4.6 ± 3.4 cm. Survey respondents who noted a rotational grazing pasture management system were asked for pasture sward height prior to and after grazing. Mean sward height before grazing was 5.7 ± 2.4 cm, and after grazing was 3.4 ± 2.2 cm. Pastures were most frequently described as non-uniform - presenting with areas of lawns and roughs (n=183, 62.9%), followed by uniform (n=64, 22%) and sparse (n=44, 15.1%).

Average paddock size was 1.0 ± 2.2 Ha. Most horses were turned out in a paddock on their own (n=151, 49.3%), or with one other horse (n=83, 27.1%). The mean stocking density, defined by the number of occupying the paddock divided by the number of hectares was 5.4 ± 13 horses/Ha. Some respondents noted that their competition horses were turned out with a miniature pony as a companion, or were occasionally turned out with another horse for social interaction.

3. Feeding practices

A significant relationship between daily feeding rate and discipline was discovered (p=0.007), which suggests an interaction between the two variables. Most sport horses received supplementary feed - hay or hard feed - twice a day, though horses in the recreation/pony club discipline were more commonly fed once a day. Some horses received 3 or more feeds each day, more common in eventing, show jumping, and western disciplines. A small number of horses did not receive daily supplementary feed, more so in recreation/ pony club horses.

Table 9: Proportion of horses fed each feed category

	Total horses	Percentage
Hay	288	90.3%
Other Roughage	295	92.5%
Grain	258	80.9%

Only 5 horses (1.6%) were fed grain without additional roughages. Thirty nine horses (12.2%) were fed roughages without grain.

The most popular type of hay was meadow (241 horses), followed by baleage (n=67) and lucerne (n=34).

The most common form of additional roughage was chaff, lucerne being the most common (93 horses), followed by meadow (n=72). Beets or superfibres were popular, Dunstan Betabeet being the most common (n=90). Conserved forages, such as the Fiber Fresh range, were also popular; Fiberprotect was the most prevalent of this category. Many owners fed multiple roughages in the hard feed, commonly chaff, plus beet and/or conserved forages.

There was a wide range of grains fed. Dunstan feeds were the most common, followed by NRM, and McMillans. The most common feed product was Dunstan Breed & Grow (n=32), followed by Dunstan Muscle & Shine (n=22) and Dunstan Maxim Low GI (n=20). McMillans Rapid Gain (n=13) was the most common McMillans product, followed by Cool Feed (n=11). NRM had several common products - Equijewel, Low GI Sport, and Equine Balancer (11 uses each).

Table 10: Number of concentrates fed and total quantity by discipline

	Dressage	Eventing	Show jumping	Showing	Western	Recreation /PC	Total
Number concentrates fed	1.6 ± 0.7	1.6 ± 0.8	1.6 ± 0.7	1.5 ± 0.6	1.7 ± 1	1.3 ± 0.6	1.5 ± 0.7
Total quantity (kg)	2.0 ± 2.0 kg	2.0 ± 1.2 kg	1.9 ± 1.2 kg	2.7 ± 2.7 kg	2.6 ± 2.8 kg	1.4 ± 1.2 kg	1.9 ± 1.6 kg

No significant relationship was found between number of concentrates fed per day and discipline. In addition, no significant relationship was observed between total quantity of grains fed and discipline. Recreation/pony club horses appear to consume slightly less grain than horses in other disciplines, but this was not considered statistically significant.

Table 11: Uptake of digestible energy in the population of sport horses

	Dressage	Eventing	Show jumping	Showing	Western	Recreation /PC	Total
DE demand (MJDE/day)	103.2 ± 22.6	97.5 ± 15.4	103.6 ± 16.4	96.3 ± 28.5	102.0 ± 33.1	91.3 ± 17.7	98.8 ± 20.2
DE Supply (MJDE/day)	88.6 ± 59.9	77.8 ± 56.8	79.7 ± 41.6	90.2 ± 69.8	102.4 ± 108.6	72.2 ± 54.9	81.8 ± 57.6
Energy deficit (met by pasture)	-14.6 ± 57.3	-19.7 ± 57.4	-23.9 ± 43.7	-12.58 ± 66.6	0.4 ± 83.8	-18.0 ± 49.4	-17.4 ± 54.4
DE from roughage	68.6 ± 58	56.2 ± 48.6	62.5 ± 36.9	52.8 ± 40.6	75.3 ± 74.7	56.1 ± 46.4	61.2 ± 48.1
DE from grain	20.0 ± 18.6	21.6 ± 18.8	17.9 ± 17.5	33.4 ± 40.7	27.1 ± 36.6	17.0 ± 18.0	20.6 ± 21.7

No significant differences were identified at the 95% confidence level between digestible energy demand and discipline (p=0.051), although recreation/pony club horses trended towards a lower DE demand than other disciplines. Discipline and exercise level were found to be independent of one another. In addition, no significant difference was observed between mean DE supplies across disciplines, nor was a relationship found

between workload and energy supply (p=0.181). Western horses trended for a higher DE supply, although the standard deviation is very large, indicating a large variety in the results. Energy balance, defined as DE demand subtracted from DE supply, had no significant relationship with discipline. Workload and energy balance had a significant relationship (p=0.02), with horses in Heavy exercise categories trending towards higher, positive energy balances.

No significant relationship was determined between DE from roughage or from concentrate between disciplines.

4. <u>Supplements</u>

Most (89% , 259 / 291) of responders reported the use of one or more supplements on a daily basis. The median number of supplements fed was 3, with a range of 1 - 13. Some (n=29) respondents feed more than 5 total supplements. There was no significant difference between mean number of supplements fed between disciplines. The most popular supplements fed were salt, bone and joint, mineral/vitamin balancer, digestion aid, and toxin binders. Two respondents feed multiple types of bone and joint supplements.

Chapter 5. Discussion

1. Representative survey

The response rate was high, with over 350 respondents, over a broad geographical area comprising every major region in New Zealand. The regions with the most respondents were Auckland, Manawatu, Canterbury, and Waikato, which reflects the geographic distribution of horses in New Zealand (Rosanowski et al., 2012). The spread of horses across disciplines is representative of the major Equestrian Sports New Zealand (ESNZ) disciplines, with dressage and show jumping being the most common disciplines, followed by eventing (Rogers & Firth, 2005). Horses identified as recreation/pony club mounts were common in the survey, which reflects a large proportion of horses in New Zealand being recreation horses (including pony club, trekking, riding schools, etc) (Rosanowski et al., 2012). Showing and western horses comprised only a small proportion of survey respondents. However, this likely represents their relative frequency in the New Zealand sport horse population (Rosanowski et al., 2012). For these reasons, the survey has been considered representative of the New Zealand sport horse population.

2. Possible limitations

As the survey was online, there are several associated limitations, including non-response bias and social-desirable bias. Responders were more likely to be those that were interested in, or had knowledge in, the topic. Respondents were gathered using a snowball sampling technique. The survey was shared across multiple social media pages, where respondents are assumed to be actively involved in the New Zealand sport horse industry. Although this resulted in potential limitations of the accuracy of bodyweight, condition score, and feed quantities, due to results having to be taken at face value based on the respondent's information; this sampling methodology provided an efficient method of targeting sport horse owners New Zealand wide in a timely and cost-effective manner. Due to the distribution of the survey via social media, there may be bias against older horse owners that are not active on social media, which may limit responses only to those active in social media groups.

Assumptions had to be made about feed contents, when quantities were unavailable in units of kilograms. It was decided that one scoop was equivalent to a 2L dipper such as those provided by Dunstan, NRM, etc. However, there are many different versions of a scoop available which may contain differing quantities of feed. In addition, respondents

may have differing ideas as to how much feed ‘one scoop’ is. However, in order to calculate the quantity of feed in kilograms, assumptions had to be made.
Another assumption made was in the weight of a slab or bale of hay. Data from previous studies was used. However, there is significant variation in the weights of individual bales and slabs.
To make assumptions for nutritional compositions, data from websites of commercial products was used. Some assumptions needed to be made, for example of water content when not provided to convert nutritional values from dry matter into as fed basis. For forage products, or products that did not have associated nutritional breakdowns, reference values from the university were used from a previous report (Verhaar et al., 2014), sourced via supervisor Chris Rogers.

3. Horse demographics

3.1. Breed

Overall, the most popular breed of horse in the survey were thoroughbreds. For many years, thoroughbreds and thoroughbred-influenced genetics have been popular in recreation and sporting disciplines (Bolwell et al., 2020). This is likely due to the accessibility of the thoroughbred breed as a by-product of the racing industry. Thoroughbreds have been heavily favoured both internationally and in New Zealand for the eventing discipline, due to their superior endurance, with approximately 89% of the New Zealand eventing population being thoroughbreds (Rogers & Firth, 2005). This is reflected in the survey, with 53% of horses in the eventing discipline being thoroughbreds. In recent years, the cross country phase within eventing has altered and course lengths have decreased. The high endurance provided by thoroughbreds has become less favoured (Rogers & Firth, 2005). Rogers & Firth (2005) predicted a subtle shift in popular eventing breeds in New Zealand to horses with more warmblood blood. This survey did not record any warmbloods in the eventing discipline, however it did report the popularity of ‘sport horses’ for eventing, which are generally considered mixture of thoroughbred and warmblood genetics. Due to there being no central database or requirement for horses to be registered for equestrian sport in New Zealand, there is limited knowledge in the breed/genetic makeup of the national herd (Bolwell et al., 2020). This results in a large proportion of horses being reported as ‘sport horses’, ‘stationbreds’ (thoroughbred crossed with a heavy breed, commonly a clydesdale), and ‘crossbreds’, which are descriptions of type rather than a definitive breed themselves.

In contrast to the eventing discipline, there was a high proportion of warmbloods competing in dressage and show jumping. This has also been noted within literature (Bolwell et al., 2020). In the United Kingdom, it has also been noted that 46% of dressage horses were warmbloods (Walters et al., 2008). Thoroughbreds have been historically bred for their ability to gallop and jump at speed, whereas warmbloods have been selectively bred for conformational traits such as a large hock angle and sloping shoulders, correlated with good gait score for dressage (Walters et al., 2008). Show jumpers also prefer warmbloods, likely for the power, which provides shape and height over a fence, rather than needing to jump at speed. However, the survey showed thoroughbreds being the second most popular breed for show jumping, closely followed by sport horses. Showing riders displayed no particular preference for breed, likely due to the wide range of classes available, which are designed to suit many types of horse.

Western riding was dominated almost exclusively by quarter horses and associated breeds - paints and appaloosas, which is also a common trend overseas (Mastellar et al., 2018). This is due to the western discipline and show circuit being designed to showcase the versatility of the quarter horse breed (New Zealand Western Riding Federation, 2021). Recreation horses in the survey were a wide variety of breeds. Stationbreds being the most common, followed by thoroughbreds and ‘other’ - mostly crossbreds and Arabians. Previous studies support the prevalence of mixed breed horses in New Zealand pony club (Fernandes et al., 2014b). Breeds common in pony club are likely a reflection on personal preference of the owner, or what is available on the market at the time of purchase, rather than meeting a certain mould for competition.

3.2. Gender

In equestrian sport, geldings were more common than mares. In the survey, dressage and eventing displayed a strong preference for geldings, at 74% and 72% respectively. In show jumping, showing, and recreation/pony club, the bias against mares was not as evident; and in western there was an approximately even split between males (7 geldings and 1 stallion) and mares (9). In the literature, 79% of eventing horses in New Zealand were males, and in all of ESNZ sport, 70% were males (Burk & Williams, 2008; Bolwell et al., 2020). However, in recreation/pony club in New Zealand only 56% were geldings (Bolwell et al., 2020). This trend is also evident overseas, with 69% of dressage horses in the United Kingdom being males (Walters et al., 2008), and of riding ponies in Great Britain, 54% were geldings, and 44.3% were mares (Wylie et al., 2013).

This bias against mares is likely due to the higher availability of geldings for sport, with mares preferentially going to the broodmare paddock (Bolwell et al., 2020). In disciplines with less focus on reproduction - showing, recreation, and western, mares are more available. The western discipline in New Zealand prefers to source offspring from overseas genetics to better the gene pool (American Quarter Horse Association of New Zealand, n.d.). Geldings may also be preferred due to their temperament, with mares being considered less reliable than geldings due to changes in temperament with the hormone cycle.

3.3. Age

The mean age of horses in the survey was 10.4, with a median of 10. This is similar to the mean age for dressage, eventing, and show jumping horses in the survey, but is slightly older than the mean age for showing horses, and slightly younger than for western and pony club horses. In the literature, pony club horses have been reported to be approximately 12 years of age (Fernandes et al., 2014b), which is similar to pony club horses in the survey. Eventing and show jumping horses have been reported to be a mean age of 11.1 years and 11.4 years respectively (Burk & Williams, 2008; Pratt-Phillips, 2016). This is, however, comparable to the age of horses in the current survey, and the higher age in the prior studies may be reflective of the level of training - where the prior studies reporting age have focused on horses competing at the higher levels of sport, whereas the present study encompasses both older horses competing at higher levels, and younger ones that may not have reached elite levels of competition.

3.4. Height

The mean height of horses in the survey (161.2 cm) is smaller than what has been reported in previous studies. The mean height of elite show jumping horses overseas has been reported as 167.1 cm (Pratt-Phillips, 2016), and the mean height of UK dressage horses was found to be 165.13 cm, with a positive correlation between height and level of competition (Walters et al., 2008). The difference in mean height between the present study and previous studies is likely due to the inclusion of ponies, as well as breed differences and genetic differences that may exist between the populations of sport horses in New Zealand versus overseas.

4. Body condition score and bodyweight

4.1. Body condition

Body condition is important in terms of fuel storage capabilities and influences how efficiently a horse can regulate body temperature and cooling abilities during exercise. A condition score of 5, based on the 1-9 Henneke (1983) scale, appears to be most desirable for performance horses. Horses in heavier condition are able to store more usable energy than horses in thinner condition. Thin horses are more prone to early fatigue, due to a reliance on energy derived from daily diet. Horses that are too fat require more energy to dissipate heat and cool themselves, reducing the fuel available for performance (Gibbs et al., 1995).

In the present study, it was determined that the mean ideal BCS was 5.4. Horses in the study had a current BCS of 5.4, as well as an ideal BCS of 5.4. This indicates that overall horses are holding a BCS that is considered ideal by both their owners and by literature. Similar studies have indicated mean body condition scores of 5.3 in show jumping horses (Pratt-Phillips, 2016), 6 in pony club horses (Fernandes et al., 2014b), and between 4 and 5 for eventing horses (Brunner et al., 2012; Burk & Williams, 2008). Event horses are expected to have lower condition scores than other disciplines, due to the demands of the discipline and the popularity of the thoroughbred breed. In the present study, the current and ideal BCS was lower than other disciplines, but not enough to be significant. As suggested by Verhaar et al (2014), this is likely due to the sampling frame being predominantly lower level competition horses, or horses competing across multiple disciplines.

This survey noted that both western and showing horses had a higher ideal BCS than other disciplines. Western horses also had a higher current BCS than other disciplines. Showing horses did not, due to having a small sample frame and some horses being in light condition. Western horses are often required to carry more weight (BCS 6-8) for the show ring than other performance horses, due to quarter horse breed standards (Gibbs et al., 1995). It is likely that this is also true for showing horses, to meet aesthetics. It is often perceived by owners that judges prefer the look of a more ‘well-conditioned’ horse as a sign that they are in peak physical condition.

It has previously been noted that 22% of pony club horses in New Zealand were overweight, defined as BCS 7-9 on the 9-point scale (Fernandes et al., 2015). This was not observed in the present study, although the current mean BCS (5.6) was higher than the ideal mean BCS (5.3), though this is far from overweight.

4.2. Bodyweight

The mean bodyweight of horses in the survey was 540.7kg. Previous studies for elite show jumping horses and event horses in the USA have been in agreement with mean bodyweights of 530kg (Burk & Williams, 2008; Pratt-Phillips, 2016). This difference may be due to the prevalence of large quantities of pasture in New Zealand horse diets. Horses fed large quantities of forage have been suggested to have increased bodyweights, due to the high water content of pasture and the increased dry matter intake to meet energy consumption requirements (Ellis et al., 2002; Jannson & Lindberg, 2012). Differences may also be due to breed differences. In the survey, dressage horses and show jumping horses tended to be heavier than horses of other disciplines, likely due to the prevalence of warmbloods - which were heavier in the survey than other breeds. Eventing horses were slightly lighter than dressage and show jumping horses, at 540 kg. This is not as light as eventing horses in previous studies (Burk & Williams, 2008). However, this may be due to the slight shift away from pure thoroughbreds, with the presence of sport horses. Event horses in this study were also likely to be competing at a lower level than in the previous study. Though body condition score of horses in Burk & Williams (2008) study was similar to BCS in the present study, indicating height may be the driving factor behind bodyweight in this case rather than frame. Western horses were significantly lighter than other disciplines, due to the smaller size of quarter horses compared with other disciplines - height and bodyweight were found to be positively correlated. Recreation and pony club horses, as well as showing horses were also lighter, though height was not significantly different to the overall mean height. It may be due to ponies in these disciplines where height was only recorded as <148cm, whereas bodyweight was recorded accurately.

The findings of this survey were that most riders knew their horse's bodyweight. Of this group, most knew bodyweight based off scales, followed by estimation, and then by weigh tape. Only 10 riders attempted to determine bodyweight by the provided calculation, of which only 2 respondents produced a valid output. Due to the timing of the survey publication, riders may not have had access to their horses, or access to a second person for accurate measurement. The proportion of riders who knew their horse's bodyweight was surprising, as a previous study of New Zealand pony club riders identified only 45% knew their horses bodyweight, and of this group a significant proportion had guessed (Fernandes et al., 2014b). Only 10% of riders in the aforementioned survey identified bodyweight in scales (Fernandes et al., 2014b), which was significantly different to the

current study, where 50% of riders knew bodyweight from scales. This difference is likely driven by differences in the sample population. Competitive riders may be more likely to have access to horse scales - vet clinics or at a weigh bridge, and may consider it more important than pony club riders do to accurately know bodyweight for various purposes.

5. Workload

Understanding the workload of sport horses is important in understanding energy requirements above that of maintenance. NRC (2007) provides exercise categories, based on the hours of work per week and the type of work undertaken, which gives guidelines for the energy requirements of exercising horses. For example, horses in the 'very heavy' exercise category, mostly racehorses and elite three-day-event horses, often have energy, protein, vitamin, and mineral requirements 1.5-2.0 times their requirement for maintenance (Burk & Williams, 2008). The most common exercise category according to the NRC (2007) system is 'moderate', which requires supplemental energy at 40% of maintenance. (Ebert & Moore-Coyler, 2020). Figure 4 (NRC, 2007) provides a breakdown of exercise categories and how different workloads can be applied to the model.

There is a wide variation in the workload of sport horses, usually dependent on discipline. There is no strict framework for how often a horse needs to be worked each week, and is usually based on what is best for individual horses and time available to the rider. Previous studies have noted that New Zealand sport horses, regardless of discipline, were worked for 45 minutes per day, 5-6 times per week, which is similar to international findings (Bolwell et al., 2020; Dijskistra et al., 2016; Verhaar et al., 2014). Pony club horses have been found to have approximately 3 exercise sessions per week, 60 minutes in length (Bolwell et al., 2020; Fernandes et al., 2014b). This difference is likely driven by pony club riders being younger with school commitments, and less likely to have strict exercise regimes for their horses. The current study found that horses were worked 4-5 times per week, for approximately 45 minutes, irrespective of discipline. Recreation/pony club horses were worked less frequently than most other disciplines, averaging 3.7 sessions per week. These findings are in agreement with previous studies. This data corresponds with 'moderate' exercise level, with some horses in 'heavy' work depending on the demands of the discipline. This is as expected.

Internationally, training schedules are similar to what has been reported in New Zealand. Consistency of competition structure worldwide may dictate consistent training programmes (Verhaar et al., 2014). However, some differences exist between yards and

countries. This is due to culture and climate, as well as the facilities available. For example, New Zealand horses hack out more than European horses have been reported to do (Verhaar et al., 2014). However, hacking out is popular in the UK, and UK dressage horses regularly undertake non-dressage exercise - hacking, lunging, or jumping (Walters et al., 2008). It is unknown if the pasture-based management system in New Zealand leads to differences in training practices when compared with that of European sport horses.

Competition frequency was highly variable, and was likely due to availability of competitions dependent on region. In the present study, dressage and eventing horses most commonly competed monthly or fortnightly, whereas show jumping horses competed fortnightly or weekly. This compares with the literature, where NZ show jumping horses have been noted to compete approximately 3 times per month (Dijkstra et al., 2016; Verhaar et al., 2014). Dressage and eventing horses compete less frequently than show jumping horses, at once or twice a month (Dijkstra et al., 2016; Verhaar et al., 2014). In the present study, showing and western horses commonly competed once a month or fortnightly; whereas pony club and recreation horses usually competed less frequently - a couple times a season, monthly, or fortnightly - a wide variation, likely reflecting the wide variation in pony club riders, who are likely competing in pony club competitions across a variety of disciplines. No literature is available to support or contrast these findings.

6. Pasture access

6.1 Turnout

The temperate climate in New Zealand provides a unique opportunity for sport horses to be turned out year-round. This contrasts with the international management systems of sport horses, which may have an influence on the health, growth, production, and performance of horses in New Zealand (Bolwell et al., 2020). Traditional management of sport horses, in contrast to what is seen in feral populations, involves large proportions of time spent in single stalls, often due to ease of management, perception of reduced risk of injury, and climates in other countries not being favourable for constant access to turnout. They are fed diets rich in concentrates, and forage of limited quantity, at specific times of the day (Henderson, 2007). However, turnout has been positively associated with a lower incidence of colic, respiratory issues, and stereotypies; as well as providing a greater freedom for expression of normal behaviour and ability for voluntary exercise (Fernandes et al., 2014b; Hoskin & Gee, 2004). This reduces the risk of musculoskeletal injury

(Verhaar et al., 2014) as well as stress associated with prolonged time spent in stalls (Sauer et al., 2019; Werhahn et al., 2012). Stress and abnormal behaviours, often indicators of poor welfare, can also reduce performance in sport horses (Hanis et al., 2020). Hence, it is indicative that access to turnout is beneficial to the performance of sport horses in competition.

However, despite the benefits of pasture turnout, there are also some negative aspects to consider. Toxins associated with pasture, such as endophytes, can cause health problems (Hoskin & Gee, 2004). Grazing may also increase endoparasite burden due to feed consumption near manure piles (Hoskin & Gee, 2004; Wylie et al., 2013). Free access to pasture also contributes in difficulties assessing forage intake, which may be significant in the development and management of obesity and laminitis (Wylie et al., 2013).

The present survey determined that 65.5% of sport horses in New Zealand had access to pasture for 24 hours each day. Fewer (21.3%) of the horses were turned out for between 12 and 22 hours per day, and the rest having turnout access between 0 and 11 hours each day. In previous New Zealand surveys, it was reported that 76% of pony club horses had access to 24-hour turnout (Fernandes et al., 2014b). Of the horses that did not spend 24 hours at pasture, the majority (55%) had 12 hours on pasture and 12 hours boxed (Fernandes et al., 2014b). Similarly, 85% of endurance horses in New Zealand had access to between 12 and 24 hours turnout year round, but it was not specified what proportion of these horses spent time in boxes (Bolwell et al., 2015). A separate study identified that 5 NZ show jumping horses had no access to turnout during the competition season, with little change in management between competition season and off season (Dijkstra et al., 2016). In contrast, NZ dressage horses were mostly turned out, with some boxing of horses during the winter, though this survey did not differentiate between 24/7 turnout or partial turnout (Dijkstra et al., 2016). There is a wide variety of management systems for New Zealand sport horses, possibly in an attempt to reflect the management of sport horses internationally, however the majority of sport horses in New Zealand are turned out 24/7, or having over 12 hours turnout. Pasture management provides a least cost, less intensive management system than more intensive stabling practices. This is in contrast to the United Kingdom, where stabling and the use of livery yards is common (Bolwell et al., 2020).

In a United Kingdom population of leisure horses, only 50% of horses spent 24 hours at pasture, which was reduced to 21% during the winter (Morrison et al., 2017). Similarly, a prior study determined that 60% of horses in Great Britain had access to turnout for

varying lengths of time each day, with only 36% having pasture access 24/7. A wide variation in pasture access was found, heavily dependent on the season, ranging between 56-84 hours per week at pasture (Wylie et al., 2013). United Kingdom dressage horses had access to between 15 and 60 hours per week, with only 3% turned out full time. The majority of these horses were stabled for 64-91% of the day, with surprisingly no variation between levels of competition (Walters et al., 2008).

In American event horses, 84% of horses had daily access to pasture, though time spent turned out each day was not recorded (Brunner et al., 2012). An earlier study noted turnout time averaging between 10-6 and 12.1 hours turnout each day (Burk & Williams, 2008).

Racehorses in New Zealand and internationally are managed with intensive management in large stable complexes, with turnout restricted to 6-8 hrs per day in a yard or small paddock, likely due to lack of land availability and an attempt to keep a consistent management routine between at home versus at racetracks (Bolwell et al., 2020).

The management systems` of many sport and race horses is in direct conflict of their natural behaviour. In feral populations, horses spend approximately 16 hours a day grazing in social groups (Hoskin & Gee, 2004; Werhahn et al., 2012). This poses issues in expression of natural behaviour, as well as their ability to forage and consume sufficient quantities of roughage. New Zealand sport horses, based on the present study and past findings, are more likely to be able to graze for long periods of time like their feral counterparts, than sport horses internationally.

6.2 Paddock size

The mean paddock size in the present study (1.0 ± 2.2 Ha) corresponds with previous reports. In a population of pony club horses in New Zealand, the median pasture size was 0.81 Ha (Fernandes et al., 2014b). In New Zealand sport horses, the median paddock size has been reported to be 0.44 Ha (Verhaar et al., 2014), and in endurance horses common paddock size has been reported to range between 0.4-1.2 Ha (Bolwell et al., 2015). There are no regulations for paddock size for horses in New Zealand under animal welfare regulations (New Zealand Government, 2018), which results in a wide variety of paddock sizes. The majority of horses in both the present study and previous works are kept on their own, or with one other horse (Verhaar et al., 2014). This study noted that some competition horses were kept with a miniature horses for companions, or occasionally turned out with a companion for social interaction.

Internationally, horses are usually turned out on larger areas, with 10 acres being reported as the average pasture size in the USA (Mastellar et al., 2018), and 2 acres in Great Britain (Wylie et al., 2013). Turnout groups of two or more were popular (Wylie et al., 2013).

Differences in sport horse management between New Zealand and overseas likely drive the difference in paddock size. As horses in New Zealand spend the majority of their time at pasture, this drives a need to manage the grass available via restrictions in paddock size. Smaller paddocks housing a single horse is also likely an attempt to reduce injuries by fighting, or owners having only one horse.

6.3 Grazing management systems

Grazing management systems are important in the management of pasture intake and productivity of grass growth. The present study found the most common grazing management system to be rotational grazing, followed by strip grazing and set stocking. This corresponds with the results from a prior study, however set stocking was more popular in the present study than previously (Fernandes et al., 2014b). Rotational grazing is beneficial for horse grazing systems, as it improves grazing efficiency, and it allows smaller paddocks to be feasible (Jordan et al., 1995; Singer et al., 2002). However, it does require expenses in additional fencing materials and water troughs, depending on paddock layout (Singer et al., 2002). If this is not feasible then another grazing management system, or a combination of multiple systems may be better.

6.4 Pasture type

New Zealand pastures are traditionally dominated by perennial ryegrass. This provides a good forage source for horses due to its high nutritive value, and grows well year round, providing grazing all year (Verhaar et al., 2014). The most common pasture type for horse grazing in New Zealand is a ryegrass & clover mix (Huntington & Jenkinson, 2001; Randall et al., 2014; Rogers et al., 2007). The present study is in agreement with the literature. However, it appears that in practice many owners did not know what pasture species was sown in their horse's paddock. This may provide issues in management and feeding decisions, as uncertainty in the composition and nutritive value can significantly impact the quality of the horse's diet.

Horses display selective grazing behaviour, preferring grasses with a high ratio of non-structural to structural carbohydrates. Ryegrass species were found to be the most preferred, whereas Cocksfoot and Yorkshire fog species were the least preferred, due to

having a high lignin content. Preferential grazing is advantageous to horses with high energy requirements (Randall et al., 2014). Selecting a species that is less palatable would be disadvantageous when a high pasture consumption is necessary; but it may be preferential when horses are at risk of obesity or laminitis and require a low energy pasture source.

7. Feeding practices

7.1 Forage

Forage is the most important component of a horse's diet, and must contribute the greatest proportion of dry matter, be it pasture or hay, or a combination of both. Regardless of discipline, horses should consume at least half of their diet as forage (Williams & Burk, 2010). In general, horses need to consume approximately 2-2.5% of their bodyweight in forage each day. When pasture comprises a large proportion of the diet, this should increase to approximately 3% due to the high water content (Williams & Burk, 2010). However, pasture is often an overlooked component of the diet, due to difficulties in estimating intake and nutritional value (Verhaar et al., 2014). Traditionally, forage is viewed as a 'filler' rather than an important nutrient source (Lawrence, 2008).

In addition to pasture, most horse owners will feed additional forage sources - commonly hay or chaff. In the present survey, 90.3% of respondents fed hay, and 92.5% fed other roughage sources - chaff, conserved forages, or beets. This is in agreement with previous research, where 100% of NZ endurance horses were reportedly fed forage (Bolwell et al., 2015), and 82.6% of horses in Great Britain received additional forage to pasture (Wylie et al., 2013).

Meadow hay was the most common type of hay fed by respondents of the survey. This is likely due to its popularity and availability in New Zealand. However, meadow hay is widely variable in its nutritional value, based on its composition and clover content, so it can be inconsistent in its nutrient content (Huntington & Jenkinson, 2001). In the present study, lucerne hay was the 3rd most common form of hay, following meadow and bailage. Previous literature has cited lucerne hay as being most common, especially in Australia and USA (Huntington & Jenkinson, 2001). Lucerne has less cell wall and lignin than meadow hay, hence being more palatable and consumed more readily than meadow hay (Eduard et al., 2008). However, hay with a low nutrient content can be beneficial as it satisfies grazing and gut fill requirements, with providing excess energy.

The feeding of chaff or other roughages in a mix with concentrates is popular in New Zealand. This practice is beneficial in diets as it can slow down the intake of concentrate,

and prevent starch overload in the large intestine (Huntington & Jenkinson, 2001). Fermented forages, such as those marketed by Fiber Fresh are increasing in popularity in the diets of New Zealand sport horses, which is reflecting European trends (Bolwell et al., 2015; Verhaar et al., 2014). Beets and superfibres were also reported as common in the present survey. These are high energy sources, considered less disruptive to the microbial population. As starch overload issues are becoming increasingly prevalent, easily digested fiber sources are replacing starch-based concentrates (Lawrence, 2008).
It is also common to feed multiple types of forage, as was reported in the survey. As horses are selective browsers, multiple forage sources may provide horses with more autonomy over food choice (Henderson, 2007).

Whilst forage may be sufficient to sustain the nutrient requirements of many horses, it is often the case for sport horses that high energy feeds, most commonly concentrates, are necessary in order to meet nutrient requirements. A large quantity of forage is necessary to provide adequate intakes of energy, protein, and other nutrients, which is increased significantly by increasing workload (Grace et al., 2002). Due to gut fill limitations this is often not possible. Most horses in light and moderate exercise will be able to consume 2-2.5kg of dry matter for each 100kg of bodyweight. Consequently, The NRC (1989) expects that horses in light work might consume a diet containing 80% roughage and 20% concentrate. However, if the quality or quantity of forage is limited, higher levels of concentrate will be required. Horses in heavy workload will need high quality forage and large quantities of concentrate to meet their DE requirement. NRC (1989) suggests a diet containing 33% roughage and 67% concentrate (Lawrence, 1990; Lawrence, 2008). However, these recommendations may not account for continuous access to pasture, which has a higher content of DE than hay. In the present study, the average daily DE requirement was met by 20% DE from concentrates/grain and approximately 80% roughage across all disciplines. Of the roughage component, 62% came from hay and roughage in hard feed, with the remainder assumed to be met by pasture consumption. This reflects the NRC (1989) recommendations for horses in light work. However, the majority of horses in the present study were in moderate-heavy work, which suggests a higher reliance on forage for sport horses in New Zealand.

7.2. Concentrates

In the present study, 80.9% of horses were fed some form of grain or concentrate feed. This is comparable to previous results, where 86.1% of horses in Great Britain were fed

supplemental hard feed (Wylie et al., 2013), and 70% of owners in MidWest USA fed concentrates (Mastellar et al., 2018). In New Zealand pony club horses, 82% were fed hard feed (Fernandes et al., 2014b). NZ endurance horses were fed commercial premix concentrates by 58% of owners, straight grain by 23% of owners, and both concentrates and grain by 11% (Bolwell et al., 2015). From the available literature, there does not appear to be a difference in the proportion of horses consuming concentrates/grain between New Zealand and internationally.

Horses in the present study consumed an average of 1.9 kg of concentrates per day. No significant difference was reported across disciplines. A previous New Zealand study for a population of sport horses reported an average concentrate consumption across all disciplines (show jumping, dressage, eventing) as 1.7kgDM/day (Verhaar et al., 2014), which supports the findings of the present survey. Pony club horses in the present study consumed an average of 1.4kg/day of concentrates, which is slightly lower than the mean concentrate consumption by horses in other disciplines, but the difference was not large enough to be considered statistically significant. Fernandes et al (2014b) reported a lower total quantity of grain fed to pony club horses in New Zealand compared with sport/production horses, but did not provide any values for comparison.
In comparison, significantly higher concentrate consumption has been reported for sport horses overseas. Eventing horses have been reported to consume 4.34 kg/day (Brunner et al., 2012), and 5.2-6.2kg/day (Burk & Williams, 2008). In show jumping horses, an average grain consumption of 3.1 kg/day was reported in Sweden (Brunner et al., 2015), and 3.9 kg/day in USA (Pratt-Phillips, 2016). Racehorses in New Zealand have been reported to consume 5.5kg/day of concentrates, where their management is more similar to sport horses overseas than the pasture-based management common in New Zealand (Bolwell et al., 2020). The differences in grain consumption between New Zealand and overseas is proposed to be due to the higher availability of pasture in New Zealand, which reduces the reliance on high-energy supplementary feedstuffs to meet energy requirements. Overseas studies have also focused primarily on elite-level sport horses, whereas New Zealand studies have observed the industry as a whole. Elite-level sport horses in New Zealand may also consume high quantities of grain, but this is yet to be determined.

Traditional sport horse diets are comprised of high concentrate, low forage rations to satisfy energy requirements. However, this practice is associated with gastric function

disturbances - alteration in microbial population of hindgut, gastric ulcers, colic, and increased risk of laminitis. To compensate for this, it is recommended that starch intake should be limited to <1 g/kgBW per meal (Luthersson et al., 2009), which equates to approximately 1 kg concentrate per meal. An upper limit of 2.5 kg concentrate per day is recommended, to reduce risk of digestive upsets (Burk & Williams, 2008). Risk of colic is increased 5-6 fold in horses consuming more than 2.5 kg concentrate per day (Geor, 2007). Quarter horses and related breeds are also at greater risk of genetic-based conditions exertional rhabdomyolysis and polysaccharide storage myopathy (PSSM), when consuming high concentrate/starch diets (Rivero et al., 2008). However, the feeding practices in New Zealand are such that these issues are unlikely to be prevalent. Owners of horses consuming high-starch or limited forage diets should be aware of the potential issues in order to minimise them, however, based on the present survey, this group appears to be the minority. Low starch concentrate feeds, as well as superfibers, are heavily marketed and appear to be common in New Zealand sport horse feeding, which aid in minimising issues. The present study found a prevalence of beets, with Dunstan Betabeet being the most common, being consumed by 90 horses in the survey. Low GI feeds, such as Maxim Low GI and Low GI sport, were common concentrate feeds in the survey. These products are low starch, low sugar, high forage-based concentrate feeds, which would reduce the risk of starch overload in the horse's diet. Endurance horses in New Zealand have been reported to consume common feed types: speedibeet, soybean, and rice-bran, which are highly digestible fiber sources (Bolwell et al., 2015), which supports findings from the present study. The feeding of fats and oils, as has previously reported as a popular alternative energy source (Williams & Burk, 2010), was not as prevalent in the present study as expected, with 25% of owners in the study indicating they fed oils.

7.3 Feeding frequency

Feeding frequency varies mostly depending on what is convenient for owners. Pony club horses both in the present study and in literature are more often fed less frequently, once a day being most common (Fernandes et al., 2015). Likely due to school commitments, or horses requiring less feed than sport horses in heavier workloads. Most sport horses were fed twice a day, though a large proportion were fed once a day. In literature, most horses are reported to be fed 3-4 times per day (Hanis et al., 2020). This system is likely due to the management of horses in stalls, requiring more meals when pasture isn't available, to satisfy feed intake requirements for hindgut health. Horses boarded in public facilities likely

have staff providing round the clock feeding. Whereas in New Zealand, where horses are typically kept at the owner's own property (Fernandes et al., 2015; Verhaar et al., 2014), feeding has to coincide with when owners are able to - such as prior to and after work/school commitments.

8. Digestible energy

The total digestible energy requirements for working horses include the energy required for work, resting maintenance, and thermal regulation (Potter et al., 1990). However, according to the NRC (2007), most studies have not accounted for energy costs involved in post-exercise metabolic rate in energy utilisation calculations. It is suggested that the maintenance requirements may need to be increased by 10% for some horses to account for this (Ebert & Moore-Coyler, 2020). In addition, horses of nervous disposition may require a higher level of maintenance energy - up to 15% more (Ebert & Moore-Coyler, 2020). In the present study, known supplementary feed quantities - i.e. everything consumed minus pasture - account for approximately 83% of the total energy requirement. Adjusting the total digestible energy demand to account for potential individual needs - metabolic rate, temperament - should still allow for energy supply to match additional unforeseen requirements, assuming horses have the ability to intake sufficient quantities of pasture.

When horses grazing pasture are provided with additional feed, a substitution effect occurs with little to no increase in total energy consumption. Concentrate provisions are consumed preferentially, and the remainder of the diet is composed of pasture (Hoskin & Gee, 2004; Verhaar et al., 2014). This means that a diet of known digestible energy content can be provided, and pasture will be consumed until the body's requirement is satisfied, if it is available. It is assumed, from previous studies, that performance horses consuming a mixed diet can derive approximately 50% of their daily DE requirement from pasture, dependent on pasture availability and nutrient composition (Verhaar et al., 2014). In the present study, supplementary feed comprises on average 83% of the horse's daily DE requirement, leaving only 17% to be supplied by pasture. The implication of this, is that many horses are likely being oversupplied with supplementary feed. Assuming horses have access to sufficient pasture to graze, the quantity of supplementary feed provided could be decreased significantly whilst still meeting daily energy requirements, providing a more cost-effective solution to feeding horses. This trend existed across all disciplines in the survey, including in recreation/pony club horses. Owners may be unaware of the

energy content/nutrition composition of the feeds their horses consumed, or of pasture itself. New Zealand ryegrass pastures tend to have a high digestible energy content, at 10-12 MJDE/kg, which may not be known or accounted for when owners are formulating diets (Hoskin & Gee, 2004).

The energy deficit, which was defined as the known energy supply minus the energy demand, also displayed large standard deviations across all disciplines. This suggests that many horses were in positive energy balance without the inclusion of pasture, suggesting a total oversupply of feed on a daily basis. Intake above digestible energy requirements results in surplus energy. This can be stored as fat, creating issues with obesity. It can also be expended in nonessential physical activities, which results in misbehaviour, undesirable during exercise (Buckley et al., 2013).

Even in performance horses, forage can comprise a significant portion of the diet. In a study of horses training for dressage, show jumping, and moderate-level eventing in the UK, horses were consuming an average of 83.9% of their total energy requirement from forage (Ebert & Moore-Coyler, 2020). Horses in the present study were consuming an average of 62% of their total energy requirement from forage, not including pasture provisions, which equated for approximately 17% of the energy requirement, when calculating the energy deficit from known supply. This corresponds with the prior published literature. It can hence be derived from this that it is likely to be provision of additional forages that is substituting the energy that could be being derived from pasture.

Pasture is overall a higher quality forage source than hay or chaff, due to not only its higher DE content per kg, but also its provision of vitamins and minerals and the high protein content (Hoskin & Gee, 2004). Whereas the quality of hay varies widely between bales depending on composition, so is not as reliable as pasture in providing a constant nutrient source (Huntington & Jenkinson, 2001).

9. Supplements

The basic principle of supplementation is to give a horse one or more dietary ingredients in addition to what is provided in forage and concentrates in order to meet nutrient requirements. They are usually given with the goal of improving performance, preventing a problem from occurring, and combating or managing a problem after in arises (Williams & Burk, 2010). However, horse owners typically have little knowledge of their horse's nutrient

requirements and intake (Williams & Burk, 2010; Huntington & Jenkinson, 2001; Wylie et al., 2013). In addition, there is limited literature on the scientific evidence demonstrating the efficacy of supplement use, meaning whether or not they function as marketed remains to be seen (Wylie et al., 2013). Despite this, there is a heavy perception by owners that supplements are important to health and performance. This results in a high proportion of supplement use, and many different supplements being fed in the diet. The marketing of supplements in the industry is strong, and owners are persuaded to feed them under the guise of performance enhancement in some form, without knowledge of their composition.

In the present study, 89% of respondents fed one or more dietary supplements on a daily basis. This corresponds with previous New Zealand data, where 82% of pony club horses are reported to be fed supplements (Fernandes et al., 2014b), and 100% of endurance horses were fed supplements (Bolwell et al., 2015). Overseas, there appears to be more variation. In one US study, 54% of owners indicated they fed supplements (Mastellar et al., 2018); whereas in another, 84% of owners reported supplement feeding (Swirsley et al., 2017). It is likely there were regional differences in the management of horses. In Great Britain, 59.2% of horses received additional supplements (Wylie et al., 2013). These results indicate the majority of horses receive supplements. The higher proportion of supplement feeding in New Zealand is likely due to pasture-based management, feeding supplements to aid grass consumption - for example toxin binders, or to manage known pasture mineral deficiencies - such as magnesium and selenium.

In the present study, the most common supplements fed were salt, bone and joint, mineral/vitamin balancers, digestion aid, and toxin binders. This corresponds with New Zealand endurance horses, however electrolytes were also popular in the population (Bolwell et al., 2015). Joint supplements have been reported as common across multiple studies (Agar et al., 2016; Williams & Burk, 2010; Swirsley et al., 2017; Wylie et al., 2013). It is likely that sport horses are given joint supplements as a preventative aid to maximise career length, rather than to treat a diagnosed problem (Williams & Burk, 2010).

Salt or electrolytes are popular in the diets of sport horses, used to replace sodium losses in sweat (Williams & Burk, 2010). Salt can be provided in the diet in different forms, either mixed with concentrate or as a free access salt lick (Brunner et al., 2012). Many concentrates formulated for competition horses have salt included in the feed composition. Additional salt can causes excesses of sodium and chloride, which may have negative impacts on the horse, and will be excreted in urine, which may negatively impact the environment (Williams & Burk, 2010).

Mineral and vitamin balancers were reported as common, which has also been reported as popular in British sport horses (Wylie et al., 2013). They are used to balance mineral and vitamins in the horses diet, and are beneficial for horses which are not fed concentrates, which usually include mineral and vitamins, as well as horses who do not have access to significant quantities of pasture. However, in New Zealand horses consuming pasture, which typically contains adequate mineral and vitamin contents, additional minerals or vitamins should not generally be required.
Toxin binders are popular for New Zealand horses consuming pasture to mitigate toxins and endophytes present in the grass and are used as 'calmers'.

The median number of supplements fed in the present study was 3, with a range of 1-13. This is similar to previous studies, where three-day-event horses in the USA were fed a mean supplement number of 4.2 (Burk & Williams, 2008). Agar et al. (2016) reported the average number of supplements fed in populations of dressage and eventing horses was 2, with a range of 0-6 in dressage horses, and 0-12 in eventing horses.
Oversupplementation has been hinted as an issue in sport horse populations worldwide (Hoffman et al., 2009). These results do not indicate obvious oversupplementation; however, when multiple horses are fed upwards of 10 supplements, such as in the present study and Agar et al. (2016), it is concerning and could indicate towards oversupplementation. Horses fed nutritional supplements are twice as likely as unsupplemented horses to have excess dietary nutrients, which can lead to health problems through vitamin and mineral imbalances (Hoffman et al., 2009). Owners are not always aware of the effects of the supplement or its interaction with other dietary components, which can lead to over-supplementation of certain nutrients or nutrient interactions.

Chapter 6: Conclusion

The survey found a wide range in results, due to wide variation in the base population and management of sport horses in New Zealand. However, it was easy to identify trends in the feeding management of the population. Management of horses was consistent across all disciplines, despite differences in breed and competition frequency, turnout, workload, feeding rate and feed consumption showed little variation across disciplines. New Zealand sport horses overall appear to consume less grain than horses overseas, likely due to the prevalence of pasture grazing. Despite this, the digestible energy content of the diet, excluding pasture, does not appear wholly appropriate when pasture is then factored in. This is due to a large quantity of non-pasture roughage in the diet. The results suggest that most horses have access to plentiful ryegrass pasture, which could easily substitute a significant portion of hay that is consumed. A significant proportion of owners feed supplements and many feed more than one. Oversupplementation has not been ruled out as an issue in New Zealand sport horses.

This data is useful for gaining an insight into the workload and management of New Zealand sport horses, as well as the digestible energy requirement and supply from known feed sources. This information could be relevant for veterinarians and associated professionals in the nutrition and management of performance horses and the optimisation of competitive performance; as well as giving owners a better understanding of the impacts of their chosen feeding and management practices.
Future studies should quantify pasture uptake, giving a more accurate assessment of total nutrient consumption. A full nutritional profile for each horse would also be beneficial, as opposed to solely digestible energy. This would quantify deficiencies/excesses for each nutrient and provide indicators of over- or under-supplementation that may impact the horse or the environment.

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Appendix A: Survey for Feeding and management practices in the New Zealand Sport Horse Industry

Description of horse

Age of horse

- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11
- 12
- 13
- 14
- 15
- 16
- 17
- 18
- 19
- 20
- 20+

Select the best descriptor of the horse's breed

- Sport Horse
- Thoroughbred
- Warmblood
- Stationbred
- Quarter Horse type
- Draft/heavy breed
- Other (specify)

Height

- <148 cm
- 148 cm
- 149 cm
- 150 cm
- 151 cm
- 152 cm
- 153 cm
- 154 cm

- 155 cm
- 156 cm
- 157 cm
- 158 cm
- 159 cm
- 160 cm
- 161 cm
- 162 cm
- 163 cm
- 164 cm
- 165 cm
- 166 cm
- 167 cm
- 168 cm
- 169 cm
- 170 cm
- 171 cm
- 172 cm
- 173 cm
- 174 cm
- 175 cm
- 176 cm
- 177 cm
- 178 cm
- >178 cm

Gender

- Mare
- Gelding
- Stallion

Body Condition

Is the horse...

Gaining condition
Losing condition
Maintaining condition

Using the image for reference...

... What is the horse's current body condition score?

1 - Poor
2 - Very Thin
3 - Thin
4 - Moderately Thin
5 - Moderate
6 - Moderately Fleshy 7 - Fleshy

8 - Fat
9 - Extremely Fat

... What is the horse's ideal body condition score?
1 - Poor
2 - Very Thin
3 - Thin
4 - Moderately Thin
5 - Moderate
6 - Moderately Fleshy 7 - Fleshy
8 - Fat
9 - Extremely Fat

Determining nutrient requirements - bodyweight and exercise

Do you know the horse's weight?

- Yes
- No

Select option, enter horse's weight (kg)

- Weigh tape ——
  Scales ——
  most accurate estimation ——

Using the diagram above, please provide the horse's girth measurement (cm)
Using the diagram above, please provide the horse's length - point of shoulder to point of buttock (cm)
Bodyweight = 0

What is the horse's main discipline?

- Dressage
- Eventing
- Show jumping
- Showing
- Western
- Recreation/pony club

During the competition season, approximately how often do you compete or plan to compete the horse

- Weekly
- Fortnightly
- Monthly
- A couple times
- Not at all

On average, how many exercise sessions does the horse receive each week

- 1
- 2
- 3
- 4

- 5
- 6
- 7

What is the average length of each training session

- 15 minutes
- 30 minutes
- 45 minutes
- 60 minutes
- 75 minutes
- 90 minutes

Provide the approximate weekly exercise regime for the horse

- Flatwork —
- Jumping —
- Hacking —
- Lunging —
- Other (please specify) — ——

Management

What is the approximate size of your horse's current paddock?

Hectares OR Acres

Paddock size __

How many horses occupy the paddock, including your horse?

—

What is the approximate sward height of the grazed pasture, in cm

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11
- 12
- >12

Approximately how many hours does the horse spend on pasture each day?

- 24 hours
- 23 hours
- 22 hours

- 21 hours
- 20 hours
- 19 hours
- 18 hours
- 17 hours
- 16 hours
- 15 hours
- 14 hours
- 13 hours
- 12 hours
- 11 hours
- 10 hours
- 9 hours
- 8 hours
- 7 hours
- 6 hours
- 5 hours
- 4 hours
- 3 hours
- 2 hours
- 1 hour
- 0 hours

Is the horse stabled/yarded on a daily basis?

- Yes
- No

How many hours stabled/yarded per day?

- 24 hours
- 23 hours
- 22 hours
- 21 hours
- 20 hours
- 19 hours
- 18 hours
- 17 hours
- 16 hours
- 15 hours
- 14 hours
- 13 hours
- 12 hours
- 11 hours
- 10 hours

- 9 hours
- 8 hours
- 7 hours
- 6 hours
- 5 hours
- 4 hours
- 3 hours
- 2 hours
- 1 hour
- 0 hours

On a normal day, under normal management practices for the horse - i.e. at home, on an average exercise day, how many times per day is supplementary hard feed provided?

- 0
- 1
- 2
- 3
- >3

Feeding - Pasture

What is the best description of the grazing management system do you employ currently?

- Set stocking - Horses maintained for long periods of time in a single paddock with little alteration of paddock
- Strip/break fencing - Routine shifting of fence-line to provide additional feed
- Rotational - Horses change paddocks regularly/frequently (either between large pastures or smaller electrical taped sections of a single pasture)

Select the image which best reflects pasture cover in grazed paddocks

- Sparse
- non uniform - lawns & roughs
- Uniform

Do you know what pasture type is sown on the property?

- Ryegrass pure sward
- Ryegrass + clover mix
- Mixed sward
- Tall fescue
- Other ___
- Unsure

Does the horse receive additional feed aside from pasture

- Yes
- No

Feeding - Roughage

Does the horse currently receive hay?

- Yes
- No

What type?

- Meadow (default)
- Lucerne
- Clover
- Timothy
- Bailage/haylage

Quantity per day?

Please enter quantity in the relevant units column or select free access if applicable
Slices OR 1/2 Bale OR kilograms OR Free access

Does the horse receive additional supplementary feed - ie hard feed

- Yes
- No

What additional forages do you feed on a daily basis?
Select all that apply
Chaff
Conserved forages
Fiberprotect
Fibermix
Fiberezy
Fiberboost
Fiberlucerne
Beet
Maxisoy
Mcmillans Grain Free
Fibrebeet
Speedibeet
Other (please specify brand and type)

Quantity of selected forages fed - total quantity on a daily basis
Icecream container OR Scoop OR Kilogram OR Double Handful

Feeding - Concentrates/grain

Does the horse receive concentrates/grain?

- Yes
- No

What concentrates/grain does the horse receive on a daily basis?
Cambridge Grains
Balancer

Broodmare
General purpose
Maximise
Overdrive
Parole
Safe & Sound
Steddy Neddy
Topline plus
Coprice
Cool Conditioner
Maximum performance
Rice Bran
High Joule
Versatile
Veteran
Performer
Dunstan
Breed & Grow
Competition mix
Coolfeed
Eezy mix
Maxim low-GI
Old horse
Resolve
Sport Horse
Sweet mix
Muscle & Shine
All-4-Feet
Extruded barley
Extruded maize
Extruded rice
Fiskens
Advance
FF Plus
Fifty Fifty
Harness
Balancer
Parole
Protein Mix
Ultra low GI
Maintenance mix
Hygain
Allrounder
Balanced
Senior
Grand Prix Premium
Honey B
Ice
Micrbarley

Micrlupin
Micrmaize
Micrspeed
Powatorque
Release
Showtorque
Trucare
Trugain
Zero

Mcmillans

Rapid Gain
Cool feed
Sport Horse/Energy Max
Protein Plus
Premium Plus
Muscle Relieve

Mitavite

Xtra Cool
Economix Active
Cool Crusada
Munga
Gumnuts
Promita
Extrubarley
Extrucorn
Extrulupin

NRM

Coolade
Horse & Pony
Low GI Sport
Sweetfeed
Ultimate Sport
Equijewel
Equine Balancer

Prydes

Easiconditioner
Easiprep
Easisport
Biomare cubes
Essentials 150
Easikeeper
Elite 300
Easiride
Easigoing
Easi Off-the-track
Easiresponse
Easiresult
Easiperformance
Polomix

Stamina
Racing Cube
Old Timer Coprameal Boiled barley Oats
Other (specify brand and type)

Quantity of each type of grain fed to the horse on a daily basis

» Balancer
» Broodmare
» General purpose
» Maximise
» Overdrive
» Parole
» Safe & Sound
» Steddy Neddy
» Topline plus
» Cool Conditioner
» Maximum performance
» Rice Bran
» High Joule
» Versatile
» Veteran
» Performer
» Breed & Grow
» Competition mix
» Coolfeed
» Eezy mix
» Maxim low-GI
» Old horse
» Resolve
» Sport Horse
» Sweet mix
» Muscle & Shine
» All-4-Feet
» Extruded barley
» Extruded maize
» Extruded rice
» Advance
» FF Plus » Fifty Fifty
» Harness » Balancer
» Parole
» Protein Mix
» Ultra low GI
» Maintenance mix
» Allrounder
» Balanced
» Senior
» Grand Prix Premium
» Honey B

» Ice
» Micrbarley
» Micrlupin
» Micrmaize
» Micrspeed
» Powatorque
» Release
» Showtorque
» Trucare
» Trugain
» Zero
» Rapid Gain
» Cool feed
» Sport Horse/Energy Max
» Protein Plus
» Premium Plus
» Muscle Relieve
» Xtra Cool
» Economix Active
» Cool Crusada
» Munga
» Gumnuts
» Promita
» Extrubarley
» Extrucorn
» Extrulupin
» Coolade
» Horse & Pony
» Low GI Sport
» Sweetfeed
» Ultimate Sport
» Equijewel
» Equine Balancer
» Easiconditioner
» Easiprep
» Easisport
» Biomare cubes
» Essentials 150
» Easikeeper
» Elite 300
» Easiride » Easigoing
» Easi Off-the-track
» Easiresponse
» Easiresult
» Easiperformance
» Polomix
» Stamina
» Racing Cube

» Old Timer
» Coprameal
» Boiled barley
» Oats
» Other (specify brand and type)

Feeding - Supplements

Icecream container OR Scoop OR Handful OR Double handful OR Kilogram

Does the horse receive additional dietary supplements on a daily basis?

- Yes
- No

What is the total number of supplements fed to the horse on a daily basis

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10+

Select the supplement categories that best reflect the supplements the horse receives, and where possible specify brand and name

- Amino acids
- Anti-oxidant
- Bone & Joint
- Blood supplement
- Calmer/relaxer
- Condition & Weight gain
- Digestion aid
- Electrolytes
- Hoof health
- Hormone balancer
- Mineral/vitamin balancer
- Magnesium
- Selenium
- Salt
- Skin & Coat health
- Toxin binder
- Ulcer treatment/prevention
- Oil

Quantity of selected supplements fed on a daily basis

Grams OR Teaspoon OR Scoop OR Handful OR Double handful

Appendix B: Examples of actual survey layout

Age of horse

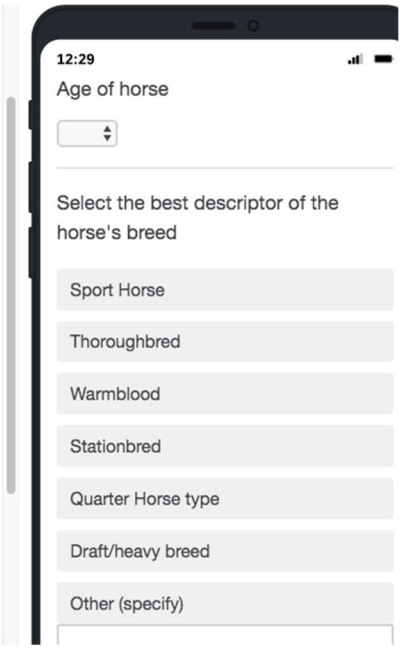
Select the best descriptor of the horse's breed

- Sport Horse
- Thoroughbred
- Warmblood
- Stationbred
- Quarter Horse type
- Draft/heavy breed
- Other (specify)

Height

Gender

- Mare
- Gelding
- Stallion



What is the best description of the grazing management system do you employ currently?

- Set stocking - Horses maintained for long periods of time in a single paddock with little alteration of paddock
- Strip/break fencing - Routine shifting of fence-line to provide additional feed
- Rotational - Horses change paddocks regularly/frequently (either between large pastures or smaller electrical taped sections of a single pasture)

What is the approximate size of your horse's current paddock?

	Hectares OR	Acres
Paddock size		

How many horses occupy the paddock, including your horse?

- Sparse

- non uniform - lawns & roughs

- Uniform

Quantity of selected forages fed - total quantity on a daily basis

	Scoop OR	Icecream container OR	Handful OR	Double handful	Kilogram
Meadow	☐	☐	☐	☐	☐
Fiberprotect 	☐	☐	☐	☐	☐
Speedibeet 	☐	☐	☐	☐	☐