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Oxygen cost of recreational horse-riding in females

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Abstract

Background: The purpose of this study was to characterize the physiological demands of a riding session comprising different types of recreational horse riding in females. **Methods**: Sixteen female recreational riders (aged 17-54 years) completed an incremental cycle ergometer exercise test to determine peak oxygen consumption (VO_{2peak}) and a 45 minute riding session based upon a British Horse Society Stage 2 riding lesson (including walking, trotting, cantering and work without stirrups). Oxygen consumption (VO_2), from which metabolic equivalent (MET) and energy expenditure values were derived, was measured throughout. **Results**: The mean VO_2 requirement for trotting/cantering (18.4 ± 5.1 $ml.kg^{-1}.min^{-1}$; 52 ± 12% VO_{2peak}; 5.3 ± 1.1 METs) was similar to walking/trotting (17.4 ± 5.1 $ml.kg^{-1}.min^{-1}$; 48 ± 13% VO_{2peak}; 5.0 ± 1.5 METs) and significantly higher than for work without stirrups (14.2 ± 2.9 $ml.kg^{-1}.min^{-1}$; 41 ± 12% VO_{2peak}; 4.2 ± 0.8 METs) (P = 0.001). **Conclusions**: The oxygen cost of different activities typically performed in a recreational horse riding session meets the criteria for moderate intensity exercise (3-6 METs) in females, and trotting combined with cantering imposes the highest metabolic demand. Regular riding could contribute to the achievement of the public health recommendations for physical activity in this population.

Introduction

Physical activity guidelines for health promotion recommend that all healthy adults aged 18-65 years should aim to take part in at least 150 minutes of moderate intensity aerobic activity each week, or at least 75 minutes of vigorous-intensity aerobic activity each week, or equivalent combinations of moderate and vigorous intensity aerobic activities.[1-3] Exercise intensity may be expressed as an absolute measure, for example metabolic equivalents (METs) where one MET is equivalent to oxygen consumption (VO_2) at rest (3.5 $ml.O_2.kg^{-1}.min^{-1}$), or as a relative measure such as percentage of maximal oxygen consumption (VO_{2max}). A perceptual scale such as Borg's Rating of Perceived Exertion (RPE)[4] may also be used as a subjective measure of intensity. In terms of energy expenditure, one MET is also expressed as a standard resting metabolic rate of 1.0 kcal (4.184 kJ).$kg^{-1}.h^{-1}$.[5] Moderate intensity physical activity is categorized as 3-6 METS, 40-60% VO_{2max} or an RPE of 12-13.[2,6] Vigorous intensity exercise is 6-9 METs, 60-85% VO_{2max} or RPE of 14-16.

In addition to popular activities such as walking and cycling, a wide variety of leisure, household and occupational activities performed at a moderate intensity may contribute to individuals achieving the recommended amount of physical activity. However, some popular leisure activities, for example golf and some Nintendo Wii sports, may not be of a sufficient intensity to offer health benefits.[7,8] Horse riding as a leisure pursuit offers an opportunity to increase physical activity. It has been identified as one of several "green exercises" (activities involving contact with the natural environment and green space) that promote good health by improving self-esteem and mood.[9] Psychotherapeutic benefits from horse riding therapy have also been observed.[10] In the UK, there are more than 430 riding clubs affiliated to the British Horse Society, which has over 34,000 members. In a survey of 1,248 recreational horse riders, 68% respondents said that they exercised at a moderate intensity for 30 minutes at least 3 times per week by horse riding and/or associated activities (e.g. grooming and mucking-out).[11] Over a third indicated that horse riding was the only form of physical activity that they had participated in during the preceding 4 weeks. Ninety three percent of respondents were female, and half of these were aged 45 or above, a population group for whom physical activity levels are generally low.[12] Similarly a major national survey shows that the gender (90% female) and age profile (a large proportion of over 45 year olds) of equestrianism is not matched by any other sport in the UK.[13]

There is at present limited and, indeed, conflicting empirical evidence to show if the physiological demands of recreational horse riding are likely to confer health benefits. The Compendium of Physical Activities[5,14] includes MET intensity levels for specific physical activities and is used to identify examples of moderate and vigorous intensity activities and to evaluate the contributions of various types of physical activity to daily energy expenditure. The value for general horseback riding is given as 5.5 METs, based on data averaged from walking (3.8 METs), trotting (5.8 METs) and cantering or galloping (7.3 METs). These values may not represent the physiological demand of recreational horse-riding in females as they are derived from indirect calorimetry measurements taken several decades ago in a small number of young male soldiers[15], Guatemalan male peasants performing agricultural activities[16], and more recently in five experienced competitive riders of whom only three were female.[17]

Technical innovation in the development of portable gas analysis systems has enabled the valid measurement of expired air and energy expenditure in the field during different physical activities.[18-20] In addition to the aforementioned study[17], two other studies have assessed the physiological demands of horse riding. In sixteen female equestrian athletes participating in a simulated one day event competition, VO_2 was equivalent to 6 METs (20.4 ± 4 $ml.kg^{-1}.min^{-1}$) during dressage, 8 METS (28.1 ±

4.2 ml.kg^{-1}.min^{-1}) during show jumping and 9 METS (31.2 ± 6.6 ml. kg^{-1}.min^{-1}) during cross country.[21] There was variability in the oxygen cost between riders performing in the same simulated competition but riding different horses. An earlier study of thirteen experienced and three elite horse riders reported that the intensity of walking, trotting and cantering ranged from 40-80% VO_{2max}, with walking and trotting fitting with the classification of moderate intensity, and cantering vigorous intensity (> 60% VO_{2max}..[22]

The above studies provide information about competitive equestrianism, but the physiological demands of modern-day recreational riding and its potential contribution to health-related energy expenditure is not well-documented. A three month training programme of moderate intensity simulated mechanical horse riding improved metabolic health in middle-aged and elderly individuals with type II diabetes.[23, 24] However, in younger healthy females with higher baseline fitness a 14 week horse riding training programme did not provide an adequate stimulus to improve health and fitness.[25]

The purpose of this study was to characterize the physiological demands of different types of horse riding in females during a recreational horse riding session. A secondary aim was to ascertain whether the intensity of the different riding activities was sufficient to be classed as at least 'moderate' (≥ 3 METS) and could therefore contribute to the current physical activity for health recommendations.

Methods

Participants

Twenty mixed-ability female recreational horse riders aged between 17 and 54 years were recruited from the population of students and staff on University-based Equine Studies-related courses. The participants were limited to volunteers with no known cardiovascular/pulmonary disease, pregnancy, metabolic disorders or contraindications to exercise as determined by a medical questionnaire. Nine participants were categorised as novice riders (< 2 years' experience) and seven as experienced riders (> 2 years' experience). Eight individuals were categorised as "very active" (> 6 $hr.week^{-1}$ activity ≥ moderate intensity, seven as "active" (3-6 $hr.week^{-1}$ activity ≥ moderate intensity) and one as "moderately active" (1-3 $hr.week^{-1}$ activity ≥ moderate intensity). Participation in recreational horse riding (including similar activities to those described below under "Horse Riding Session") was between one and seven hours per week (mean 4 ± 1 $hr.week^{-1}$). Prior to enrolment in the study, participants were provided with verbal and written explanations of the purpose, procedures, possible benefits, risks and discomforts associated with participation. Following this full explanation, written informed consent was obtained, in addition to written parental consent for volunteers aged under 18 years. The study was granted institutional ethical approval and was conducted in accordance with the Declaration of Helsinki.

Laboratory procedures took place during one visit to the University Human Performance Laboratory, followed 1-2 weeks later by a horse riding session in an equestrian centre.

Anthropometry

Participants visited the Laboratory having refrained from eating for at least two hours, and from heavy exercise and alcohol consumption for 24 hours. Height (m) and weight (kg) were measured using calibrated scales and a stadiometer (Detecto, USA). Body mass index (BMI) was calculated by dividing body mass by the square of the subjects' height. Skinfold thickness was measured to the nearest 0.2 mm at iliac crest, subscapular, triceps, and biceps skinfold sites and used to calculate body density.[26] Percentage body fat was estimated from body density values using the Siri equation.[27]

Laboratory cycle ergometer test

Participants performed a maximal incremental cycling test on an SRM cycle ergometer (Schroberer Rad Messtechnik, Weldorf, Germany). Following a 5 minute warm-up at an intensity of 50 Watts (W), starting power was set to 90 W or 100 W with increments of 10 $W.min^{-1}$ or 13 $W.min^{-1}$ respectively for older/less active or younger/more active participants respectively.[28] All participants were encouraged to continue cycling until volitional exhaustion. Expired air was analysed using a portable indirect calorimetry gas-exchange system (MetaMax®3X, Cortex Biophysik, Leipzig, Germany). This consists of a processing unit containing oxygen and carbon dioxide analysers and a battery pack, both worn by participants in a harness on the chest (weight = 1.5 kg) and a facemask (Hans Rudolph, Kansas City, USA) containing a turbine flow meter and a sample line connected to the processing unit. The recommended calibration procedure was conducted prior to each laboratory test. Gas sensors were calibrated against known concentration gases, respiratory volumes were calibrated using a 3 L syringe, and ambient air measurements were conducted repeatedly. VO_2 was averaged over a 10 second period, and VO_{2peak} was calculated as the highest value from a 30s rolling average during the final stage of the test. VO_{2peak} was also expressed as a percentage of predicted value.[29]

Horse riding session

Participants completed a standardised 45 minute horse riding session lead by a qualified instructor at an indoor equestrian centre. The session protocol was based on a British Horse Society Stage 2 riding lesson (Table 1) aimed at intermediate level recreational riders. This followed the "English" rather than "Western" style of riding and included the posting trot, where riders rise and sit in rhythm with the horse's stride. 4 different horses were used. These were selected on the basis of similar +/- 1 inch in height and similar temperament. All horses were familiar with the environment, and the riders were familiar with riding these horses.

RPE was recorded at 15 minute intervals without disruption to the horse riding session. Expired air was analysed continuously throughout the 45 minute protocol via the same MetaMax®3X portable metabolic measurement system used in the laboratory test, which was calibrated using ambient air prior to every horse riding session. Respiratory gas parameters were collected for each breath and data were averaged over 10s. Average values were calculated for VO_2, carbon dioxide production (VCO_2), respiratory exchange ratio (RER) and minute ventilation (V_E) and energy expenditure (kcal.min^{-1}) for the 45 minutes session. Average values were also calculated for the walk and trot work (5-15 min), trot and canter work (15-25 min), and work without stirrups (25-35 min) sections of the session.

Data Analysis

Data were analysed using IBM SPSS Statistics for Windows, Version 20. (Armonk, NY: IBM Corp.) Descriptive data is reported as mean ± standard deviation. To determine the intensity of the different types of horse riding, VO_2 was expressed as METs. VO_2 was also calculated as a percentage of individual VO_{2peak} values determined from the laboratory test, and energy expenditure (kcal.min^{-1}) was estimated from VO_2 values using the energy release for VO_2 constant of 4.9 kcal per 1 L O_2.[30] VO_2 and

169 intensity were compared for the different riding activities and level of experience using a 3 x 2 factorial
170 ANOVA with post hoc Bonferroni comparisons. Pearson's correlational analysis was used to examine
171 the relationship between oxygen cost and age, body mass, % body fat, riding frequency and fitness.
172 Statistical significance was set at $P \leq 0.05$.
173
174

Results

Twenty participants visited the Laboratory and completed the cycle ergometer test. Four participants did not complete the study as they were unable to attend the riding session. Participant characteristics are presented in Table 2. Test termination was due to volitional exhaustion in all participants. Peak power output was 180 ± 26 W, peak RPE 19 ± 1 and peak RER 1.16 ± 0.09. Table 3 presents the data for the different horse-riding activities performed during the session. There was a significant within-subjects effect in the comparison of oxygen cost between the walk/trot, trot/canter and work without stirrups sections of the riding session ($P = 0.034$, partial $\eta^2 = 0.265$, observed power = 0.69). Post hoc tests identified that the "trot/canter" activity was significantly higher than the "without stirrups" activity ($P = 0.001$). Similarly %VO_{2peak} and METS and energy expenditure values were all significantly higher during "trot/canter" than "without stirrups" ($P < 0.05$). There was a significant within-subjects effect for RPE between the different riding activities ($P = 0.032$), but the post hoc follow up tests were not significant. There were no differences in oxygen cost, intensity or RPE between experienced and novice riders. Figure 1 displays mean MET values averaged over each minute of riding session. Over the whole 45 minute riding session average METs were 4.6 ± 0.9, RPE was 13 ± 2 and energy expenditure was 241 ± 73 kcal. There were no significant correlations between age, body mass, % body fat, riding frequency or fitness and oxygen cost, with the exception of BMI and % body fat which were positively related to the oxygen cost of work without stirrups ($r = 0.688$, $P = 0.009$ and $r = 0.662$, $P = 0.009$ respectively).

Discussion

The purpose of this study was to characterize the physiological demands of different activities during a recreational horse-riding session, and to ascertain whether the intensity could be classed as at least moderate. In a group of female riders the average MET value was 5.0 for walking combined with trotting, 5.3 for trotting combined with cantering, and 4.2 for riding without stirrups. These recreational horse riding activities therefore conform to the classification for moderate intensity activity (3–6 METs), and may contribute to health-related physical activity benefits.[2,6] Mean % VO_{2peak} for the different riding activities exceeded the 40% VO_{2max} threshold commonly used as the lower threshold to define moderate exercise, while perception of effort was within or higher than the associated RPE range of 11-13. Trotting/cantering induced a significantly higher metabolic cost than exercising without stirrups, but did not classify as vigorous exercise (> 6 METs), and was lower than the 5.8 and 7.3 METs for trotting and cantering/galloping respectively reported in the updated Compendium of Physical Activities.[5, 14] None of the riding activities performed by our recreational female riders reached the Compendium's 5.5 METs for general horse riding, derived by averaging the METs for walking (3.8), trotting (5.8) and cantering/galloping (7.3), based on data collected several decades ago from male soldiers and Guatemalan agricultural workers[15,16], and more recently in 5 competitive riders of whom 3 were female.[17]

The latter study by Devienne and Guezenne (2000) measured energy expenditure during dressage and jumping activities, and reported METs of 3 for walking, 7 for trotting, 9 for cantering and 11 for jumping.[17] Averaging the walking and trotting values gives 5 METs, which matches the walk/trot METs in our study. It is also interesting that trotting elicited an intensity of 48 ± 14% VO_{2max} in the competitive dressage riders, matching the 48 ± 13% VO_{2peak} for the walk/trot section in our study. The reason for the matching intensities in terms of % VO_{2max} despite the higher absolute energy cost in Devienne and Guezenne's study is that their riders were more aerobically trained, with average VO_{2max}

values of 55 ml.kg^{-1}.min^{-1} compared with 37 ml.kg^{-1}.min^{-1} VO_{2peak} in our riders. Nevertheless, our riders were fitter than average, with VO_{2peak} values 19% higher than predicted, and all but one were categorised as active or very active. In both studies there is a high degree of variability in exercise intensity among riders for the same activity, both in terms of METS and % VO_{2max}. For example, the standard deviation around the mean METs was ± 1.5 for walking/trotting in our study and trotting in their study. This variability is higher than in other studies measuring the metabolic cost of household, garden and recreational activities in older individuals, for example sweeping (4.1 ± 0.7 METs), lawn-mowing (5 ± 0.7 METs) and golfing (2.8 ± 0.5 METs).[7, 31]

Individual differences in the oxygen cost of movement can be explained by factors including age, body mass, environmental conditions, fitness or mechanical efficiency. Differences in riding experience, technique, and motivation towards the task may also contribute to the inter-individual differences for the same riding activity. In experienced and elite riders, the reported oxygen cost of trotting and cantering is approximately 70% higher than in our group of recreational riders.[21,22] We did not detect any differences in physiological demand between novice and experienced riders, nor was age or fitness related to the oxygen cost of different activities. Higher body mass and percentage of body fat were positively related to oxygen cost, but only during work without stirrups.

Participants expended on average 241 ± 73 kcal during the 45 min session combining different riding activities, which they confirmed was representative of a typical ride for them, suggesting that they would have to repeat this 3-5 times per week to achieve the recommended 800-1200 kcal weekly energy expenditure.[2] Nevertheless, a 14 week intervention, during which similar horse-riding activities were performed 5 days per week, did not significantly improve health and physical fitness in similar sample of females.[25] The authors recommended that riding activity needs to be supplemented with alternative aerobic and load-bearing training in this population. The British Horse Society survey showed that recreational riders also participate in associated horse-care activities such as mucking out and grooming, which may also contribute to health-related energy expenditure and fitness improvements. In a recent field study, we measured ambulatory VO_2 in 8 females (18-47 yrs) during manure removal from a grazing paddock, mucking out a stable and grooming a horse (Beale et al, unpublished data). Physiological responses were similar for manure removal (4.9 ± 1.0 METs, 65 ± 6% predicted maximal heart rate, RPE 11 ± 1) and mucking out (4.6 ± 1.2 METs, 67 ± 5% predicted maximal heart rate, RPE 12 ± 1), and lower for grooming (3.7 ± 0.9 METs, 65 ± 9% predicted maximal heart rate, RPE 9 ± 1). These data suggest that the additional activities associated with recreational horse riding are also of sufficient intensity to contribute to the achievement of the physical activity recommendations in females. However, further studies are needed to more fully characterise horse-riding as a recreational activity, exploring the physiological demands of habitual riding and horse-care activities in terms of type, frequency and duration, followed by a training study to confirm whether this translates into physiological health benefits. Recreational off-road vehicle riding has recently been examined from this perspective.[32,33]

The limitations of the current study are that the sample size is small and consists only of females, although this does reflect statistical evidence that the large majority of recreational horse-riders are women. However, the majority of our participants were younger than the over 45 yr old group that constitutes half of all recreational riders. MET values were based on the premise that 1 MET is equivalent to 3.5 ml $O_2.kg^{-1}.min^{-1}$ in all individuals, a concept that has been challenged as overestimating the oxygen cost at rest.[34] Data collection was limited to a structured riding session in an indoor riding school, which may not reflect the oxygen cost and energy expenditure during typical recreational riding activities.

Conclusion

This study provides novel data on the physical demand of different recreational horse riding activities in females, and indicates that these activities meet the criteria for moderate intensity physical activity and may therefore contribute to public health guidelines. Future directions from this exploratory investigation would be to determine whether a period of regular horse-riding results in improvements in physical fitness, psychological well-being and quality of life indices.

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Table 1: Horse-Riding Protocol

Time	**Activity**
0 - 5 min	Walk warm up
5 - 15 min	Walk and trot
15- 25 min	Trot and canter work
25 - 35 min	Work without stirrups - sitting
35 - 45 min	Cool down

Table 2. Descriptive characteristics of participants (n = 16, female)

Variable	Mean ± SD	Range
Age (yr)	25 ± 11	17 - 54
Height (m)	1.63 ± 0.05	1.51 - 1.74
Weight (kg)	66.2 ± 17.1	45.1 - 109.0
BMI ($kg.m^2$)	24.7 ± 5.4	17.6 - 37.7
Body fat (%)	30.6 ± 6.4	20.2 - 44.8
VO_{2peak} ($L.min^{-1}$)	2.407 ± 0.519	1.741 - 3.459
VO_{2peak} ($ml.kg^{-1}.min^{-1}$)	37.2 ± 7.4	29.1 - 56.8
VO_{2peak} as % predicted value	119 ± 30	79 - 182

Table 3: Mean ± SD values for absolute and relative oxygen consumption (VO_2), percentage of peak oxygen consumption ($\%VO_{2peak}$), metabolic equivalent (MET), energy expenditure (EE) and RPE during the different types of riding.

	walk/trot 5-15 min	trot/canter 15-25 min	no stirrups 25-35 min
VO_2 ($L.min^{-1}$)	1.122 ± 0.287	1.240 ± 0.430 *	0.999 ± 0.499
VO_2($ml.kg^{-1}.min^{-1}$)	17.4 ± 5.1	18.4 ± 3.9 *	14.5 ± 2.9
$\%VO_{2peak}$	48 ± 13	52 ± 12 *	41 ± 12
MET[a]	5.0 ± 1.5	5.3 ± 1.1 *	4.2 ± 0.8
EE ($kcal.min^{-1}$)	5.6 ± 1.4	6.2 ± 2.2 *	5.0 ± 2.2
RPE	12 ± 2	14 ± 2	14 ± 2

[a] MET = metabolic equivalent where 1 MET is equivalent to VO_2 = 3.5 $ml.kg^{-1}.min^{-1}$

* $P < 0.05$ ("trot/canter" different from "no stirrups")

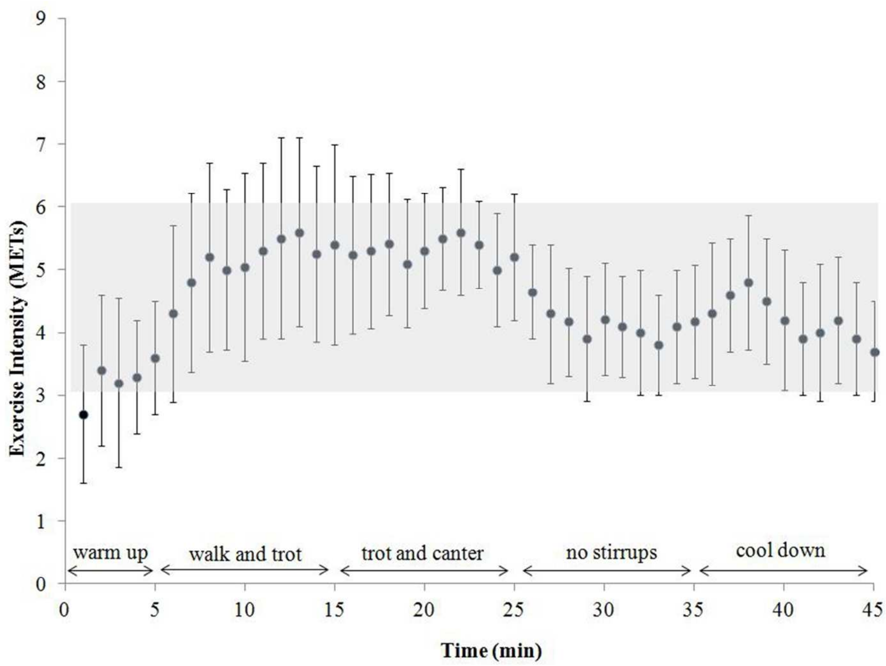

Figure 1. Mean exercise intensity expressed as metabolic equivalents (METS) averaged over each 1 minute period during the riding session. The moderate intensity exercise zone (3-6 METs) is highlighted in grey. The different activities performed are shown above the x-axis.
261x175mm (96 x 96 DPI)