Feasibility of a 5-week functional movement course for dressage horse riders

A thesis presented in candidature for the degree of Master of Research - Chiropractic

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Statement

I certify that the research presented in this thesis is original work carried out by the author. The work has not been presented for a higher degree to any university or institution other than Macquarie University, and contains no material previously published or written by any other person except where due reference is made in the text.

Keira Byrnes

1st of March, 2019

Abstract

Background: Research suggests that riders with more control over their body are able to train horses more efficiently and with less stress or injury. There is little research into improving the performance of horse riders using interventions off the horse.

Objective: The primary objective was to determine the feasibility of running a 5-week functional movement program to improve strength, flexibility and performance of horse riders. The secondary objective was to determine preliminary outcomes in horse rider performance.

Methods: A functional movement program was designed and included exercises to improve pelvic stability, scapular retraction and hip extension. Feasibility outcomes were assessed qualitatively. Quantitative assessment of muscle strength and flexibility and a Novice level dressage test were performed at baseline and after the program.

Results: Eight participants completed the program with high participant satisfaction. There were difficulties around recruitment and attendance of assessments. There were significant improvements in some of the secondary outcomes.

Conclusions: This study indicates that this is a promising area for future research. Primary results suggest that it would be feasible to run a large scale RCT to determine effectiveness of the program. Secondary outcomes indicate that horse

riders’ performance could be improved secondary to a functional movement program.

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Terminology

- Dressage: A method of riding and training a horse that develops horse obedience, as well as rider flexibility and balance. This training improves the horse's biomechanics to ensure it is most easily able to carry a rider.
- Dressage Competition: Dressage competitions involve a horse and rider performing a series of predetermined "movements" in a 20x60m arena. These movements are tasks or skills which illustrate the training of the horse, and therefore the skills of the rider. Movements are performed at markers around the arena and may involve changes in pace, direction, or shape as well as specific movements that may ask the horse to go sideways or similar. Each of these movements has a score out of ten which is judged by an accredited dressage judge. The final score is converted to a percentage, and the competitor with the highest percentage is the winner of the competition.
- Dressage Judging: Official dressage tests in Australia are judged by trained judges who are accredited under the National Officials Accreditation Scheme approved by the Australian Sports Commission.
- Dressage Test: A dressage test prescribes which movements are performed and in what order in a competition, as well as directives for how each movement in the test will be scored. It is something like the choreography which the rider must adhere to. For an example of a dressage test score sheet, see Appendix 2.
- Novice Level: Novice level refers to a particular level of difficulty of the dressage test being performed. The levels of dressage are as follows:
    - Preparatory – unofficial level
    - Preliminary
    - Novice
    - Elementary
    - Advanced
    - Prix St George
    - Inter 1 and Inter 11
    - Grand Prix – level of Olympics, World Equestrian Games etc

Chapter One: Introduction

1.1 Introduction

This thesis is an investigation into the feasibility of conducting a large-scale trial on the effectiveness of a functional movement program to improve horse rider performance, strength and flexibility. The five-week program consists of physical exercises and stretches designed to train effective biomechanics for horse riders. It is designed specifically for horse riders, and progresses from floor exercises to standing, to functional exercises performed on a model horse mimicking the motor patterns used by riders.

1.1.1 The Australian Equestrian Industry

The equestrian industry is one of the top ten industries in Australia with an estimated contribution of AUD6.3 billion to the Australian gross domestic profit (1). It provides jobs for over 240,000 people in the areas of training, husbandry (farriers, vets, grooms), feed suppliers, retail, education, transport, event organising, catering, and maintenance. Australia has been well represented at the Olympics, Paralympics and World Equestrian Games (1). Australia won three consecutive team Olympic gold medals in eventing in Barcelona 1992, Atlanta 1998 and Sydney 2000, with a team silver in Beijing 2008, and team bronze in Rio 2016. The Australian rider, Brett Parbery also placed 9th at the World Equestrian Games in 2010 in the dressage. With Equestrian Australia (the national federation for equestrian sport) placing a high priority on ensuring future success at elite levels (1), potential ways to advance rider performance are likely to become increasingly sought for.

1.1.2 Equitation Science

Historically horse riding and horse training have been described as an 'art' passed down from the ancient masters (2-4). These masters were usually military personnel trained in the cavalry, who excelled at producing well-trained horses for battle and parade (5). It is from these beginnings that many of the equestrian disciplines of today evolved, such as dressage, hunting, eventing, and racing. These practices of horse training and riding grew as they were passed down. New technology and equipment became available and so the methods of training changed and simplified to benefit the humans involved. This simplification sometimes led to a deterioration of horse welfare during the training process (4, 6). Methods for riding and training are primarily based upon tradition, competition trends and personal experience rather than scientific inquiry (4). Any scientific advances related to the equestrian sports tends to come from the veterinary aspect of horse management rather than improving riding and training itself (7, 8). Coming from this history of art and tradition, the field of equitation science has emerged and brought empirical evidence to horse training and management.

The emerging field of Equitation Science is the area of study pertaining to the training, welfare and ethology of horses. Research in this field has highlighted the importance of clarity and consistency in horse training in order to maximise the effectiveness of operant conditioning. Operant conditioning is the use of positive or negative reinforcement or punishment to train particular behaviours in humans or animals (9, 10). As the training of horses primarily uses negative reinforcement (the application of an aversive stimulus which is removed when the horse performs the correct behaviour) (11) via the rider's body, the timing and consistency of the application and removal of pressure is vital if training is to be successful (3, 12). Consistency whilst riding relies on the rider's ability to control the movement of their own body in order to increase the chances of giving one clear signal to the horse at a time (13, 14). For example, if every time the rider moves their right arm to give a signal to the horse, they also shift their centre of gravity to the left, and compensate by gripping the saddle with their right knee, the horse is forced to respond to three different stimuli at once when only one is actually intentional. This sort of confusion due to multiple signals being given or received simultaneously can lead to conflict behaviours (e.g. rearing, bucking, head tossing) and the flight response (12, 15). The confusion and resulting conflict behaviours have direct implications on both rider safety and horse welfare. Due to the size and strength of working with horses, the ability to maintain relaxation during training is likely to greatly reduce the incidence of injury amongst riders and handlers.

1.1.3 Improving Horse Rider Biomechanics

Higher demand for research in the field of improving rider biomechanics has been driven by an increased focus on equine welfare in equestrian sports (16). A 2017 summary paper by Sue Dyson (17) gives an overview of the clinical applications of equitation science and identifies relationships between horse and rider biomechanics and long term welfare of the horse. Other studies have identified poor rider biomechanics as a potential factor leading to physiological changes in the horse (18), for the horse, the need for veterinary involvement, and an early end to a horse's career. These physiological changes may occur in the horse's spine, limbs (18), overall musculature or jaw, and may affect the horse's wellbeing (8). The welfare and longevity of horses is of primary concern to those in the equestrian community and may incentives for horse owners to seek ways of improving horse riders biomechanical functioning.

Another motivation to improve rider biomechanics is the potential for a correlated improvement in competition. A 2010 study (16) found a likely link between improved rider biomechanics and an improvement in competition scores. In a dressage competition, the horse and rider are judged as a combination for each "movement" or each component of the test. There are also four "collective marks" given at the end of the test. These marks are in the broader areas of horse submission, the horse's paces, the horse's forward impulsion and the rider's position and skills. This study found that in the dressage competition at the 2008 Olympics, the greatest correlation between collective marks and the overall score was that of rider position. The authors concluded that the impression of a rider's position and skill was more indicative of the overall performance than any of the horse's overall qualities. Similarly, traditional texts about riding and competition emphasise the importance of developing a rider's "seat" (a term which roughly covers not only the rider's position but their ability to balance and use their body for most efficient communication with the horse) as the most important part of becoming a good rider. With competition being an essential driving factor for change within the equestrian industry, studies such as these are likely to have increased interest and uptake by trainers and riders.

While equitation science and the field of horse and rider biomechanics has been growing over some years, the investigation of interventions to improve rider biomechanics has emerged only recently. The majority of research into rider biomechanics has investigated correlations between horse and rider symmetry and movement and their bi-directional relationship (13, 19-21). These research fails to prove causality from either the rider or the horse, and equipment has acted as another confounding variable in determining causality of any asymmetry and movement (19, 20, 22-24). A preliminary study found promising results on the effect of physiotherapy on rider symmetry and posture (25); however, these findings have not been confirmed in larger trials. Thus far, studies have primarily been pilot or feasibility studies completed as part of students' research theses (26-28). Such studies have not yet been followed up with larger trials to provide more meaningful data.

It is common in other sports to employ the work of physiotherapists, exercise physiologists, or some level of cross-training to improve sport specific outcomes (25). While this exists to a certain extent in equestrian sport, on the whole it is vastly under-utilised (25) further research in this area could lead to greater collaboration between physical and manual therapists and equestrian athletes. It also has the potential to lead to improved health outcomes for horse riders, who tend to underestimate the physical and metabolic demands required in horse riding (29, 30).

Improvement in competition performance, particularly at an elite level, has the potential to lead to an improvement in the profile of equestrian sport in Australia, which has a direct impact on funding from groups such as the Australian Sports Commission and the Australian Institute of Sport (31). Traditionally, improved funding into a sport leads to greater funding for research into the improvement in that sport, and thus the benefits are likely to be mutually inclusive. Documented improvements would also have the potential to lead to a greater understanding of equestrian sport among practitioners such as exercise physiologists, chiropractors, physiotherapists or personal trainers. This improved understanding could lead to more extensive involvement of these practitioners in a mutually beneficial way with equestrian athletes.

1.1.4 Interventions to Improve Horse Rider Performance

Research into physical interventions designed to improve horse rider performance is a relatively new and small field of study within the larger area of equitation science. This field has the potential to provide useful information that could be applied directly in horse riding, training and competition. It also has the potential to connect different fields of research, such as exercise science, equitation science and athlete performance.

Programs off the horse are beneficial to riders due to their decreased associated risk, as well as their usefulness in training specific movements without the added dynamic of the horse's movements. Without the additional movements of the horse, it is possible for the rider to specifically target particular muscle groups and particular motions, remaining entirely focused upon their own body. From an equine welfare perspective, the ability to complete activities off the horse results in a decrease in the horse's workload and a decrease in physical strain on the horse's body incurred by carrying a less balanced rider.

Research in this area could have far-reaching future effects in the areas of rider performance and safety, equine training and welfare, as well as providing a basis for future programs to be completed off the horse.

1.2 Thesis Aims and Objectives

The overarching aim of this thesis is to contribute to the literature involving the use of physical programs completed off the horse, to improve the performance of horse riders. This will be achieved through the following research aims:

Research aim 1: To systematically review the literature to determine what exercise programs are currently being performed off the horse to improve rider performance and the effectiveness of these programs

Research aim 2: To assess the feasibility of performing a large-scale effectiveness study on a 5-week functional movement program to improve strength, flexibility and performance of horse riders.

Research aim 3: To determine preliminary data on the effectiveness of a 5-week functional movement program to improve strength, flexibility and performance of horse riders. These results will be used to inform the power calculations needed for a future full-scale effectiveness study.

1.3 Thesis Composition

This thesis is composed of five chapters. Following the introduction in chapter one, chapter 2 covers a review of the literature, addressing the first research aim.

Chapters three and four address research aims 2 and 3. The third chapter outlines the methodology used to carry out the feasibility study that is the basis for this thesis. The fourth chapter describes the results obtained from this feasibility study.

Chapter five discusses the results of this thesis, how they fit into the previous body of research, limitations that have been identified, significance and future directions.

Chapter Two: Literature Review

Effects of modalities applied off the horse on horse rider performance, balance and symmetry: A systematic literature review.

2.1 Introduction

Traditionally, horse riding has been taught only whilst a rider is actually on a horse (32, 33). This approach has been anecdotally effective, and has withstood the test of time (33) without the suggestion of change. However, there is the possibility that there are novel ways of further improving the training of horse riders, which can be done while the rider is not actually riding. Off the horse programs may be beneficial to riders by: 1) decreasing associated risk; and 2) improving the ability to train specific movements without the added dynamic of the horse's movements (27, 34, 35). From an equine welfare perspective, the ability to complete activities off the horse results in a decrease in the horse's workload and physical strain incurred by carrying a less balanced rider (13, 18). With a more holistic approach currently being taken to sports in general (36-38), many sports are looking for innovative ways to ethically improve athlete performance. In general, equestrian sports have been notoriously slow-moving when it comes to innovations in performance and training (12, 39). Equestrian athletes tend to focus on the horse as the athlete, but this focus is beginning to shift especially with further evidence of the effect of the rider on the horse (18).

The majority of research into equestrian pursuits has focused on injury prevalence (40, 41), and more recently the use of Equitation Science to improve equine training and welfare (9, 10, 12, 15, 42). There has been some research into the biomechanics of horse riding from the perspective of both the rider (21, 43) and also how that correlates with the biomechanics of the horse (13, 22, 44, 45). This research into biomechanics has been expanded into the area of the effects of the rider's posture on equine movement (13, 18). There has also been much research into the physical benefits of hippotherapy (horse riding as a therapeutic intervention) in different populations such as the elderly, or those with cerebral palsy, attention deficit and hyperactivity disorder or autism spectrum disorder (46-55).

Research into the use of modalities off the horse to improve rider performance, balance or symmetry when on the horse is of substantial interest to this review. Of particular interest is research into interventions designed specifically for horse riders, and how they compare to generic interventions applied to horse riders. This could be a valuable direction for future research with regards to improving rider performance. It could also have long term benefits in terms of equine welfare via the more effective use of operant conditioning in the training of horses, particularly the rider's ability to provide physical signals to the horse and to reward performance precisely and promptly. This area of research could ultimately provide valuable insights into the validity and possibility of new training methods for horse riders.

The aim and rationale for this review has three components: First, if applying modalities off the horse can benefit riders, then it is worthwhile to understand in what way these modalities may be of benefit. Second, it is also worthwhile to assess the current literature, and examine where future research may be targeted. Third, these results may lead to improved outcomes for riders and horses, as well as more evidence-based approaches to improving horse-rider training at all levels.

2.2 Methods

2.2.1 Design

A literature review was carried out according to the Preferred Reporting Items for Systematic Reviews and Meta Analyses (PRISMA) guidelines (56) (Figure 1). The following online databases were searched; AMED, AusportMed, CINAHL, Science Direct, Scopus, SPORTDiscus, Web of Science, Natural Science Collection, PubMed, Macquarie University Library, Mantis, Ausport, Web of Knowledge. The search was conducted using the key words listed below:

> equestrian OR horse rider OR jockey AND exercise OR pilates OR yoga OR physiotherapy OR physical therapy OR chiropractic OR osteopathy OR personal training OR strength OR cardio* OR fitness AND performance OR scores OR balance OR symmetry OR effectiveness OR efficacy OR fitness AND random* control* trial OR pilot OR feasibility OR cross-over OR longitudinal OR case study

2.2.2 Inclusion Criteria

- Exercises must be done off the horse.
- Exercises or stretches rather than riding, must form the intervention, this, for example, excludes interventions such as hippotherapy.
- Papers must be peer-reviewed – either published in a peer-reviewed journal, or as a submitted and published thesis.
- Full text must be available and in English language or translated into English.

There were no exclusion criteria applied. There was no limit on the year of article publication for inclusion.

2.2.3 Screening Method

Online databases were searched according to the search terms listed. Articles were exported to an Endnote library and duplicates manually removed. Articles were then screened by title and abstract for inclusion. Full text was obtained for remaining articles and these were screened for inclusion. Forward and reverse citation tracking was carried out on included articles, as well as relevant background articles to improve the likelihood of finding all relevant articles. Study characteristics, such as the participants, interventions, methods and nature of assessments, along with the results of the studies were extracted for later analysis. The online database search was carried out between the 2nd of April, 2018 and the 9th of April, 2018.

The results of each individual study were analysed qualitatively and studies were divided according to the subgroup of the intervention used.

Due to the number of observational studies included in this review, the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) (57) checklist was applied to each study to assess the quality of the reporting. Specifically, the combined STROBE version 4 was used, which covers 22 aspects of reporting in observational studies. For a description and interpretation of the Strobe checklist, the reader can refer to section 2.3.3 of this document where the instrument is described in detail.”

2.3 Results

The following databases were searched: AMED, Ausportmed, Ausport, Pubmed, CINAHL, Science Direct, Scopus, Mantis, SPORTDiscus, Web of Science, Natural Science Collection, Web of Knowledge and Macquarie University Library. This search yielded a total of 1827 results (Figure 2). Duplicates numbering 586 were manually removed leaving 1241 records. Forward and reverse citation tracking of relevant review articles was performed, with six further articles identified. Articles were then screened by title, abstract and full text according to the defined inclusion criteria, with five articles included in the review. Forward and reverse tracking of citations (those cited by, and those who cited) of included articles yielded no further articles for inclusion.

Figure 1 PRISMA Flowchart

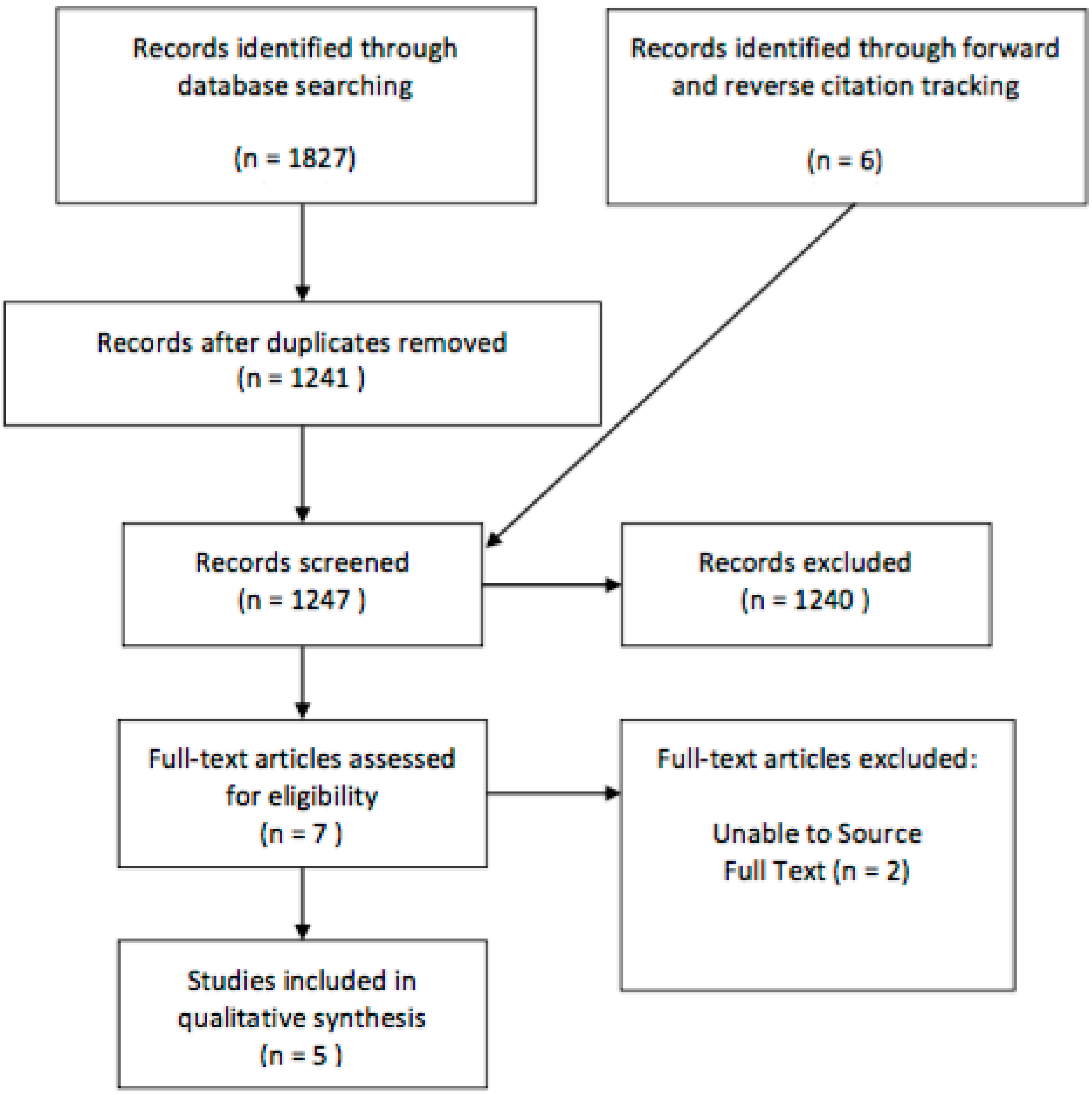


Figure 2 Database Search Results

AMED (Allied and Complementary Medicine): 2 results
AusportMed: 2 results
CINAHL: 55 results
Science Direct: 450 results
Scopus: 5 results
SPORTDiscus: 12 results
Web of Science: 47 results
Natural Science Collection: 1094 results
PubMed: 5 results
Macquarie University Library: 154 results
Mantis: 0 results
Ausport: 0 results
Web Of Knowledge: 1 result

2.3.1 Included Study Characteristics

All included studies had a small number of participants, ranging from 6 to 18. Primarily, these were pilot and feasibility studies of an observational nature. Interventions included taping (28, 58), exercise (26, 35) and manual physiotherapy (59) (Table 1). Boden (26) included two intervention groups, while only one study (59) included a control group which received no intervention. The studies were of short duration, with three having a single session intervention (28, 58, 59), and the remaining two (26, 35), a 5 to 8-week intervention. No studies included follow-up measurements. Outcome measures included muscle strength tests, functional aerobic and flexibility tests, rider posture and symmetry, postural stability, and a USEF training level test (Table 1). Despite having no date limit applied in the search criteria, all studies were published within the last five years. The studies reported no adverse events.

Table 1 Study Characteristics Data

Author/s	Year	Type of Study	Number of Participants	Intervention	Outcome Measures	Type of Riders
Alexander *et al. (58)*	2015	Randomised cross-over trial	10	Athletic taping technique over thoracic region	3D motion analysis of movement range, absolute difference and movement symmetry.	Dressage
Boden (26)	2013	Comparator trial	16 Group 1: 7 Group 2: 9	Group 1: Rider specific circuit training once a week for 8 weeks Group 2: Traditional neuromuscular and ball sport regime once a week for 5 weeks.	20m shuttle run test, sit and reach test, resting heart rate, and motion capture of deviation from P-A alignment in walk and trot.	Novice, "sedentary" riders based at Duchy College.
Kim *et al.* (28)	2013	Observational study	8	Kinesio tape was applied to the quadriceps and hamstring muscles.	Muscle strength was tested at 60°/sec and 180°/sec before and after the application of the kinesio tape	Race jockeys

Author/s	Year	Type of Study	Number of Participants	Intervention	Outcome Measures	Type of Riders
Lee (35)	2015	Feasibility study	18	8-week, home-based isometric strength training program	Step test recovery heart rate, isometric row, hip adduction, handgrip, composite muscular strength, partial curl up, isometric chest raise, composite muscular endurance, USEF training level rider test score, rider position component score, effective use of aids component score.	Dressage riders
Nevison & Timmis (59)	2013	Feasibility Study	6 3 treatment 3 control – no intervention	Physiotherapy intervention: tailored manual therapy including limb rotation and massage on muscles connecting to the pelvis. Control group relaxed for equivalent period.	Postural stability (measured via a force plate under a saddle on a high platform, pressure measurements from a pressure mat on top of a saddle on a platform.	Advanced level dressage or showjumping riders.

Characteristics of included studies pertaining to methodology

2.3.2 Results of Studies

Overall, the studies showed significant improvements in outcomes such as postural stability, rider position, symmetry, muscular speed, strength and endurance, and rider performance scores (Table 2). The results of these studies indicate that exercise interventions may be useful in improving rider position, while manual therapy may be useful in improving postural stability. The use of taping appears to be beneficial in quite specific areas, with a lack of effect in others (58). No studies reported any adverse events. Meta-analysis of results could not be performed due to the small, and heterogeneous nature of the studies available.

Taping

Alexander *et al.* (58) investigated the use of athletic thoracic taping on symmetry of dressage riders. This was a randomised cross-over study, where each of the 10 riders acted as their own control. Three-dimensional motion analysis was used to determine the degree of symmetry in the areas of trunk flexion/extension, lateral flexion and rotation, as well as pelvic posterior-anterior movement, lateral flexion and rotation. The study showed significant improvement in the area of trunk lateral flexion following the application of the tape, with no substantial change in any other outcomes.

Kim *et al. (28)* investigated the use of kinesio taping on the quadriceps and hamstrings of 8 race jockeys to improve peak torque, average torque and total work of the knee at 60°/sec and 180°/sec. The authors found statistically significant improvements in all outcome measures for both right and left knees with the application of the kinesio tape.

Exercise

The study by Boden (26) was a small (n=16) comparison trial carried out as part of a Master of Research thesis. The trial compared the use of an 8-week rider specific fitness program (group 1) to a 5-week traditional neuromuscular and ball sport regime (group 2) for improving rider position, resting heart rate, beep test (a running endurance test) results and sit-and-reach test (measuring functional hamstring length) results. Group 1 showed no significant improvement in resting heart rate or beep test results, whereas group 2 did.

Both groups showed significant improvement in the sit-and-reach test and rider position, but there were no significant between-group differences. This study seems to indicate that fitness programs in general may improve rider position.

Lee (35) investigated the use of an 8-week isometric strength training program to improve muscular strength and endurance of dressage riders, and whether this correlated with improved scores in the USEF Training Level Rider Test (TLRT). The test includes scores such as the Rider's Effective Use of Aids, which judges how effective the rider is at using their body to communicate with the horse, and the Rider Position scores, which judges how correctly the rider sits in the saddle. The author found significant improvements in muscular strength, endurance and the TLRT scores. There was a significant correlation between both muscular strength and endurance, and TLRT scores. There was also a significant correlation between muscular endurance and Rider's Effective Use of Aids scores, as well as a significant correlation between muscular strength and Rider's Position scores.

Manual Therapy

Manual therapy in this case refers to physiotherapy, which is a physical therapy where the practitioner uses their hands to perform techniques such as soft tissue work, joint mobilisations and assists in stretching or muscle release. Nevison and Timmis (59) investigated the use of physiotherapy to the pelvis of experienced dressage and showjumping riders on postural stability and symmetry of pressure. This study included an intervention group (n=3) of tailored manual physiotherapy to the pelvic area of experienced riders, compared to a control group (n=3) who spent an equivalent time doing nothing. They found a significant improvement in postural stability in the intervention group. They also found a decrease in the bias towards and increased pressure to the right-hand side of the pressure sensor pad following the intervention. The control group did not show any change between baseline and final assessment.

Table 2 Study Results Data

Author/s	Year	Results
Alexander *et al.* *(58)*	2015	Tape significantly increased ($p<0.05$) the average range of trunk lateral flexion. No other significant changes were found in trunk flexion-extension, trunk rotation, pelvis posterior to anterior, pelvis lateral flexion or pelvis rotation.
Boden (26)	2013	Group 1 showed no significant difference in resting heart rate or beep test results ($p>0.05$) where group 2 did show significant differences ($p<0.001$ and $p<0.05$ respectively). Group 1 showed significant change in the sit and reach test ($p<0.05$) compared to group 2 ($p>0.05$). Rider position data was not normally distributed. Following the intervention, both group 1 and 2 showed a significant difference between anatomical landmarks ($p<0.001$). The strides that the data was collected from showed no significant difference in results ($p>0.05$). Both groups improved significantly in rider position ($p<0.005$) following the intervention, group 1 showed the highest significant difference ($p<0.005$) between week 2 and 4, where group 2 showed significant improvements between week 2 and 3 ($p<0.001$). There was no significant difference between groups in the improvement of rider position ($p>0.05$). Group 1 ($p<0.001$) and group 2 ($p<0.05$) both showed significant improvement in leg length.
Kim *et al.* (28)	2013	There were significant improvements to all peak torque measurements following the application of kinesio tape: At 60°/sec right extensor peak torque ($p=0.004$), right flexor ($p=0.012$), left extensor ($p=0.004$) and left flexor ($p=0.043$). At 180°/sec peak torque the right extensor ($p=0.033$), right flexor ($p=0.024$), left extensor ($p=0.002$) and left flexor ($p=0.002$). There were significant improvements to all average torque measurements: At 60°/sec right extensor average torque ($p=0.005$), right flexor ($p=0.003$), left extensor ($p=0.006$) and left flexor ($p=0.005$). At 180°/sec average torque the right extensor ($p=0.001$), right flexor ($p=0.008$), left extensor ($p=0.014$) and left flexor ($p=0.004$). There were significant improvements to all total work measurements following the application of kinesio tape: At 60°/sec right extensor total work ($p=0.008$), right flexor ($p=0.008$), left extensor ($p=0.002$) and left flexor ($p=0.017$). At 180°/sec total work the right extensor ($p=0.001$), right flexor ($p=0.048$), left extensor ($p=0.017$) and left flexor ($p=0.017$).

Author/s	Year	Results
Lee (35)	2015	There were significant improvements in muscular strength (p<0.005) and muscular endurance (p=0.001). Riders showed significant improvements in the USEF TLRT scores between baseline and final assessment (p=0.037). There was no significant correlation found between changes in muscular strength and rider test performance (p=0.96) but there was a significant correlation found between the changes in muscular endurance and the changes in total riding test score (p=0.011), with muscular endurance accounting for almost 30% of changes in total riding test performance scores. A significant correlation was found between changes in muscular endurance and the Rider's Effective Use of Aids score (p=0.019), accounting for 24% of the changes in the score. There was no correlation, however, between muscular endurance and changes in Rider Position score (p=0.285). Muscular strength showed no significant correlation with changes in Rider's Effective Use of Aids score (p=0.351) but did approach significance with changes to Rider Position score (p=0.08) and likely accounted for 17% of changes. Both Rider's Position score and Rider's Effective Use of Aids score showed significant correlation with overall rider test scores (p<0.005 for both). In order to examine variables that could influence performance, exploratory analysis examined the relationship between hours spent riding per week and total riding test performance scores, but these showed no significant correlation (p=0.418). Similarly, changes in cardiovascular fitness showed no significant correlation with riding test performance (p=0.404).
Nevison & Timmis (59)	2013	Participants in the treatment group showed significant reduction in postural instability (p=0.007). Initial bias towards increased pressure to the right hand side of the saddle at baseline was not present in the intervention group following the intervention. There was no significant change in peak pressure, mean pressure or maximum force in the intervention group. The control group showed no change in any outcome from baseline to second assessment.

Data extracted from the results section of included studies

2.3.3 Quality Assessment

The STROBE checklist (57) was used to assess the quality of the reporting of included studies. This checklist contains 22 items, pertaining to the thoroughness of reporting in each section of the included articles. The checklist ascertains the how clearly and specifically the article states their design, methodology and results, ensuring that the article is thorough and reproducible. The scores of the STROBE checklist (57) ranged from 13 to 20 out of 22, indicating relatively high-quality reporting of these trials (Table 3). The results sections of all included papers were reported well, with each of the papers covering each aspect of the checklist. The discussion sections were mostly well reported, however Kim *et al.* (28) and Nevison and Timmis (59) failed to report the limitations of their studies. The main weakness of studies, except for Lee (35), was a lack of reporting around statistical power in sample sizes. Each of the included studies had relatively small sample sizes, and this was rarely addressed. Similarly, only Lee (35) and Nevison and Timmis (59) discussed any aspect of blinding or bias in their studies.

Table 3 STROBE Checklist Results

	Alexander *et al.* (58)	**Boden (26)**	**Kim *et al.* (28)**	**Lee (35)**	**Nevison & Timmis (59)**
Title and Abstract:					
1. Title and Abstract	*			*	*
Introduction:					
2. Background/Rationale	*	*	*	*	*
3. Objectives	*			*	*
Methods:					
4. Study Design	*	*	*	*	*
5. Setting		*			
6. Participants	*	*	*	*	*
7. Variables	*	*		*	*
8. Data Sources/ Measurements	*	*	*	*	*
9. Bias				*	*
10. Study Size				*	

	Alexander *et al.* (58)	**Boden (26)**	**Kim *et al.* (28)**	**Lee (35)**	**Nevison & Timmis (59)**
11. Quantitative Variables	*	*	*	*	*
12. Statistical Methods	*	*		*	*
Results:					
13. Participants	*	*	*	*	*
14. Descriptive Data	*	*	*	*	*
15. Outcome Data	*	*	*	*	*
16. Main Results	*	*	*	*	*
17. Other Analyses	*	*	*	*	*
Discussion:					
18. Key Results	*	*	*	*	*
19. Limitations	*	*		*	
20. Interpretations	*	*	*	*	*
21. Generalisability	*	*	*	*	*
Other Information:					
22. Funding	*	*			
Total Scores:					
	19/22	18/22	13/22	20/22	18/22

Scores according to the STROBE checklist. * Indicates that the paper met the criteria for this point on the checklist.

2.4 Discussion

Based upon the results of the included studies, it would appear that modalities applied off the horse may be beneficial to outcomes for horse riders. All studies showed statistically significant improvements in their outcome measures following their respective interventions. These results indicate that this may be a promising area of future research, but due to small sample sizes and short duration of both interventions and assessment, the results of these studies must be interpreted cautiously. Heterogeneity of the studies in the areas of populations, interventions, and outcome measures used make comparisons and overall trends even more difficult to ascertain.

2.4.1 Limitations of this Review

This review was limited primarily by the small number of included studies. The small field of research, combined with difficulty in accessing full-text articles resulted in only 5 articles being included in the final review. This small number and the heterogeneous nature of the articles included makes it difficult to draw meaningful conclusions regarding the value of the literature, as would be possible in a meta-analysis. As such, this literature review provides descriptive rather than inferential analysis of the research to date.

2.4.2 Significance

The finding of this review indicate that investigating the effectiveness of modalities which can be applied to riders off the horse to improve outcomes whilst riding is a promising area of research. The lack of current studies indicate that this area is still in its infancy and as such has much scope for future investigation. If future, higher quality studies show similar results, they may provide evidence-based information to alter traditional practices within the equestrian industry. Research in this area could initiate a movement towards more evidence-based coaching of horse riders, ideally leading to better outcomes for both humans and horses.

2.4.3 Generalisability

The small sample sizes make the results of the individual studies less generalisable. While these studies do incorporate a small range of riding disciplines (dressage, jumping, racing) there is not enough breadth of investigation to provide generalisable conclusions from the results of this review.

2.4.4 Future Research

Further research is required to gain meaningful and industry applicable results. With so little research into this area, there is scope for future investigation. Future research could investigate the efficacy of interventions designed more specifically for horse riders, rather than generic interventions based upon pre-existing frameworks. Additionally, larger sample sizes, longer follow up periods, and more varied populations would be beneficial to improve the validity and generalisability of results. Therefore, filling these research gaps could influence other areas related to the equestrian field. Such domains could refer to 1) the rider biomechanics in the application of signals in horses, 2) the scope for the sued of external modalities in improving performance at the elite levels of the sport, and 3) the rider safety through an improved ability to respond to the horse's actions.

2.5 Limitations in the Included Studies

A number of common problems have been identified, which are investigated individually below.

2.5.1 Study Methodology

Those studies investigating interventions done off the horse to improve rider biomechanics on the horse were mostly pilot or feasibility studies of an observational nature and ranged from 6-18 participants. The studies were of short duration, generally having only a single intervention, no randomisation and a short intervention of 5-8 weeks. There is often no blinding of participants or practitioners and very little blinding of assessors. There was also often no follow-up period, making it impossible to ascertain how long any results may last following the intervention. The small scale of these studies and lack of randomisation and a control group means that results may be skewed by biases, small sample sizes or less reliable data, and this limits the conclusions that can be drawn from results,

2.5.2 Assessing Horse/Rider Asymmetry

Many studies have highlighted difficulties in accounting for variables when investigating the relationship between horse and rider biomechanics. Variables include the level of training of the horse, the experience of the rider, the gear being used on the horse, the effect of the rider on the horse, and that of the horse on the rider. Another variable is the speed at which the pair are moving. A 2017 literature review by Clayton and Hobbs (60) summarised the current research into the analysis of horse and rider biomechanics. The authors categorised the data according to the particular "gait" of the horse (e.g. walk, trot, canter or gallop). The authors concluded that each gait led to a different biomechanical relationship between the horse and rider, which needs to be accounted for when designing interventions to improve rider biomechanics. A causal relationship between the biomechanics of the rider on the horse or horse movement on the rider has not been determined, although correlations in asymmetry between the two have been demonstrated. A 2017 summary paper by Sue Dyson (17) investigated common issues in identifying the underlying cause of asymmetry, including the effects of the biomechanics of the horse, the rider, the fit of the saddle, the ground, and other equipment on the physical wellbeing of the horse. Further studies on saddle fit also found strong correlations between ill-fitting saddles and both horse and rider asymmetry, but were unable to determine causality (34-36). For example, a saddle may sit unevenly on the horse's back because it is made and fitted incorrectly, because the horse's musculature is asymmetrical, or because the rider sits asymmetrically and creates uneven downward pressure through the saddle. All three components on their own have the potential to cause asymmetry in the others, and this is magnified if more than one component is asymmetrical. If these asymmetries are ongoing, they have the potential to perpetuate each other, i.e. if the saddle sits unevenly, and the rider's weight continues to shift unevenly then their muscle development will be uneven.

2.5.3 Valid and Reliable Outcome Measures

A lack of valid, reliable and objective outcome measures has limited research in this field. Prior research (16) has investigated the use of subjective measures by professionals in the industry, however this research has highlighted a lack of inter-assessor reliability amongst riding coaches, riding professionals and judges in both showing and dressage. The difficulty in controlling confounding variables in horse riding makes reliable outcomes even more challenging to find. Newer technology, both designed specifically for riding and appropriated from other research fields has recently emerged and are now capable of addressing these problems (39). However, validation of this new technology within horse riding is limited, and researchers then need to account for the technology's inherent limitations. For example, pressure distribution pads measure only the pressure which is applied perpendicular to the pad, and therefore does not account for pressure applied in any other direction, meaning that only a portion of the pressure from the rider is measured by these pads, which limits the accuracy of the results.

2.5.4 Practical Use of Research Outcomes

Within the current research, there has been difficulty translating rigorous research into the pragmatic situation. For example, many studies (26, 58) investigating rider biomechanics by means of video motion capture, have the horse and rider maintain a specific speed in a very controlled trajectory. This allows for much more homogeneity of results, but does not accurately reflect the biomechanics of the riders in their usual riding environments. Conversely, other studies (35) have aimed to minimise the interference of the study conditions on the regular behaviour of the horse and rider and thus provide more "real world" data. But this increases the heterogeneity of results. The difficulty lies in designing research which is of high quality but includes data which are both accessible and useful in a practical way to riders and coaches working in the industry.

2.5.5 Lack of Implementation of Research

Implementation of research in the equestrian community has also been limited by a lack of relatability between researchers and riders, as well as a lack of adequate communication of the research to those in the industry (61). In a 2013 paper (3), Andrew McLean described traditional horse training as an "anthropomorphic hall of mirrors", and stated that a rigid adherence to anthropomorphism (the tendency for riders and trainers to impose human attributes on horses) is one reason why the equestrian community has been slow, and even resistant to take up the practices shown to be effective by scientific inquiry. This paper suggests that the love of horses prevents the equestrian community from embracing evidence-based practice. Whilst this may be the case, there has also been a lack of relatability between research findings and actual "real world" benefits to members of the equestrian community. The theoretical improvements in human safety, equine welfare and performance, have for the most part not yet been communicated in a way that engages the equestrian community and thus have failed to provide the necessary motivation for interest and change within the equestrian community.

Resolution of these difficulties is likely to improve not only the quality of the research, but also the ability for the equestrian community to apply findings in a way that directly impacts on rider performance, equine welfare and rider education.

2.6 Conclusion

This review highlights a promising area of future research which has the potential to alter industry practice, and possibly provide a means of ethical enhancement of equestrian athlete performance. Despite small and limited studies, the research has shown promising results, with significant improvements in outcomes such as postural stability (59), rider position (26, 35), symmetry (26, 58), muscular speed (35), strength and endurance (28, 35, 58), and rider performance scores (35). Results of these studies indicate that exercise interventions may be useful in improving rider position (26, 35), while manual therapy may be useful in improving postural stability (59). The use of taping appears to be beneficial in quite specific areas, with a lack of effect in others (28). The results of the included studies are encouraging, but more research in this area is required to draw meaningful conclusions that could be applied to a broader population of horse riders. This literature review has been useful in informing the methodology applied in this thesis as it has highlighted the tension between incorporating outcome measures that are valid and reliable, but also making the findings of the research directly applicable and implementable to practitioners in the field. By incorporating the existing findings and new advancements, as well as acknowledging and improving on previous difficulties, this field has the potential to reach much further than the specific subject matter of a single trial, and may have impacts on research, horse welfare, and equestrian sport alike.

Chapter Three: Materials and Methodology

3.1 Introduction

This research was designed as a feasibility study to inform a future large-scale intervention trial. For this reason, the primary outcomes pertain to the feasibility, while secondary outcomes assess the potential effectiveness of the functional movement program as an intervention.

3.2 Research Procedures

3.2.1 Trial Design

A before and after study design was used. A small number of horse riders were recruited. They underwent a baseline physical assessment and dressage test. Immediately following the dressage test, they answered two questions on a numerical rating scale (Appendix 3) pertaining to their self-reported balance, and self-reported effectiveness during the dressage test. Participants then attended 5 functional movement classes, once a week and lasting one hour. In the last functional movement class, the participants completed numerical rating scales for their opinion of the relevance of, and their satisfaction with the program, as well as their completion of homework exercises. Following the completion of the functional movement program, an identical physical assessment and dressage test were repeated.

3.2.2 Participants

In order to be included in the study, participants were required to be between 18 and 65 years of age and not pregnant if female. They were to be financial members of Equestrian Australia, and have competed at a minimum Novice level within the last 12 months. In order to follow instructions during the intervention, the participants were required to speak English. Those with contraindications for exercise, for example, cerebral palsy, hemiplegia, diplegia, active neuromusculoskeletal injury were excluded from the study.

3.2.3 Recruitment

A poster was placed in the Galston Equestrian Club and on their social media site, with email and telephone links for potential participants to contact (Appendix 4) Those who responded were interviewed to assess whether they met inclusion criteria. Responders who met the inclusion criteria were provided with the participant information and consent form (PICF) via e-mail. Those who signed and returned the PICF via e-mail were included in the trial.

As recruitment ability was one of the feasibility outcomes, four months was allowed for recruitment with a maximum of 20 participants in order to maintain a manageable class size for the intervention.

The Galston Equestrian Club was chosen as the single recruitment centre due to its large membership and number of followers within a small geographic area. The area around Galston and Arcadia is densely populated with horse riders, and specifically those who often compete in dressage, making it an ideal location from which to recruit participants.

3.2.4 The Functional Movement Program

The functional movement program is a five-week program designed to improve the strength, flexibility and competition performance of horse riders. The program was custom designed to account for gross motor patterns used in horse riding, and break them down into their component parts, then train the rider off the horse in a way that progressively works back up to the initial gross motor pattern in a more biomechanically effective and symmetrical way. This program mainly focuses on the areas of pelvic stabilisation, hip extension and the stabilisation of the scapulae, as these are deemed to be important for dressage riders. These movements are used to create commands of the horse for particular parts of the dressage test, such as transitions within a pace, transitions to and from each pace and also to improve the balance of the rider to allow the horse to move more freely. (Appendix 1)

The program begins with simple exercises and stretches based primarily on yoga, Pilates, and clinical rehabilitation exercises and stretches. These are then progressed to movements more similar to those used in riding, with the program concluding with practising gross motor patterns on the model horse.

Participants are given written and video instructions for the exercises, as well as recommendations of the frequency with which to practice exercises at home between classes (Appendix 1).

These classes were run by the researcher and carried out in a room in Oakville, NSW, local to the members of Galston Equestrian Club. The room provided sufficient space to carry out the classes, and having an indoor venue provided protection against any possible inclement weather.

3.2.5 Outcome Measures

3.2.5.1 Primary Outcomes

The feasibility measures were chosen to assess the viability of a large-scale effectiveness trial.

The primary outcome measures answered the research feasibility aims:

1. Ability to recruit participants in a four-month period
   Outcome measure: the number of patients initially recruited within the four-month recruitment period
2. Ability of participants to attend and complete the 5-week program.
   Outcome measure: percentage of participants completing the 5-week program
3. Self-reported ability of participants to complete all the home-based exercises as prescribed.
   Outcome measure: numerical rating scale given to participants at the final weekly class, with the question: "On a scale of zero (0) to ten (10), with zero being never completed, and ten being completed exactly as specified, how would you rate your completion of the exercises and stretches at home as they were prescribed to you?"
4. Ability of participants to attend baseline and follow-up assessments.
   Outcome measure: percentage of participants to attend each assessment
5. Self-reported level of participant satisfaction with the program.
   Outcome measure: numerical rating scale given to the participants at the final

weekly class, with the question: “On a scale of zero (0) to ten (10), with zero being completely dissatisfied, and ten being completely satisfied, how would you rate your satisfaction with the classes (i.e. was there satisfactory individual attention given, were the class sizes satisfactory, was the equipment and tuition satisfactory)?”

6. Participant self-reported opinion of the relevance of the program.
   Outcome measure: numerical rating scale given to the participants at the final weekly class, with the question: “On a scale of zero (0) to ten (10), with zero being completely irrelevant, and ten being very relevant, how would you rate the functional movement exercises and stretches to your riding?”.

3.2.5.2 Secondary Outcomes

Secondary outcome measures were designed to answer the second research question: Do the results from this unpowered study suggest that the program on a larger scale would improve the strength, flexibility and competition performance of horse riders? The secondary outcome measures were chosen to determine the effectiveness of the functional movement program. The program targets the movements of pelvic stabilisation, hip extension, and scapular stability, using the measures of strength and flexibility

The length and strength of the targeted muscles were measured at baseline and after the 5-week program. This physical assessment was carried out by an experienced chiropractor, who also underwent a training session specifically to determine the exact procedure used for each of the tests and thus standardised the testing (Table 4). The tests used were chosen as they have been validated in the literature, and/or are industry standard. In detail, the secondary outcome measures were:

1. Rider performance in a dressage test.
   The dressage test was judged by an experienced, high-level judge. The participants completed the Novice 2.1 dressage test (Appendix 2) at both assessments. The tests were completed in the week prior to beginning the program, and within two weeks of the completion of the program, with scores recorded as a percentage of the total marks as they are in a dressage competition. The dressage test was included as a measure of competition performance. The specific dressage test itself was chosen because it was of a sufficient level to ensure that beginners would not be included in the trial, but is low enough within the levels of dressage to have a sufficient pool of riders from which to recruit.

2. Self-reported balance, and self-reported effectiveness.
   At the conclusion of the dressage test, each participant was given a numerical rating scale with the questions: “On a scale of zero (0) to ten (10), with zero being completely ineffective, and ten being the most effective you have ever been, how would you rate the effectiveness of your riding during the dressage test today?” and “On a scale of zero (0) to ten (10), with zero being completely unbalanced, and ten being the most balanced you have ever been, how would you rate your balance during the dressage test today?”
3. Abdominal muscle strength.
   Measured using the double leg lowering test as described and validated by Ladeira *et al*. (62). An electronic goniometer (Dualer IQ™) was used to assess the angle of the femur relative to the table when the participant began to increase lumbar flexion. For this measure, a decrease in the angle represents an improvement in abdominal muscle strength, and indicates that the abdominal muscles are able to stabilize the pelvis under greater load from the lowering of the hips.
4. Hip flexor length.
   Measured in the Modified Thomas position as described by Kim, 2015 (63), with a Dualer IQ™ goniometer to measure how many degrees above or below horizontal the extended femur would be allowed to drop under gravity. This was measured as the number of degrees below horizontal the femur rested. Therefore, a reading in the positive measurement indicates a shorter muscle length, with the femur was angled above the horizontal, i.e. with the knee above the level of the hip, and a negative reading indicates a longer muscle length with the femur angled downwards. Each side was measured independently.
5. The length of the pectoralis minor.
   Measured as described by Kendall *et al. (64)* by calculating how many centimetres the shoulder was raised off the table when the participant was at rest in a supine position. The larger the measurement, the shorter the muscle. Each side was measured independently.
6. Hip extensor strength.
   Measured as described by Kendall *et al.* (64) by having the participant lay face down, and push up into the PowerTrack II™ Commander Muscle Tester which was placed on their posterior thigh. Measurements were taken for both the left and right, and each was assessed three times, with an average of the scores used for final results.

7. The strength of medial stabilisers of the scapula.
   Measured as described by Kendall *et al.* (64) with the use of the PowerTrack II™Commander Muscle Tester. The participant was laying prone, with the shoulder abducted to 130 degrees, and asked to maintain that position as the assessor pressed downward on their posterior wrist. Measurements were taken for both the left and right arms, and each was assessed three times, with an average of the scores used for final results.

Table 4 Physical Assessment Procedure

Double Leg Lowering	Participant lays supine on the table with knees straight and hips at 90 degrees. They are asked to slowly lower their legs towards the table, keeping the knees straight. The angle of their legs from the table is measured when their back begins to arch, this is assessed by placing a hand under the participant's lumbar spine and noting the angle when the pressure comes off the hand. Goniometre: Attach the Primary sensor to the thigh with a strap, 10cm from the joint line of the knee. With the subject supine on a table, place the hip to be evaluated in neutral position and extend the knee in neutral position. Press the Start/Stop button to establish 0, then have subject flex hip until the iliac spine begins to move and record the angle.
Modified Thomas Test	Participant sits at the foot of the table, with their ischial tuberosities just on the edge of the table. From there, they hold one knee in a flexed position, and lay back into a supine position, holding the knee. Goniometre: Attach the Primary sensor to the thigh with a strap, 10cm from the joint line of the knee. With the subject supine on a table, place the hip to be evaluated in neutral position and extend the knee in neutral position. Have the subject flex the opposite hip and knee and hold them in position in order to flatten the spine to the couch. Press the Start/Stop button to establish 0, then have subject extend the hip until the iliac spine begins to move and record the angle. This is repeated 3 times bilaterally, and an average measurement is recorded.
Hip Extension Test	Participant lays prone on the table, with the hip extended and knee flexed. The assessor applies a downward pressure to the distal posterior thigh (as shown below), and this pressure is measured using the Commands Muscle Tester. The test is repeated three times bilaterally and an average is taken. *Taking knee to tension, not to a specific height off couch.
Strength of Medial	Participant lays prone, with shoulder abducted to 130 degrees and elbow extended with palm facing the floor. The Commands Muscle Tester is used to measure the

Stabilisers of Scapulae	amount of force applied to the posterior forearm, 10cms from the wrist, before the scapula moves. This is repeated 3 times bilaterally and an average measurement is taken.
Length of Pectoralis Minor	Participant lays supine on the table. Distance of acromion process from the table is measured in centimetres using a ruler. This is repeated bilaterally.

3.3 Ethical Considerations

This study obtained ethics approval from the Macquarie University Human Research Ethics Committee, reference number 5201700946.

The ethical concerns were reducing the risk of injury to participants and maintaining the privacy of the information provided by participants. These considerations were addressed in the following ways:

The risk of injury was mitigated by including only adults, with no contraindications for exercise, to the study. Similarly, all exercises were explained in depth, and participants were given time to ask any questions prior to carrying out any exercise. The participants practiced each exercise in class under the supervision of the researcher who corrected form in order to minimise the chance of injury. The researcher is a qualified chiropractor, with an up-to-date first aid qualification, and able to seek medical assistance at any time. In order to ensure exercises were practiced correctly at home, participants were issued with a copy of the exercises in both written and video form, with detailed instructions for correct procedure. At all times during the trial, it was made clear that participants were free to leave if they felt the trial was unsuitable for them.

Privacy of participants was maintained by verbally screening for inclusion criteria, and if recruited, recording no personal information aside from the participant’s name. Participants’ names were recorded only on the PICF, where they were also assigned a number, and these forms were stored on a password-protected USB drive in the researcher’s locked filing cabinet. All outcome measures referred only to the participant’s number.

3.4 Statistical Methods

The feasibility outcomes underwent descriptive analysis as measurements of time, attendance and averages of satisfaction, compliance and relevance scores.

The secondary outcomes are presented quantitatively as means and standard deviations. Changes over time, from baseline to the end of the program, were analysed using paired t-tests with the null hypothesis that there would be no change from baseline scores and an alternative hypothesis that there would be a statistically significant improvement from baseline to post-program scores. These paired t-tests used a calculation of 95% confidence intervals and p values (p-value less than 0.05 indicated a statistically significant difference between groups). The data was entered into excel, and checked by two independent researchers before being exported for statistical analysis. The analysis was carried out using the Minitab Express software 5.1.0, which was downloaded from the student accessible section of Macquarie University website. Missing data as a result of participant drop out during the trial were excluded from statistical analysis, on the bases that the sample size was already too small to determine the effectiveness of the program, and that being a feasibility trial, the increased possibility of bias was more acceptable (65).

3.5 Conclusion

The trial was a feasibility study, presenting a small-scale version of a larger trial which would investigate the effectiveness of a five-week functional movement program in improving horse rider competition performance, as well as improving strength and flexibility of the rider. The objectives of the research were primarily to determine the feasibility of running such a trial, and secondly to identify any trends in results. The methodology used was chosen for its relevance, practicality and pragmatism, with consideration for the objectives of the research as well as the constraints of both the research area and the limited budget and timeline.

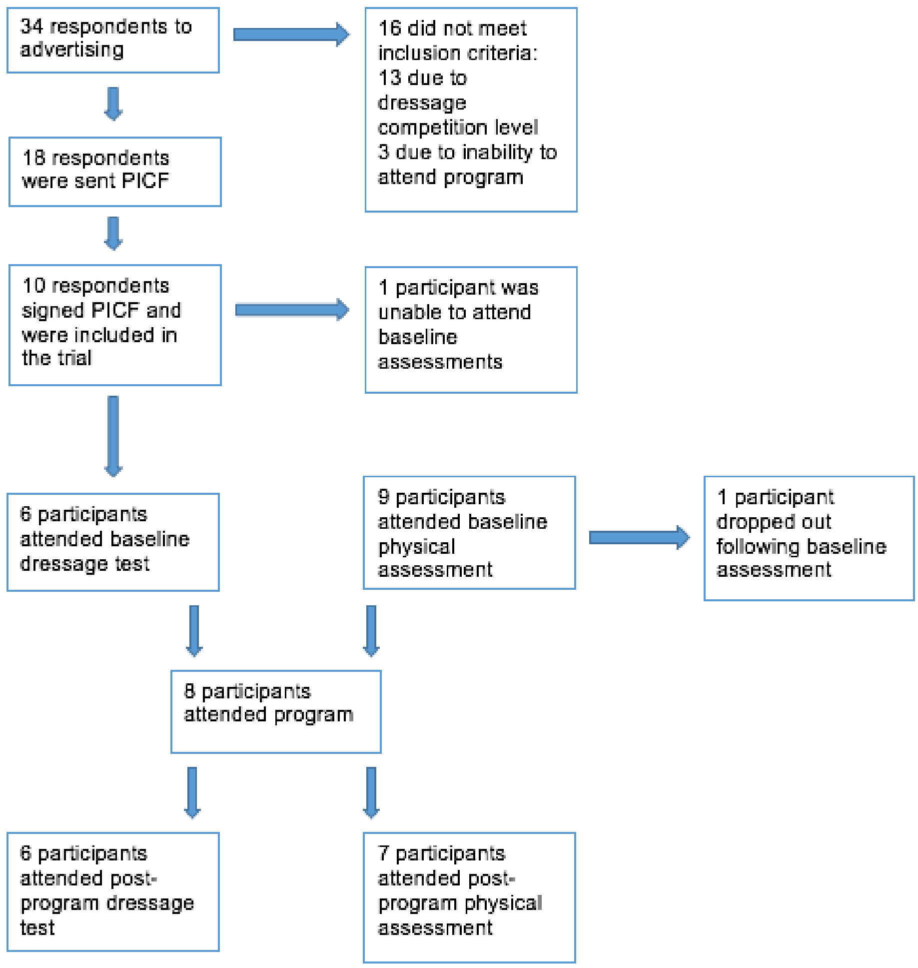
Chapter Four: Results

4.1 Primary outcomes

4.1.1 Recruitment

Initially, 4 months had been allocated to the recruitment of participants, beginning in March 2018. A combination of person circumstances, as well as a lack of follow up from enquiries, led to recruitment taking 5 months (from June to September 2018) with a total of 10 participants. Recruitment is summarised in figure 3.

Figure 3: Recruitment Flowchart



Based on the power analysis using G power 3.1 (version 3.1.9.4) (66), for a medium effect size (0.5) where p≤0.05, a minimum of 42 participants would be required.

4.1.2 Attendance of Program

There was 100% completion of the 5-week program.

4.1.3 Completion of Exercises at Home

Self-reported homework completion scores varied greatly within the group with a mean score of 5.7/10 for how closely the participants completed the exercises at home based upon the recommended frequency. Results are presented in Table 5.

4.1.4 Attendance at Assessments

The initial physical assessment was attended by 9/10 participants initially included in the trial. One of the 10 participants dropped out of the trial immediately following the initial assessment due to concerns regarding suitability for the trial. The initial physical assessment was carried out in a Pilates studio due to its ease of access, coupled with inclement weather on the day of the assessment.

The post-program physical assessment had 6/10 participants complete their assessment on one day the week following the completion of the program, but the remaining assessment was not completed until 2 weeks after the program finished. The first six were completed at the Rural Sports Facility in Galston, while the final assessment was completed on campus at Macquarie University.

The baseline physical assessment was timed to allow half an hour per participant, with the participants asked to arrive 10 minutes prior to their allotted time. All participants were punctual for their assessment and had dressed according to the requirements e-mailed to them prior to the assessment. Each assessment was undertaken within 15 minutes, with the majority of assessments taking 9 minutes. This shorter time informed the scheduling of the secondary physical assessment, and is useful knowledge as it would allow for scheduling of greater numbers in a larger scale trial.

Six out of ten participants at the baseline assessment completed the dressage tests and the same 6 participants all completed their post-program dressage test (Figure 3).

The post-program physical assessment had the majority of the participants attend at their allotted time, aside from one who was delayed in travel to the Rural Sports Facility. These assessments were scheduled at the amended 15-minute intervals, and the majority of assessments were again completed within 10 minutes.

There was some difficulty organising the attendance for the assessment of secondary outcomes. Conflicting work schedules of the participants impeded the attendance of the post-program physical assessment.

4.1.5 Relevance Satisfaction and Homework Completion Scores

Participant scores assessing the perceived relevance of the program were high as were the scores assessing the participant satisfaction with the program. Results are presented in Table 5.

4.2 Secondary Outcomes

4.2.1 Rider Performance

The scores for the dressage tests, self-reported balance and self-reported effectiveness showed a statistically significant improvement between the baseline and the post-program assessment (Table 5).

4.2.2 Physical Assessment

Nine participants completed the baseline physical assessment, with 7 completing both the baseline and post-program assessments. One participant did not complete the post-program analysis due to having dropped out of the research immediately following the baseline assessment, the second participant was unable to attend the post-program assessment due to unexpected work schedules. The scores of those participants who failed to complete the post-program assessment were disregarded in the statistical analysis. The results of the physical assessments are presented in table 5. There was a statistically significant improvement in the double leg lowering test and the left hip extension strength scores between the baseline and post-program assessment. No other tests showed statistically significant changes in scores. Left hip flexor length and right pectoralis length scores showed a small trend towards improvement, while right hip extension strength, medial scapular stabilizer strength bilaterally, right hip flexor length and left pectoralis minor length showed a small trend towards worsening.

Table 5 Results of Secondary Outcome Measures

Outcome Measure	Number of participants	Score Range - baseline	Mean (SD) - baseline	Score Range - post	Mean (SD) - post	Mean Difference (SD) (post - baseline)	95% Confidence Interval	p value
Dressage Test (%)	6	60.6 – 69.1	65.8(1.2)	61.9 – 70.2	67.1(1.2)	1.3(0.8)	0.5, 2.1	0.0095
Effectiveness NRS	6	5.0 – 8.0	6.3(0.5)	7.0 – 9.0	7.8(0.8)	1.5(0.8)	0.6, 2.4	0.0071
Balance NRS	6	5.0 – 8.0	6.2(1.3)	7.0 – 9.0	7.8(1.0)	1.7(0.5)	1.1, 2.2	0.0005
Double Leg Lowering (°)	7	51.0 – 62.0	54.0(9.4)	12.0 – 47.0	29.1(12.4)	-24.9(16.3)	-40.0, -10.0	0.0069
Hip Extension Strength – Left (°)	7	66.0 – 98.3	80.7(12.6)	99.7 – 148.3	120.8(16.4)	40.1(20.7)	21.0, 59.2	0.0022
Hip Extension Strength – Right (°)	7	74.1 – 136.0	101.7(24.2)	74.8 – 131.3	99.8(19.1)	-2.0(22.8)	-23.0, 19.1	0.8276
Medial Scapular Stabilisation – Left (N)	7	38.1 – 105.1	59.9(21.4)	35.2 – 66.0	52.4(10.8)	-7.5(20.8)	-26.7, 11.8	0.3777

Outcome Measure	Number of participants	Score Range - baseline	Mean (SD) - baseline	Score Range - post	Mean (SD) - post	Mean Difference (SD) (post - baseline)	95% Confidence Interval	p value
Medial Scapular Stabilisation – Right (N)	7	40.3 – 90.2	54.4(18.2)	27.9 – 55.7	44.1(10.0)	-10.3(17.3)	-26.3, 5.8	0.1676
Hip Flexor Length – Left (°)	7	-5.0 – 27.0	9.3(9.7)	-6.0 – 9.0	2.6(5.7)	-6.7(7.9)	-14.1, 0.6	0.0664
Hip Flexor Length – Right (°)	7	-4.0 – 31.0	8.4(12.3)	-9.0 – 9.0	1.9(8.0)	-6.6(9.3)	-15.1, 2.0	0.1093
Pectoralis Minor Length – Left (cm)	7	4.0 – 7.5	5.8(1.5)	3.9 – 9.0	6.3(2.2)	0.5(1.6)	-1.0, 2.0	0.4332
Pectoralis Minor Length – right (cm)	7	2.5 – 9.0	6.5(2.3)	3.7 – 10.5	7.4(2.4)	0.9(1.4)	-0.4, 2.2	0.1547

Chapter Five: Discussion

5.1 Introduction

This study aimed to investigate the feasibility of running a trial to determine the effectiveness of a functional movement program on horse riders' strength, flexibility and performance. The results of the study indicate that in order to be feasible, it may be necessary to increase recruitment avenues and time, but that the program itself is likely to have high participant retention. Secondary findings showed a statistically significant improvement in rider performance following the program. Similarly, abdominal strength improved significantly in the post-program assessment. Other effects of the program on specific muscle groups were not significant and varied. Preliminary results indicate that this program may be effective in improving rider performance and abdominal strength.

5.2 Strengths and Weaknesses of This Study

5.2.1 Strengths of the Study

The primary strength of this study is in its feasibility data. The data collected from a feasibility study is instrumental in the success of a larger trial, which would assess the effectiveness of the program. This research showed a high retention rate of participants through the course of the intervention and provided insights into how best to manage retention of participants into the final outcome assessments. It also showed high scores from the self-reported scales pertaining to satisfaction and relevance of the program, indicating the potential for similarly high completion rates in future research. There was also less time necessary to complete physical assessments than initially anticipated, and this can improve the scheduling of a larger trial.

All participants received training from the same chiropractor throughout the program, and therefore the style and method of training was consistent for the group. The training was supervised, with each exercise being explained and practised until participants were able to perform them each correctly. The chiropractor delivering the program was blinded to the results of the baseline and post-program assessments until all results had been collected and therefore had no bias towards focusing on any particular exercises.

The physical assessments were performed by a blinded qualified and experienced chiropractor, who had experience in conducting clinical physical assessments, as well as undergoing training for the particular tests used in this study. The dressage test was similarly judged by a highly qualified and experienced dressage judge. For both the physical assessment, and the dressage test, the same assessor was used for all participants, and across both the baseline and post-program assessment. Both assessors were blinded to the identity of the participants. These measures decrease the likelihood of bias at assessments.

Through the use of numerical rating scales, participants were given the opportunity to provide their opinion on the relevance and their satisfaction with the program. These scores are useful for a larger scale trial, as they may indicate a likelihood for similarly high completion rates of the program.

Secondary outcomes were chosen to assess specific aspects of the program. The dressage test, along with the participants' self-reported effectiveness and balance scores are pragmatic ways of assessing the influence of the program on rider performance. A mean improvement of 1% in a dressage test, as was seen in this study can often determine the placings in a competition where the top scores are often close. The physical assessments use more objective measures to assess the individual components of the program by testing individual muscle groups.

5.2.2 Weaknesses of the Study

As this was a feasibility trial, the focus was on whether the study was possible to do, i.e. the primary outcomes, and its perforce underpowered status requires that the secondary outcomes are interpreted within this context. While the secondary outcomes related to effectiveness, they were compared based on a single group's before and after scores, which does not rule out the possibility that any improvement may merely be temporal, or due to external factors. The lack of a control group, randomization and participant blinding is a limitation when interpreting the secondary outcomes; it was deemed an acceptable methodology in the context of a feasibility trial. While the conclusions that can be drawn from the secondary outcomes are limited, it does give some positive indications of the benefits that may be derived from the program, that warrant investigation in a larger trial.

Due to the multiple outcome measures and small sample size, it is possible that any statistically significant results in the secondary outcomes could be due to chance alone, and thus must be interpreted with caution. The effectiveness of the program would need to be assessed in a full-scale clinical trial.

The dressage tests, while pragmatic for the equestrian industry, were a subjective measurement, as were the self-reported scales. However, as previously mentioned, the use of the same experienced judge for all dressage tests decreased possible variation in scores.

There was a large variability in the completion of the exercises at home, as demonstrated in the large range of scores on the homework numerical rating scale. This variability could be interpreted as a need for improvement of the way the homework is delivered, or the implementation of reminders (eg via text message) to participants to ensure higher compliance in a larger scale trial. While there was a recommendation of how many repetitions of the exercises were to be completed weekly, it is possible that variation in completion could affect the results of the program. The program itself is designed so that the exercises and stretches are practiced within class until they can reliably be done to a suitable standard, but the bulk of the practice is to be done at home. Whether the participants are then completing the exercises either as frequently, or as correctly as in class is difficult to monitor, however this is common across any exercise program requiring practice without supervision.

The design of this study does not allow for assessing the suitability of secondary outcome measures for determining the effectiveness of the program. The secondary outcome measures used were chosen due to their pragmatism, or because they were industry standard, however, it is possible that there may be better means of assessing the effect of the program, whether through different physical assessments, or the use of technology such as motion capture to determine improvements in rider performance. There is the scope for further research to investigate such questions, with potential research in the area of comparisons of specificity and reliability of outcome measures for use in this particular area of research.

5.3 Strengths and Weaknesses of This Study in Relation to Other Studies

Similar to other studies reviewed in Chapter Two, this study found significant improvement in some outcome measures after the intervention. These results are congruent with the current research into interventions applied to riders whilst off the horse. Previous studies have shown benefit in specific areas such as postural stability (26, 27, 59), symmetry (59) and rider performance (35), while other outcomes showed little or no change. Our results cannot be compared to other studies due to differences in study design, outcome measures, intervention etc

For example, Lee (35), used physical assessments along with a dressage test to assess not only specific muscular improvements, but also improvement of competition outcomes. While Alexander et al. (58) and Nevison and Timmis (59) respectively included more objective outcome measures, such as 3D motion analysis and pressure sensors, the authors of these articles acknowledged the difficulties in correlating any positive findings to positive outcomes in riding performance.

Unlike Boden (26) or Nevison and Timmis (59) our study had no control group and was not a cross-over design as in Alexander study (58) which alters the interpretation of results but satisfies the primary aim of investigating feasibility. In our opinion, this was deemed to be acceptable, as the small sample size meant that effectiveness was not going to be measured accurately by this trial because our study was underpowered. Therefore, it was more valuable to gain feasibility data around participant retention and satisfaction through the intervention.

Another difference in this trial was the design of the program itself. This program was designed specifically for horse riding with a background of riding, coaching and the biomechanical understanding from chiropractic training. The exercises and stretches were reverse-engineered from the gross motor patterns of riders, rather than being adopted from another modality. Ideally with a full-powered effectiveness trial it may be possible to modify the program to improve the effectiveness of individual stretches and exercises.

5.4. Significance of Findings

5.4.1. Logistics of Conducting a Large-Scale Effectiveness Trial

The findings of this research indicate that it may be possible to run a larger, fully powered trial to determine the effectiveness of a functional movement program for horse riders. Modification to the recruitment process, by either including a larger geographical area, or allowing a greater amount of time for recruitment is likely to allow more respondents to be included in the trial.

Modifications in scheduling may improve the retention of participants through to the post-program assessments. By scheduling the post-program physical assessment as an extension of the weekly program and asking participants to commit to 7 weeks of attendance at the same time, place and day there is likely to be a greater rate of attendance at the post-program assessment. Similarly, attendance at the dressage tests could have been improved by scheduling them as a part of the trial, rather than trying to organize these separately. The program itself was completed by all participants who started and scored highly in the relevance and satisfaction scores given by participants.

The completion of homework exercises as directed varied significantly between participants. It is possible that when running a more extensive trial, the use of reminders via text message or similar media could improve the completion rate.

Unlike other research in this field, which found assessments to be time-consuming as a result of time taken to set up and operate elaborate equipment (26, 58, 59), the physical assessments were completed in less time than what was originally allocated, and this could be beneficial when performing assessments on a larger sample size.

5.4.2 Secondary Outcome Measure Results

The secondary outcomes of this research investigated trends of change in various areas such as dressage test scores, muscle length and strength, and self-reported performance. The results showed statistically significant improvements in the areas of dressage test scores, self-reported balance and effectiveness, abdominal muscle strength, and the strength of hip extensor muscles on the left. All other measures showed no significance, and scores before and after the intervention showed trends towards either remaining the same, or becoming slightly worse. This may be due to external factors, a flaw in the outcome measures used, the way the exercises were practiced at home, or potentially the program is ineffective in these areas. Determining the validity of the physical assessment in relation to this program would require a specific trial investigating the specificity and reliability of the result of these tests when compared to the results of other possible means of testing for these particular movements. Similarly, determining the effectiveness of the program itself would require a full-scale effectiveness trial. Additionally, the variable time taken between the completion of the program, and the post-program assessments may have affected the participants' scores. For this reason, it would be useful in a larger trial to schedule post-program assessments for the week following the completion of the program. While the small sample size and lack of a control group means that results of the effectiveness of the program must be interpreted with caution, these results indicate that this may be a worthwhile study to pursue in a larger scale.

5.5 Unanswered Questions and Future Research

The results from this study, as well as those within the current literature, would indicate that future research in this area may be worth pursuing. Future research could include full scale randomised controlled trials to determine effectiveness of the functional movement program, investigation into the best methods of assessing rider performance, and studies which tie research into interventions completed off the horse to other areas of equitation science such as horse training.

Ideally, future research would include a large scale trial to determine the effectiveness of a functional movement program for horse riders. This could be a full-scale randomised controlled trial with a minimum of 42 participants and a follow-up assessment to determine whether any effects of the program lasted beyond the completion of the program. Initially such a trial could include a control group undertaking no intervention, but subsequent trials could be conducted with other programs completed off the horse, and determine the effectiveness of these programs when compared with each other. Trials could also be conducted using riders of different levels to determine whether such programs are beneficial for a particular level of rider as opposed to another, with their differing levels of balance and symmetry (19, 43). The same could be repeated with multiple and narrower age groups to determine whether effectiveness may be influenced by the age of the participants. Multiple randomised controlled trials of a similar nature would be valuable for increasing the generalizability of results, as well as forming the basis for future meta-analyses in this area.

In the future, research could also be used to identify and validate the most effective methods of assessing rider performance. Current research into the use of technology in the area of equitation science would indicate that the use of technology in future research could improve the validity of results by providing more objective results (39). Technology in this field includes the use of pressure gauges and sensors, motion capture (39) and tools such as the Commands Muscle Tester and goniometer used in this research. Trials investigating whether the results from such outcome measures correlate with improving rider performance have the potential to lead to greater applicability of research findings into industry practice.

It would also be valuable to undertake research into the causality of asymmetry between horse and rider. As there is no current evidence for the cause of any asymmetry, future research could incorporate longitudinal studies in this area, as an attempt to determine whether the horse, human, or equipment create and perpetuate asymmetry, and thus where interventions are best directed.

Being a relatively small area of research, more high quality studies could then inform links to other areas of research such as the effect of horse rider biomechanics in the application of learning theory in horses and the use of external modalities for improving horse rider safety and their possible effectiveness at improving competition performance at the elite levels of the sport. As such, this area of research has the potential to grow not only in quality but also by branching out into other areas of research within the field of equitation science.

5.6 Conclusion

This research complements the current literature in the area of interventions applied to horse riders off the horse. There is congruence in the general trend towards improvement in some areas following these interventions, and as with other research in this field, this study indicates that this may be an area of research worth pursuing, but larger scale trials are needed to determine the effectiveness of interventions. There may need to be modifications to the recruitment and assessment process in order to gain larger sample sizes in future research, but the completion rate of the program itself showed a high retention of participants once they began the trial. The key difference of this study is the intervention having been specifically designed for horse riders, as opposed to being adapted from another modality such as strength training (35), physiotherapy (59) or taping (28, 58). Future research has the potential to link to other areas of equitation science such as learning theory, welfare, safety and elite performance, and also to inform future industry practice.

Research into off the horse interventions can increase the body of literature around equitation science and inform coaching practices within the equestrian industry itself. These interventions could be used not only in a high level competition setting, but also at lower levels to improve the training and welfare (4, 6, 13, 16) of horses. If programs such as the functional movement program prove to be effective, they could be implemented on a larger scale within the industry. This study indicates that the program is well attended, and deemed to be both relevant and have high satisfaction rates by participants, with promising preliminary results in rider performance. Our preliminary results were encouraging and paved the road for a better-powered trial. Trials similar to this one as the potential to conclusively determine the effectiveness of a functional movement program. Such a program could be practically implemented and accepted within the equestrian industry setting the foundation to a more scientific approach to improve and train horse riders; indirectly improving horses’ welfare.

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Appendix 1

Exercise/Stretch Descriptions (descriptions are as they appear to participants)

Week	Exercise	Description	Frequency
1	Breathing - supine	Laying on your back, with spine in neutral, knees bent, and arms relaxed by your side. Tuck your chin towards your throat to elongate the neck. Gently place one hand on your belly, and the other on the lower part of your ribcage. Slowly breathe in, filling your belly first, then your chest. Your chest should expand forward into your hand, out to the side, and back into the floor. Exhale slowly from your chest first, then from your belly. If you feel any tension in your ribcage, really think about breathing into those areas, notice where your ribs move well, and where they don't move so much.	10 reps as often as possible
1	Bridge	Laying on your back, with spine in neutral, knees bent with feet flat on the floor as close to your body as possible, and arms relaxed by your side. Tuck your chin towards your throat to elongate the neck. Breathe here, relax, focus. Breathing out, lift your hips slowly off the ground to make a straight line from your knees to your chest. Hold here for 10 seconds, breathing normally, then slowly lower down to the ground. Take note of having your neck, shoulders, and jaw relaxed. You want your spine to stay neutral throughout the movement, rather than arching excessively, or allowing your bottom to drop as you reach the top of your bridge.	5 reps, 3 times per week
1	Toe taps - Supine	Laying on your back, with spine in neutral, knees bent, and arms relaxed by your side. Tuck your chin towards your throat to elongate the neck. Breathe here, relax, focus. Breathing out, lift your	5 reps, 3 times per week

		knees and hips to 90 degrees. Breathe in, and on the out breath you are dropping one toe to the floor, tapping the floor, and returning the leg to its table top position. Repeat alternating legs. The knees here should stay at 90 degrees, only the angle of the hip should change. Take note of having your neck, shoulders, and jaw relaxed. Work with your breath. If you feel your lower back arch, and move further from the floor as you lower your leg, lower it only to the point where your back can stay close to the floor. If that means you don't quite tap the floor, that's okay	
1	Scapula retraction - seated	Sitting with arms relaxed by your side, chin a little towards your throat, and your posture upright. Take some breaths, think of relaxing your shoulders down away from your ears, relaxing your jaw. You may roll your shoulders back and gently roll your neck from side to side if that helps you. Take a deep breath in, and as you breath out, think of bringing the bottom corners of your shoulder blades down and in towards your spine. The movement should be slow, and small. Take note of your shoulders, trying to keep them relaxed as you do this movement. Relax back to neutral, then slowly repeat. This is a particularly difficult movement to keep specific. Lower your expectations of the movement, and focus instead on activating those muscles between the lower part of your shoulder blades. If you can activate those a little, even if it doesn't make your shoulder blades move, that will be more beneficial than a big movement recruiting your upper shoulders.	5 reps as often as possible
1	Hover hold	Start with a plank position, then drop down to your elbows. Your elbows should be at 90 decrees and sitting directly under your shoulders. Palms flat on the floor. Feet hip distance apart and knees straight. The aim is to make your entire body into one straight line from your heels to your head. Then just hold and remember to breathe!	30 seconds, 3 times per week

		Throughout the hold, you want to think about having your head and neck in line with your body looking to your hands so it's not dropped down below your shoulders, your whole spine should be straight. Also thinking of keeping your shoulders away from your ears. Beware of your hips slowly drooping towards the floor, also of having your butt too high in the air. Straight lines are the aim here.	
1	Squats with external rotation and towel	Standing tall, with abdominals and glutes turned on. Feet at least hip width apart, with a rolled towel under the balls of your feet and knees turned slightly out. Shoulders relaxed and down and arms in riding position. Slowly bending knees and hips to lower into a squat, and slowly rise. You want your knees to stay at least the same distance apart throughout the movement, they are not allowed to collapse in. Your chest should stay tall and open through the movement, and eyes stay straight ahead. To add breath, breathe in as you lower, and out as you rise. Keeping your chin tucked towards your throat will help to take pressure off your neck as you do this. Think of having your tail bone tucked under throughout the movement. Slower is always better. As with all the exercises, the aim is form! If you feel that you are losing your form at a certain point, stop the squat there. If you are not sure what your form is like, do these in front of a mirror.	5 reps, 3 times per week
1	Dynamic lunges	Take a big step forward being aware of how you place the foot so the weight is evenly distributed across the foot. Sink down so your back knee is close to the ground. Pushing out of your front leg (using your glutes), you can either bring the back foot in to step your feet together before your next lunge, or if you feel balanced, you can go straight to your next lunge by bringing your back foot forward to become the new front foot. Things to remember: The front knee wants to be directly above your ankle as you sink, and you want to be quite careful that it stays pointing out over your toes rather than falling in. Your lower	8 reps, daily.

		back needs to stay neutral and tall. Imitate your riding position of your upper body. Your abdominals and your glutes are going to keep your spine long and prevent you from either arching your back or collapsing through the middle. You can help be aware of this by placing your hands on your hips as you do it.	
1	Hip internal rotation stretch	Laying on your back, with spine in neutral, knees bent, and arms relaxed by your side. Tuck your chin towards your throat to elongate the neck. Breathe here, relax, focus. Tuck your feet close to your hips, but wider than your hips. If you can hold your ankles with your hands while keeping your shoulders relaxed and your back long, do that, if not, don’t worry. One leg at a time, you are going to drop your knee in towards the other knee, and towards the floor. Your foot will roll from being flat, to being on the inside edge of your foot, or even your ankle depending on your flexibility. Repeat with the other leg. You are dropping your leg only to the first point of stretch, then breathing for 4 breaths before resetting. Your pelvis should not twist, and your hip should not lift off the ground. You can place your hands on the front of your pelvis to make sure it stays level. Shoulders, neck and jaw should be relaxed throughout. Be really patient with your stretches, breathe a lot, and only do what your body needs, it should only be going to the first point of stretching, not into pain.	2 reps each side, twice per day.
1	Kneeling lung	Start on hands and knees. Take your right foot forward into a lunge, left knee stays on the floor. Your right ankle should be directly under your right knee. Hands go inside your right foot. Eyes up, chest open and tall. Squeezing your butt, try to gently lower your hips towards the floor until you feel a stretch down the front of your left hip. Breathe generously. From here you can move a little, when you find a tight spot in the left hip, pause, take deep breaths, then move again. If this	1 rep each side, daily.

		is not enough of a stretch, you can wriggle your left foot back to drop you deeper, or you can drop from your hands to your elbows. Reset to hands and knees, then repeat with the other foot forward. You can’t really go too wrong with this one. Feel what your body needs and do that. Main thing is to check your front knee is above your ankle, and keep your lower back relatively neutral, we are trying to stretch the hip, not the lower back.	
2	Breathing - seated	Sitting in a chair, with spine in neutral, knees bent, and even pressure through both seat bones. Tuck your chin towards your throat to elongate the neck. Gently place one hand on your belly, and the other on the lower part of your ribcage. Slowly breathe in, filling your belly first, then your chest. Your chest should expand forward into your hand, out to the side, and back into the chair. Exhale slowly from your chest first, then from your belly. If you feel any tension in your ribcage, really think about breathing into those areas, notice where your ribs move well, and where they don’t move so much.	10 breaths as often as possible
2	Foot tapping abdominal exercise	Lay on your back on the floor with your chin gently tucked towards your throat, your arms by your sides with palms facing up. Throughout the exercise you are aiming to keep your lower back neutral. Take a breath in and lift one leg so the hip and knee are at 90 degrees. When you next breathe in, lift the other leg to meet it From here you are going to tap your ankles and toes together fairly rapidly. When you have a rhythm, you can start taking your legs up and out by slowly straightening the knees. Note here, the lower you make your legs, the harder this exercise becomes. So start by taking your legs up towards the ceiling, then slowly lower. As you straighten your legs, keep tapping, and keep your lower back neutral.	Once daily.

		When you get to the point where your back starts to arch away from the floor, bring your legs back in a fraction, until you can continue without your back arching. You are going to remain there for at least 10 taps of the feet, then slowly bend your knees back to your starting position, and slowly lower them one at a time back to the mat so you can rest.	
2	Hovers with knee drops	This is the same as the hover from week one. Starting from a regular hover, you are going to drop one knee to tap the ground, then lift back to straight. The aim here is to keep your entire torso still, without rolling from side to side as you drop the knee.	5 reps per side, daily.
2	Single leg bridge	This is the same as the bridge from week one, except that rather than starting with both feet flat on the ground, you are going to have one foot lifted just off the ground. You will then push off the other foot into a bridge, hold for 5 seconds, then slowly lower. Repeat on the other side.	3 reps per side, 3 per week.
2	Scapula retraction with shoulder flexion	This is the same as the scapula retraction exercise from week one, but once you have pulled your shoulder blades back, you are then going to raise your arms slowly in front of your body. The aim is to keep your shoulder blades glued in place, and only raise the arms as far as you can without any movement from your shoulder blades, then slowly lower.	5 reps, 3 per week.
2	Squats with theraband	These are exactly the same as the squats from last week, except that you are going to tie a loop of pink theraband around the outside of your knees. As you do your squats, you are going to keep your knees pressed out into the theraband – it shouldn't fall down.	5 reps, 3 times per week
2	Pigeon	Start on hands and knees. Take your right foot forward as though you are going to sit cross legged. Take your left leg straight out behind you, initially with the weight on your hands. Eyes up, chest open and tall. Slowly try to breathe and relax into it, and try to gently lower your hips towards the floor until you feel a stretch down the front of your left hip and/or into your right glutes.	1 rep each side, daily.

		Breathe generously. From here you can move a little, when you find a tight spot, pause, take deep breaths, then move again. If this is not enough of a stretch, you can wriggle your left foot back to drop you deeper, or you can drop from your hands to your elbows. Reset to hands and knees, then repeat with the other foot forward. If this position is stressful for your body, you can bend your back leg and sit instead.	
2	Pec door stretch	Find a door frame. Put your right forearm up against the door frame, so that your hand is directly above your elbow, and your elbow is in line with your shoulder. Gently step/lean past the doorway. You should feel this in the front of your chest, and up towards your shoulder. When you reach the first point of resistance breath gently into it. Hold for 3 breaths then swap sides. In this stretch you are gently using your bodyweight to traction your pec muscles. If you are feeling discomfort in your shoulder, you can put a little of your shoulder against the door frame to stop it going forward of your arm.	1 rep each side as often as possible.
2	Forward folds	Standing tall, with abdominals and glutes turned on. Feet at least hip width apart and shoulders relaxed. Take a deep breath in. As you breathe out, gently bend your knees, and start to fold forward, keeping the spine long, and aiming to flex from the hips. The aim is to reach your hands towards the floor, and press your chest to your thighs. You may bend your knees as much as you need to get to this point. You will ideally feel a gentle stretch down the back of your thighs.	Hold for 5 deep breaths, daily
3	Hover with arm movements	This starts in the hover position from week one. So keeping the spine dead straight, without dropping or raising the hips. From there, you are bringing one arm under your belly, then back to the starting position, then the other arm. The aim is that nothing should move aside from that arm. There should be no trunk rotation, no	30 seconds, 3 per week.

		rolling of the hips with the movement or twisting through the lower back. Your feet should have equal weight onto the floor.	
3	Scapula retraction with trunk rotation	Start by practicing your scapula retraction exercises from previous weeks. Tie a theraband around a door handle, post, table or similar so that it is at elbow height but won't come loose when you pull against it. Stand with the theraband in front of you, and hold it with your left hand like you would the reins. From there, you are going to bring your shoulder blades back, then rotate your trunk to the left against the resistance of the band. The aim to keep your shoulder blade glued to your ribcage, and move the shoulder and torso as a whole as you rotate. If you feel your shoulder blade begin to move, make your rotation smaller.	5 reps per side, 3 per week.
3	Prone hip extension	Laying on the floor on your stomach. You want to have your back as neutral as possible. Keeping your knee straight, you are trying to lift your thigh just a little off the ground. The aim is to clench your butt first. So see if you can just clench your butt, and encourage that leg up. If your back starts to arch, or your knee starts to bend, you have recruited other muscles. Similarly, if you find yourself 'twisting' through your back, you are recruiting muscles higher up. If you are not sure, place a ball or something round on your back, if it rolls, you are rotating and the movement isn't localised. Remember, the movement will be small. The aim is not the lifting of the leg, it is the activation of the glutes. If this barely lifts your leg, don't panic!	5 reps each side, twice daily.
3	Hip abduction on "horse"	Sitting on the horse, find your neutral spine, with equal weight in both seat bones. From there, activate your abdominals and glutes as you would in a hover position. One leg at a time, take your thigh sideways away from the saddle, keeping your pelvis and torso still and weight even in both seat bones. Slowly lower the leg back to the saddle, then repeat on the other side.	Twice on each side, when riding.

3	Supine twists	Laying on your back, with spine in neutral, knees bent, and arms stretched out to the side and palms facing up. Tuck your chin towards your throat to elongate the neck. Lift your hips to the right, then slowly drop your knees towards the left. Your shoulder blades should stay flat on the floor, and you can look towards your right hand. Relax and breathe as much as possible into the sides of your ribs.	10 breaths each side, daily
3	Hamstring and QL stretch - seated	A) Sitting on the floor with your legs stretched out in front of you. Pull your seat bones back and check you are sitting evenly on both. Inhale and raise your arms up to the side, as you exhale lower forward over your legs, keeping your spine as long as possible. Only going to the first sign of stretch, then breathing generously. Hold for as many breaths as you want. Note here; hands soft wherever they end up, if that’s on your calves rather than your feet or ankle, don’t stress. You’re not pulling yourself down here. Be a little patient. B) Sit up. Take your left leg and tuck the foot into the inside of your right thigh, trying to gently lower your knee toward the ground, again, only to the first point of resistance. Pull your seat bones back again. Inhale and raise your arms up, exhale and fold forward over your right leg. The centre of your chest should be over the centre of your leg. Breathe generously and hold for as long as you want. C) When you are ready, roll up, take your left arm back behind you, then over your head, to make a ‘C’ shape with your arm and your back, leaning over your right leg. The right arm again can rest on your right leg. This stretch should be in the left side of your lower back. Breathe generously, relax your jaw, and hold for as many breaths as is enjoyable.	15 seconds each side, daily.

4	Toe-touch / heel-touch (mushroom)	Laying on your back, with spine in neutral, knees bent, and arms up over your head. Tuck your chin towards your throat to elongate the neck. Breathe here, relax, focus. Breathing out, lift your hips to 90 degrees keeping your knees as straight as possible with toes pointed towards the ceiling. Breathe in and keeping your knees at the same distance apart, touch your toes together. The movement is to touch your toes together, then touching your heels together, then back to toes. The knees should stay as still as possible. To help this you can tie a theraband around your knees to push outwards. Keep breathing.	4 reps, 3 per week.
4	Standing hip extension	Begin by standing with neutral spine, arms relaxed by your size, feet shoulder width apart, looking straight ahead. Lift one leg just a few centimetres off the ground in front of you. Turn the toe out slightly by externally rotating the hip. Keeping the same degree of knee bend, starting with your glutes bring the leg slowly behind you. The aim is to keep the low back still, without increasing the arch or rotating. Add some breath into it, so breathe in to lift the leg, then out to extend the hip. You can do this with a slightly bent leg to imitate your canter transitions.	5 reps each side, twice daily.
4	Squats with half halt	The squats are exactly the same. To add an extra challenge, you can have some “reins” attached to something, as you are in your squat to a usual 2 or 3 point position, ask for a ‘half halt’. As you do, think about beginning the movement by breathing in, activating your abdominals, then adding the scapula retraction.	5 reps, 3 per week.
4	Hip extension on “horse”	This begins the same as the hip abduction on “horse” but instead of brining your thigh away from the saddle, you are going to bring your thigh back towards the model horse’s rump. The feeling you want is to bring the knee back, rather than the heel. This will require activation of the abdominals to prevent your lower back arching and pelvis tipping forward. The aim is to do the movement as slowly and controlled as possible, with no movement through your trunk.	2 reps each side, when riding or in class.

4	Adductor stretch	Starting on your hands and knees, take your knees out as wide as they comfortably go, ankles stay in line with your knees, and feet point outwards so that you have the inside of your ankle on the ground. From there you can play with whether you want to take your knees a little wider. Take a deep breath in, and slowly lower to your elbows, relax your neck and jaw, and just breathe here.	5 breaths, 3 per week.
4	Upper traps/ levator scap stretch	A) Start standing tall and relaxed. Chin tucked a little towards your throat, arms relaxed. Behind your back, gently take your left wrist in your right hand. Slowly and gently, tilt your head to the right. Your right hand is not pulling on your left wrist, just adding the tiniest bit of weight so the shoulder stays down. You are going only to the first point of stretch, then breathing generously. The neck only should tilt, the rest of your body stays straight. The head is tilting only to the side, not forward, and not turning. The stretch should be along the top of your shoulder and up a little into the side of your neck. B) Return to neutral. Drop your chin towards your chest, then turn your head to look under your right armpit. Breathe generously. This is usually a pretty gentle stretch, you may not feel much. Take at least 4 breaths then release. Return to neutral, swap your hands and repeat the opposite way.	1 rep each side, 3 per week.
5	DNS supine with theraband.	This starts from the same position as the toe taps exercise in week one. Hips and knees bent to 90 degrees, and feet and knees hip width apart. Loop the theraband around your knees, cross the theraband from the right knee to the left hand, and vice the versa so that it makes a cross over your stomach. Hold your hands up in front of you, as though you are holding a bowling ball. As you breathe in, slowly take your legs and hands out wide, hold for a second, then as you breathe out, slowly bring both legs and hands back to the starting position.	4 reps, 3 per week.

		The aim is for a smooth and controlled movement, which is equal on both sides. The low back should stay in neutral, and shoulder blades stay flat against the floor.	
5	Rolling hover	This begins in the usual hover position. From this position, and keeping the body completely straight, roll slowly into a side hover. So you are rolling to balance on one forearm, with your feet stacked on top of each other. There should be no rotation through your body as you roll, and your body should make a straight line from your head to feet the entire time. Roll back to hover with the same slow and controlled movement. Repeat on the other side.	2 reps per side, 3 per week.
5	Standing hip extension with circumduction	This exercise begins the same as the standing hip extension exercises. Before extending the hip, turn your toe out to the side, taking the leg out to the side approximately 20 centimetres then back, to make a small half circle. Return to the original standing position by reversing the movement. The movement should come only from your leg, with no movement through your pelvis or torso. To add resistance, you can tie a theraband around the leg of a table or similar, then around your ankle.	2 reps per side, 3 per week.
5	Canter transition on "horse"	This exercise is a combination of "hip extension on 'horse'" and "scapula retraction with trunk rotation". The exercise begins the same way as the other exercises on the model horse. From here, you are going to take a breath in and activate the abdominals as you do in a hover position. The right leg is going to go slowly back as in the hip extension exercise, simultaneously you will bring your shoulder blades back, and rotate your torso to the left. The movement to this position, and out of, are as slow and controlled as possible, focusing on specific movement.	When riding or in class.
5	Half halt on "horse"	This is the same as the squat with half halt, except you are on the model horse. To imitate your half halt on a horse, you are beginning the movement with a squeeze from your calf, then activating your abdominals, then the shoulders.	When riding or in class.

Appendix 2

Novice 2.1 Dressage Test

Novice 2:1 ©
Effective 1/1/14

EQUESTRIAN AUSTRALIA

Bridle No.					
Competitor/Participant					

Event ____________________ Horse ____________________ Horse | Pony (please circle)

Rider ____________________ Open | YR | JNR (circle)

Judge Name ____________________ Date ____________________

Purpose: *To confirm that the horse, in addition to the requirement of Preliminary Level, has developed the thrust to achieve improved balance and throughness and to maintain a more consistent contact with the bit*
Introduces: *10m half circle in trot, 15m circle in canter, and lengthening of stride in trot and canter*
Instructions: *To be ridden in a snaffle.* All trot sitting or rising unless stated otherwise

TEST			DIRECTIVE IDEAS	Judges Marks (10)	Coefficient	Total	REMARKS
1	A X	Enter in working trot Halt, Salute Proceed in working trot	Straightness on centreline and in halt; immobility; quality of trot; willing; balanced transitions				
2	C EX XB	Track left Half circle left 10m Half circle right 10m	Bend and balance in turn; shape of half circles; straightness on centreline showing supple change of bend; quality of trot				
3	KXM MC	Lengthen stride in trot Working trot	Moderate lengthening of frame and stride; quality and consistent tempo of trot; willing, balanced transitions; straightness				
4	C Before C C	Circle left 20m rising trot, allowing the horse to stretch forward and downward Shorten the reins Working trot	Forward and downward stretch over the back into a light contact maintaining balance and quality of trot; bend; shape and size of circle; smooth, balanced transitions		2		
5	Between C & H	Medium walk	Willing, balanced transition; quality of trot and walk				
6	HP PF	Free walk on a long rein Medium walk	Reach and ground cover of free walk allowing complete freedom to stretch the neck forward and downward; quality and regularity of medium walk; willing, balanced transitions; straightness		2		
7	F A	Working trot Working canter right lead	Willing, balanced transition; quality of trot and canter		2		
8	E	Circle right 15m	Quality of canter; shape and size of circle; bend				
9	MP Between P & A	Lengthen stride in canter Develop working canter	Moderate lengthening of frame and stride; quality and consistent tempo of canter; willing, balanced transitions; straightness				
10	KXM X	Change rein Working trot	Willing, balanced transition; quality of canter and trot; straightness				
11	C	Working canter left lead	Willing, balanced transition; quality of canter		2		
12	E	Circle left 15m	Quality of canter; shape and size of circle; bend				
13	FR Between R & C	Lengthen stride in canter Develop working canter	Moderate lengthening of frame and stride; quality and consistent tempo of canter; willing, balanced transitions; straightness				
14	C	Working trot	Willing, balanced transition; quality of trot		2		
15	HXF FA	Lengthen stride in trot Working trot	Moderate lengthening of frame and stride; quality and consistent tempo of trot; willing, balanced transitions; straightness				
16	A X	Down centreline Halt, Salute	Bend and balance in turn; straightness on centreline; willing, balanced transition; immobility				

Leave arena in walk on a long rein at A

Novice 2:1 ©

COLLECTIVE MARKS

Paces (freedom and regularity)		1		
Impulsion (desire to move forward, elasticity of the steps, relaxation of the back and engagement of the quarters)		1		
Submission (attention and confidence; harmony, lightness and ease of the movements; acceptance of the bridle)		2		
Rider's position and seat; correctness and effect of the aids		2		
TOTAL MARKS	270			

Course Errors (Cumulative)	1st -2	2nd - 4 (= 6)	3rd Elimination	Minus Total Faults	
FINAL MARK					
PERCENTAGE					

Judge Signature: ____________________

Appendix 3

Numerical Rating Scales

Self Assessment

Based purely on your riding while competing in the dressage test today, please answer the following questions:

Effectiveness:
On a scale of zero (0) to ten (10), with zero being completely ineffective, and ten being the most effective you have ever been, how would you rate the effectiveness of your riding during the dressage test today?

Please circle:

0 1 2 3 4 5 6 7 8 9 10

Balance:
On a scale of zero (0) to ten (10), with zero being completely unbalanced, and ten being the most balanced you have ever been, how would you rate your balance during the dressage test today?

Please circle:

0 1 2 3 4 5 6 7 8 9 10

Participant Assessment:

Based upon your experience as a participant in the functional movement classes, please answer the following questions:

Relevance:
On a scale of zero (0) to ten (10), with zero being completely irrelevant, and ten being very relevant, how would you rate the functional movement exercises and stretches to your riding?

Please circle:

0 1 2 3 4 5 6 7 8 9 10

Satisfaction:
On a scale of zero (0) to ten (10), with zero being completely dissatisfied, and ten being completely satisfied, how would you rate your satisfaction with the classes (i.e. was there satisfactory individual attention given, were the class sizes satisfactory, was the equipment and tuition satisfactory?

Please circle:

0 1 2 3 4 5 6 7 8 9 10

Homework:
On a scale of zero (0) to ten (10), with zero being never completed, and ten being completed exactly as specified, how would you rate your completion of the exercises and stretches at home as they were prescribed to you?

Please circle:

0 1 2 3 4 5 6 7 8 9 10

Appendix 4

Participant Information and Consent Form

INFORMATION AND CONSENT FORM

Study Title: A Pilot Study to Investigate Whether a Five-Week Functional Movement Course Improves Horse Rider Performance

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Purpose of this Study

Functional movement courses are a programme of exercises and stretches, designed by a chiropractor, that are done off the horse to improve performance in dressage competition. These exercises aim to break down the movements performed during riding into their smaller components in order to improve the movements overall. This study aims to determine if a five-week functional movement course improves rider performance as measured in dressage scores. Your participation could further our understanding of whether this course is of benefit to riders, and to what extent it may improve performance.

Principal Investigator:

Dr. Stephney Whillier, Faculty of Science and Engineering, Department of Chiropractic, Macquarie University

Email: stephney.whillier@mq.edu.au

Other Investigator(s):

Keira Byrnes, Chiropractor and Masters of Research student

Procedure

There will be a short physical assessment of approximately half an hour prior to starting, and at the completion of the course. This is done to test the length and the strength of the muscles targeted during the course. You will also be required to compete in a novice level dressage test at Galston Equestrian Club prior to beginning the course. The functional movement course consists of a 1 hour exercise class each week for five weeks, and will require the ability to follow verbal commands in English. Exercises and stretches will be taught by demonstration and verbal explanation, and involve slow and controlled movements. Written explanations of all weekly exercises will be provided on a USB at the conclusion of each class.

Participant Requirements

For this study, we need volunteers who are:

Aged between 18-65 years

Financial members of Equestrian Australia who have competed at Novice level dressage in the last 12 months.

Planning to compete at two dressage competitions run by Galston Equestrian Club in 2018.

Not suffering from any condition that would prevent them from undertaking exercise.

Risks

There is a negligible chance of physical injury such as muscle strain. To prevent any discomfort to you the exercises and stretches will be thoroughly explained, with feedback during the class to ensure correct technique.

Benefits

The potential benefit is the improvement of scores in a dressage test.

Compensation & Costs

There will be no costs or compensations associated with participating in the course.

Confidentiality

Your confidentiality will be maintained in that:

Any personal information you provide will be e de-identified and kept separate to your consent form. All information will be stored in a locked cabinet and will not be disclosed to third parties.

No individual results, only group statistical data, will be published

Rights

Your participation is voluntary and you can withdraw at any point. Refusal to participate, withdrawal of consent or discontinued participation will not result in any penalty or loss of benefits or rights to which you might otherwise be entitled.

Right to Ask Questions & Contact Information

Please feel free to ask questions at any point, either directly or via email. If you have any questions at a later point, desire additional information, or wish to withdraw your participation please contact the Principal Investigator by mail, phone or e-mail.

Voluntary Consent: Participant's Copy

I ____ agree that the above information has been explained to me and all my current questions have been answered. I understand that I may ask questions about any aspect of this research study during the course of the study and in the future. By signing this form, I agree to participate in this research study, knowing that I can withdraw from further participation in the research at any time without consequence. I have been given a copy of this form to keep.

PARTICIPANT SIGNATURE ___________________________ DATE_____________

I _________________________________ certify that I have explained the nature and purpose of this research study to the above individual and I have discussed the potential benefits and possible risks of participation in the study. Any questions the individual has about this study have been answered and any future questions will be answered as they arise.

SIGNATURE OF PERSON
OBTAINING CONSENT___________________________ DATE_____________

The ethical aspects of this study have been approved by the Macquarie University Human Research Ethics Committee. If you have any complaints or reservations about any ethical aspect of your participation in this research, you may contact the Committee through the Director, Research Ethics (telephone (02) 9850 7854; email ethics@mq.edu.au). Any complaint you make will be treated in confidence and investigated, and you will be informed of the outcome.

Voluntary Consent: Investigator's copy

I __________________________________ agree that the above information has been explained to me and all my current questions have been answered. I understand that I may ask questions about any aspect of this research study during the course of the study and in the future. By signing this form, I agree to participate in this research study, knowing that I can withdraw from further participation in the research at any time without consequence. I have been given a copy of this form to keep.

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SIGNATURE OF PERSON

OBTAINING CONSENT____________________________ DATE_____________

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