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# An equine-assisted therapy intervention to improve pain, range of motion, and quality of life in adults and older adults with arthritis: A randomized controlled trial

Sharon White-Lewis (PhD, RN)[a,*], Rebecca Johnson (PhD, RN, FAAN, FNAP)[b], Sangbeak Ye (PhD)[a], Cynthia Russell (PhD, RN, ACNS-BC, FAAN)[a]

[a] School of Nursing and Health Studies, University of Missouri-Kansas City, 2464 Charlotte Street, Kansas City, MO 64108, United States of America
[b] Research Center for Human-Animal Interaction, MU College of Veterinary Medicine, University of Missouri, 900 East Campus Drive, Columbia, MO 65201, United States of America

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ABSTRACT

*Research aim:* To compare equine-assisted therapy to exercise education on pain, range of motion, and quality of life in adults and older adults with arthritis.
*Background:* Quality of life for adults and older adults is negatively impacted by arthritis pain, stiffness, and decreased function. Equine-assisted therapy provides unique movements to the rider's joints and muscles improving pain, range of motion, and quality of life and has improved outcomes in balance, gait, strength, functional mobility, and spasticity for older adults, stroke, spinal cord injury, and multiple sclerosis patients. No research has investigated the effects on adults and older adults with arthritis.
*Methods:* Twenty adults and older adults with arthritis recruited from rheumatology clinics participated in a randomized controlled trial for six weeks. Participants and research assistants were blinded to assignment. Standardized valid and reliable instruments were used to measure pain, range of motion, and quality of life targeting back, knees, shoulders, and hips.
*Results:* Mean age was 63.85 (SD 6.885, 53–75) years. Pain significantly improved in shoulders ($p = 0.007$), hips ($p = 0.027$), and back ($p = 0.006$), not knees ($p = 0.061$). Range of motion improved for back ($p = 0.02$), hips ($p = 0.04$), shoulders ($p = 0.005$) and not knees. Quality of life improved for upper limb ($p = 0.002$), lower limb ($p = 0.021$), and affect ($p = 0.030$), not social interaction and symptoms.
*Conclusion:* This randomized controlled trial provides evidence that equine-assisted therapy decreases pain, and improves range of motion, and quality of life for adults and older adults with arthritis. Further fully powered research with cost/benefit outcomes would be beneficial.

## 1. Research purpose

Osteoarthritis creates pain, stiffness, and decreased functionality affecting adults' and older adults' quality of life. No research has investigated the effects of equine-assisted therapy (EAT) on adults and older adults with arthritis. The purpose of this study was to assess the effects of an EAT intervention compared with an exercise education (ExEd) attention-control intervention on pain and mobility in the hips, knees, shoulders, and back of adults with nonspecific arthritis, osteoarthritis, rheumatoid arthritis, combined osteo and rheumatoid arthritis, and polyarthropathy. A licensed registered nurse with experience in orthopedic rehabilitation was the principal investigator. The study was designated the HEAT study – Horses and Education as Arthritis Therapy.

## 2. Background

In the United States arthritis accounts for $128 billion in lost income and medical costs (Centers for Disease Control and Prevention (CDC), 2013). Incidence of arthritis is increasing due to obesity and growing aging population (Bijlsma, Berenbaum, & Lafeber, 2011). Adults (40–65) and older adults (> 65) with arthritis experience joint pain, stiffness, damage to cartilage, and decreased range of motion particularly in their hips, knees, shoulders, and back. Current arthritis interventions include both pharmacologic and non-pharmacologic approaches. Pharmacologic treatments include opioids (Chaparro et al.,

* Corresponding author.
*E-mail addresses:* whitelewiss@umkc.edu (S. White-Lewis), rajohnson@missouri.edu (R. Johnson), yesa@umkc.edu (S. Ye), russellc@umkc.edu (C. Russell).

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**Table 1**
Sample demographics.

| ($n$ = 20) | | Both groups | EAT | ExEd | $p$ value between groups |
|---|---|---|---|---|---|
| Age (years) | Range | 53–75 | 53–70 | 54–75 | |
| | Mean | 63.85 ± 6.89 | 61.90 ± 6.05 | 65.80 ± 7.42 | $p$ = 0.358 |
| Gender (n %) | Males | 4 or 20% | 4 or 40% | 0 | |
| | Females | 16 or 80% | 6 or 60% | 10 or 100% | $p$ = 0.037 |
| Race (n %) | African American | 3 or 15% | 1 or 10% | 2 or 20% | |
| | Asian | 1 or 5% | 1 or 10% | 0 | |
| | Hispanic | 1 or 5% | 1 or 10% | 0 | |
| | White | 15 or 75% | 7 or 70% | 8 or 80% | $p$ = 0.000 |
| Arthritis diagnosis (n/%) | Arthritis – nonspecific | 4 or 20% | 2 or 20% | 2 or 20% | |
| | Osteoarthritis | 8 or 40% | 7 or 10% | 1 or 10% | |
| | Rheumatoid arthritis | 4 or 20% | 1 or 10% | 3 or 30% | |
| | Osteo and rheumatoid arthritis | 2 or 10% | 0 | 2 or 20% | |
| | Polyarthropathy | 1 or 5% | 0 | 1 or 10% | |
| | Erosive arthritis | 1 or 5% | 0 | 1 or 10% | $p$ = 0.060 |

*t*-Test calculated age and gender. Chi square calculated race and diagnosis. $p$ value < 0.05 for EAT and ExEd group.

2013), anti-inflammatories, morphine, anesthetics or steroids (Staal, de Bie, De Vet, Hildebrandt, & Nelemans, 2008). Practice guidelines suggest biopsychosocial approaches including exercise to strengthen leg and hip muscles, and improving range of motion (Fernandes et al., 2013). The World Health Organization (World Health Organization, 2010) also recommended physical activity including aerobic physical activity, strength, flexibility and balance for this population.

An emerging non-pharmacologic intervention to improve physical and psychological well-being is EAT (Ratliffe & Sanekane, 2009). Unique movements of the horse translate tri-rotational movements from the horse to the rider (Selby & Smith-Osborne, 2013) which targets the spine and hip joints by a movement that is not weight bearing which limits joint damage. Typically during riding, the rider adjusts to the varying movements of the horse which increases muscle, balance and stretching (Yorke, Adams, & Coady, 2008).

Previous meta-analyses of papers testing interventions with horses used to improve cerebral palsy in children, provide evidence to support the physical, neuromuscular connection and improvements (Nimer & Lundahl, 2007; Tseng, Chen, & Tam, 2013). A systematic review of EAT intervention research targeting physical symptoms in adults indicated significant improvement in 94% of studies through design rigor was lacking (White-Lewis, Russell, Johnson, Cheng, & McClain, 2017). Balance improved significantly in 14 studies (Aranda-Garcia, Iricibar, Planas, Prat-Subirana, & Angulo-Barroso, 2015; Araujo, Silva, Costa, Pereira, & Safons, 2011; Beinotti, Correia, Christofoletti, & Borges, 2010; de Araújo et al., 2013; Frevel & Mäurer, 2014; Hammer et al., 2005; Homnick, Henning, Swain, & Homnick, 2012, 2013; Hwang, Lee, & Lee, 2015; Kim & Lee, 2014; Kim, Lee, & Lee, 2014; Muñoz-Lasa et al., 2011; Sager, Drache, Schaar, & Pöhlau, 2008; Silkwood-Sherer & Warmbier, 2007; Sunwoo et al., 2012), with improvements in quality of life/self-efficacy/well-being for nine studies (Beinotti, Christofoletti, Correia, & Borges, 2013; Brock, 1988; Cerulli et al., 2014; Farias-Tomaszewski, Jenkins, & Keller, 2001; Frevel & Mäurer, 2014; Homnick et al., 2013; Lechner et al., 2003; Mackay-Lyons, Conway, & Roberts, 1988; Sager et al., 2008), cadence, gait and stride significantly improved in eight (Beinotti et al., 2013, 2010; Frevel & Mäurer, 2014; Kim & Lee, 2014; Lee, Kim, & An, 2015; Lee, Lee, & Park, 2014; Mackay-Lyons et al., 1988; Muñoz-Lasa et al., 2011), stability improved in six studies (Araujo et al., 2011; Hwang et al., 2015; Kim & Lee, 2014; Lechner et al., 2003; Lechner, Kakebeeke, Hegemann, & Baumberger, 2007; Menezes et al., 2013), and muscle strength/coordination also improved in six studies (Aranda-Garcia et al., 2015; Cerulli et al., 2014; Frevel & Mäurer, 2014; Hammer et al., 2005; Hwang et al., 2015; Lechner et al., 2007), and spasticity in four studies (Boswell, Gusowski, Kaiser, & Flachenecker, 2009; Lechner et al., 2003, 2007; Sager et al., 2008). The purpose of this study is to compare equine-assisted therapy to exercise education on outcomes in adults and older adults with arthritis.

## 3. Methods

### 3.1. Design

The study, which used a used two-armed parallel single blinded RCT approach, was registered at Clinical Trials.gov (NCT03141853) (National Institute of Health, 2017). Engel's Biopsychosocial Model which embraces physical, psychological, and social influences, guided the study (Engel, 1977).

### 3.2. Sample/setting

Twenty-one adults and older adults with arthritis were recruited from four arthritis clinics located in the Midwest and a Commemorative Airforce event and assigned to groups using 1:1 block randomization. The EAT intervention was provided in a Professional Association of Therapeutic Horsemanship International (PATH) certified riding stables. The Ex Ed intervention was delivered in a nursing school. Inclusion criteria were: 1) age over 45, 2) clearance to ride a horse as evidence by a written prescription from a physician or advanced practice registered nurse; 3) ability to read and understand English, 4) mild to moderate pain in one joint (shoulder, hip, knee, or back). measured by the Visual Analog Scale and (Hawker, Mian, Kendzerska, & French, 2011), 5) decreased range of motion by 20% or greater compared to the normal values on the *Range of Motion Evaluation Chart* (Washington State Department of Social and Health Services, 2014) and 6) transportation accessibility to a therapeutic riding center. Exclusion criteria were: 1) fear of horses, 2) allergies to horses, 3) self-reported osteoporosis, 4) inability to abduct hips wide enough to straddle a horse comfortably, 5) lack of transportation, or 6) horse riding in the previous six months.

Sample size was determined by systematically reviewing 31 intervention studies utilizing EAT for physical disabilities where the sample size mean of these studies was 18.9 participants (White-Lewis et al., 2017). Demographic information is contained in Table 1.

### 3.3. Procedures

Approval was obtained from the University of Missouri-Kansas City Institutional Review Board. The participants were screened by the Primary Investigator (PI) at a convenient place of their choosing. The EAT intervention was provided on PATH certified horses chosen for their quiet temperament and matched to the riders' height, weight, and abduction range at the hip joint. The Ex Ed intervention arthritis education classes were provided in a conference room at a local nursing school.

The EAT intervention, which was provided on the same day of the week and time within the cohorts, included grooming, saddling, and riding the same horse for 1 h each week for six weeks (Johnson et al., 2018). The EAT curriculum was created by collaboration from a physical therapist, occupational therapist, advanced practice orthopedic nurse, and a PATH certified instructor. A safety training session based on the United States Pony Club Safety Booklet (United States Pony Club Safety Committee, 2017) was administered to each participant with a demonstration/return demonstration. The horses remained at a walk with two trained and experienced therapeutic riding side-walkers to support the rider. A PATH certified trainer and the PI, a licensed registered nurse, were present at all times to ensure safety of animal and rider. Mounting was assisted by either steps or a ramp at the level of the horse's back allowing participants to sit backwards and swing their right leg over the saddle and horse. All mounting was supported by two staff members for safety. After mounting, 30 min of riding tasks was performed. Each week progressed to more difficult tasks from riding the horse at a walk around the arena on horseback stretching and learning to communicate with the horse through the reins, to independent weaving through cones and leaning over the horse to complete tasks such as placing a ball in a basketball goal. Several stretching exercises such as knee lifts, ankle rolls, and hand to opposite knee touches were performed as a warm up. Human-animal bonding time after riding was provided by allowing the participant's time to groom and give treats to the horse.

Participants were monitored for discomfort during the intervention by the PI and the PATH instructor and not required to perform a protocol task if uncomfortable. To prevent human-animal bond separation anxiety, participants were invited to continue the therapeutic riding at their own cost after the intervention ended.

The ExEd group received exercise education in sessions of the same time length and frequency as the EAT group. Their curriculum was developed from traditional, evidence based exercise education for adults and older adults with arthritis (Fernandes et al., 2013; Hughes, Wallace, & Baar, 2015), the exercise program from the Arthritis Foundation ("How-to Exercise With Arthritis,", n.d.), and previous literature (Aging, 2011; Bijlsma et al., 2011; Gecht-Silver, 2017; Kohn, Belza, Petrescu-Prahova, & Miyawaki, 2016). Education topics included: 1) an overview of arthritis and the benefits of exercise (social, physical, and psychological), 2) stretching, endurance versus strength training, 3) pain limitations and internet exercise tools, 4) intensity and planning, 5) starting and maintaining a program, 6) keeping exercise interesting and high intensity exercises. Participants developed an exercise planning calendar with a personal plan to exercise after the study though they were asked not to increase their exercise during the six-week study period to prevent confounding variables effecting the results.

Fidelity to both protocols was achieved by an independent observer, documenting real time corrections if necessary. Participants were instructed to continue all medications during the study. Changes of medications during the six-week period were allowed if deemed medically necessary by their healthcare provider.

### 3.4. Instrumentation

Pain and active range of motion in the back, knees, hips, and shoulders, and quality of life measurement occurred at baseline and post intervention at weeks three and six. Active range of motion (ROM) was measured with a hand-held goniometer that measures the joint angle in degrees. The participant bent the joint until stiffness began. Measurements included shoulder range of motion (abduction and flexion), back range of motion (forward and bilateral flexion), knee (flexion), and hip (abduction and flexion with knee flexed and extended). Reliability was reported as good to excellent for passive and active ROM (Baker, Kin, Moreside, Wong, & Rutherford, 2016; Fieseler et al., 2015; Kolber & Hanney, 2012) with an intra-class correlation (ICC) coefficient of 0.96–0.99 for shoulders (Nussbaumer et al., 2010) and an ICC 0.90 for hip abduction and deemed the goniometer reading valid compared to an electromagnetic tracking system (Fieseler et al., 2015).

Pain was measured using the 1–100 mm Visual Analog Scale (VAS) (Ferreira-Valente, Pais-Ribeiro, & Jensen, 2011) which has moderate to good reliability in measuring musculoskeletal pain with rho values of 0.60–0.77 (Boonstra, Schiphorst Preuper, Reneman, Posthumus, & Stewart, 2008). Higher scores indicate more pain.

Quality of life (QOL) was measured using the Arthritis Impact Measurement Scale 2 (AIMS 2) short form using a five-point Likert scale. The AIMS2 has content, construct, and convergent validity compared with the Sickness Impact Profile ($p < 0.001$) and the Medical Outcomes Short Form ($r > 0.60$) (Arkela-Kautiainen et al., 2003; Carr, 2003) with internal consistency of 0.79–0.89 and test retest reliability of 0.72–0.97 (Arkela-Kautiainen et al., 2003).

### 3.5. Data analysis

All data were collected on paper by the PI or research assistants (RA), entered into the RedCap data management system, and cleaned before analysis. Data analysis was conducted using SPSS version 22 ("IBM knowledge center - IBM SPSSstatistics v22.0.0 documentation,", n.d.) and supervised by the study biostatistician. Data were considered non-parametric due to the small sample. For demographic data, percentages were reported. The exploratory variables were calculated within groups with Friedman's test and between groups using Mann Whitney U. Significance was set at < 0.05.

The QOL and ROM values were subdivided into meaningful categories after factor analysis including the QOL categories of upper limb, lower limb, symptoms, and social interaction (Guillemin et al., 1997) and the ROM categories of back, knees, hips, and shoulders. Scores for QOL were then combined into a summative score and represented in Table 3 and then ROM data was represented separately in Table 4.

## 4. Results

Fifty-one adults and older adults were contacted by the PI for screening. Twenty-one consented and 20 completed the study with an attrition of one participant (attrition rate 5%). Demographics are listed in Table 1 and the Flow Diagram of participant recruitment is listed in Table 2.

Results within and between group comparisons on the outcomes of pain and ROM for back, knees, hips, and shoulders, and QOL are outlined in Table 3. Significant improvement occurred at six weeks between groups for back pain ($p = 0.021$) and range of motion for back, hips, and shoulder reported in Table 4. Quality of life demonstrated significant improvement between groups at three and six weeks for upper limbs and at six weeks for affect.

## 5. Discussion

The EAT intervention improved back pain, and back and right hip, ROM. at 6 weeks, but not at 3 weeks, suggesting that the motion during EAT may take longer to impact ROM and, subsequently pain. The right hip improvements and left hip non-improvements were probably due to the stretching of the right leg over the saddle when mounting from the platform was required. EAT significantly improved back, hip, and shoulder ROM in the experimental group and not in the control group. Movement is known to improve joint pain (Graham, Kremer, & Wheeler, 2008; Hughes et al., 2015) and EAT has a unique tri-rotational movement that could account for the improvements (Selby & Smith-Osborne, 2013). Araujo et al. (2011) found that older adults increased core strength after EAT due to the horse's movement over uneven ground and this would have provided muscular support to the back and hips. Also, the significant decrease in pain after EAT may result in long

**Table 2**
Participant flow diagram.

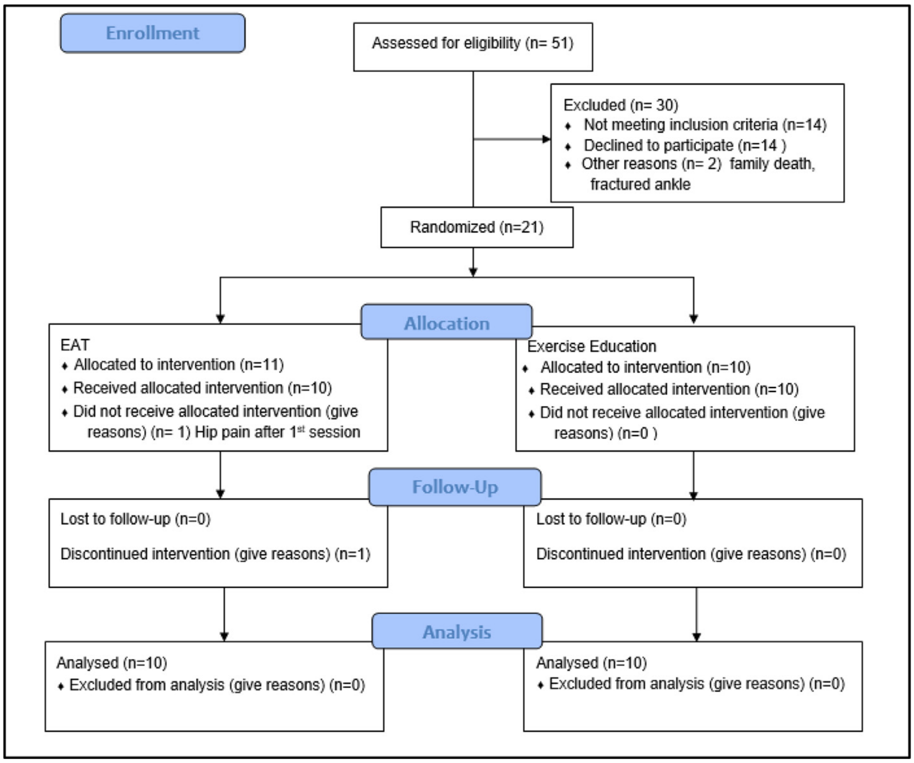


**Table 3**
Pain and QOL results.

| | | Group | Baseline Week 0 Mean ± SD | Mid-intervention Week 3 Mean ± SD | Post-intervention Week 6 Mean ± SD | Within group |
|---|---|---|---|---|---|---|
| Pain (mm) VAS | Back | EAT | 41.10 ± 30.60 | 28.70 ± 28.88 | 14.80 ± 18.47 | $p$ = 0.006* |
| | | ExEd | 39.00 ± 28.63 | 33.70 ± 24.38 | 29.60 ± 20.93 | $p$ = 1.00 |
| | | Between groups | $p$ = 0.31 | $p$ = 0.17 | $p$ = 0.021* | |
| | Knee | EAT | 46.10 ± 30.59 | 27.50 ± 24.55 | 24.40 ± 26.51 | $p$ = 0.06 |
| | | ExEd | 43.90 ± 25.74 | 38.60 ± 23.48 | 37.60 ± 27.30 | $p$ = 0.93 |
| | | Between groups | $p$ = 0.76 | $p$ = 0.33 | $p$ = 0.27 | |
| | Hip | EAT | 43.90 ± 37.07 | 31.00 ± 31.06 | 24.80 ± 19.70 | $p$ = 0.027* |
| | | ExEd | 34.30 ± 26.31 | 34.80 ± 21.00 | 24.80 ± 19.70 | $p$ = 0.12 |
| | | Between groups | $p$ = 0.60 | $p$ = 0.97 | $p$ = 0.23 | |
| | Shoulder | EAT | 48.90 ± 38.07 | 26.80 ± 25.50 | 16.10 ± 21.47 | $p$ = 0.007* |
| | | ExEd | 17.80 ± 11.35 | 34.60 ± 28.42 | 20.00 ± 22.49 | $p$ = 0.53 |
| | | Between groups | $p$ = 0.16 | $p$ = 0.31 | $p$ = 0.45 | |
| QOL (Likert) | Upper limb | EAT | 9.70 ± 2.87 | 8.20 ± 1.81 | 8.20 ± 1.81 | $p$ = 0.002* |
| | | ExEd | 10.10 ± 1.88 | 10.80 ± 3.16 | 10.80 ± 3.16 | $p$ = 0.20 |
| | | Between groups | $p$ = 0.85 | $p$ = 00.008* | $p$ = .008* | |
| | Lower limb | EAT | 13.40 ± 3.78 | 12.40 ± 3.81 | 10.50 ± 2.99 | $p$ = 0.021* |
| | | ExEd | 13.50 ± 4.30 | 12.80 ± 4.08 | 12.50 ± 4.035 | $p$ = 0.45 |
| | | Between groups | $p$ = 0.91 | $p$ = 1.00 | $p$ = 0.24 | |
| | Affect | EAT | 9.40 ± 4.43 | 8.80 ± 3.52 | 6.40 ± 2.55 | $p$ = 0.030* |
| | | ExEd | 10.40 ± 3.27 | 9.70 ± 3.23 | 9.20 ± 2.94 | $p$ = 0.303 |
| | | Between groups | $p$ = 0.32 | $p$ = 0.47 | $p$ = 0.043* | |
| | Symptoms | EAT | 9.30 ± 3.50 | 7.00 ± 3.56 | 6.60 ± 3.41 | $p$ = 0.052 |
| | | ExEd | 8.60 ± 2.12 | 9.10 ± 1.66 | 8.30 ± 2.54 | $p$ = 0.336 |
| | | Between groups | $p$ = 0.59 | $p$ = 0.15 | $p$ = 0.17 | |
| | Social interaction | EAT | 10.80 ± 3.23 | 10.20 ± 2.61 | 9.30 ± 3.00 | $p$ = 0.164 |
| | | ExEd | 10.70 ± 2.36 | 10.70 ± 2.59 | 11.70 ± 2.869 | $p$ = 0.303 |
| | | Between groups | $p$ = 0.85 | $p$ = 0.56 | $p$ = 0.07 | |

Statistical significance is set at $p < 0.05$. Statistically significant values are signified with an asterisk. Friedman's test calculated within group statistics. Mann Whitney U calculated between group statistics.

**Table 4**
Range of motion.

| | | Group | Baseline Week 0 Mean SD | Mid-intervention Week 3 Mean SD | Post-intervention Week 6 Mean SD | Within group Week 0–3 | Within group Week 3–6 | Within group Week 0–6 |
|---|---|---|---|---|---|---|---|---|
| ROM (degrees) | Back | | | | | | | |
| Goniometer | Flexion forward | EAT | 73.5 ± 22.16 | 81.5 ± 18.61 | 102 ± 16.72 | $p = 0.54$ | $p = 0.006$* | $p = 0.014$ |
| | | ExEd | 88 ± 18.85 | 72.9 ± 32.52 | 71.2 ± 28.71 | $p = 0.12$ | $p = 0.76$ | $p = 0.02$* |
| | | Between groups | $p = 0.11$ | $p = 0.62$ | $p = 0.02$* | | | |
| | Flexion right | EAT | 16.4 ± 3.47 | 19.4 ± 6.24 | 27.5 ± 7.70 | $p = 0.27$ | $p = 0.01$ | $p = 0.006$ |
| | | ExEd | 18.7 ± 4.87 | 17.4 ± 4.6 | 19 ± 5.12 | $p = 0.39$ | $p = 0.48$ | $p = 0.65$ |
| | | Between groups | $p = 0.34$ | $p = 0.59$ | $p = 0.02$* | | | |
| | Flexion left | EAT | 18.8 ± 4.91 | 25.7 ± 6.86 | 32.8 ± 8.87 | $p = 0.03$* | $p = 0.006$* | $p = 0.013$* |
| | | ExEd | 20 ± 6.94 | 19.6 ± 4.91 | 19.4 ± 3.98 | $p = 1$ | $p = 0.72$ | $p = 0.76$ |
| | | Between groups | $p = 0.44$ | $p = 0.048$* | $p = 0.0004$* | | | |
| | Hip | | | | | | | |
| | Flexion Rt. knee flexed | EAT | 83.7 ± 16.58 | 85 ± 15.21 | 85.7 ± 14.45 | $p = 0.78$ | $p = 0.91$ | $p = 0.63$ |
| | | ExEd | 66 ± 25.64 | 67 ± 25.78 | 72.1 ± 19.08 | $p = 1$ | $p = 0.48$ | $p = 0.15$ |
| | | Between groups | $p = 0.045$* | $p = 0.082$ | $p = 0.15$ | | | |
| | Flexion Rt. knee extended | EAT | 61.4 ± 26.7 | 72.3 ± 25.49 | 83.1 ± 27.25 | $p = 0.19$ | $p = 0.33$ | $p = 0.09$ |
| | | ExEd | 66.2 ± 52.28 | 49.4 ± 20.29 | 64.4 ± 20.73 | $p = 0.19$ | $p = 0.057$ | $p = 0.39$ |
| | | Between Groups | $p = 0.68$ | $p = 0.05$* | $p = 0.04$* | | | |
| | Flexion Lt. knee flexed | EAT | 75 ± 30.46 | 81.3 ± 21.49 | 81.5 ± 18.24 | $p = 0.15$ | $p = 0.88$ | $p = 0.68$ |
| | | ExEd | 64.4 ± 19.54 | 77.4 ± 24.73 | 75.2 ± 18.39 | $p = 0.04$* | $p = 0.85$ | $p = 0.13$ |
| | | Between groups | $p = 0.19$ | $p = 0.70$ | $p = 0.40$ | | | |
| | Flexion Lt. knee extended | EAT | 58.4 ± 27.14 | 70.0 ± 21.04 | 75.7 ± 31.25 | $p = 0.29$ | $p = 0.68$ | $p = 0.19$ |
| | | ExEd | 52.2 ± 22.79 | 62.5 ± 18.78 | 61.7 ± 20.92 | $p = 0.19$ | $p = 0.91$ | $p = 0.22$ |
| | | Between groups | $p = 0.68$ | $p = 0.52$ | $p = 0.18$ | | | |
| | Abduction Lt. | EAT | 37.4 ± 14.34 | 55.9 ± 18.96 | 61.5 ± 10.78 | $p = 0.002$* | $p = 0.185$ | $p = 0.009$* |
| | | ExEd | 38.4 ± 19.4 | 64.9 ± 41.57 | 50.4 ± 10.67 | $p = 0.59$ | $p = 0.53$ | $p = 0.92$ |
| | | Between groups | $p = 0.90$ | $p = 0.79$ | $p = 0.01$* | | | |
| | Abduction Rt. | EAT | 40.4 ± 18.51 | 51 ± 17.13 | 57.6 ± 15.25 | $p = 0.07$ | $p = 0.31$ | $p = 0.02$* |
| | | ExEd | 40.6 ± 29.97 | 57.9 ± 35.38 | 45.9 ± 6.90 | $p = 0.13$ | $p = 0.23$ | $p = 0.68$ |
| | | Between groups | $p = 0.76$ | $p = 0.91$ | $p = 0.06$* | | | |
| | Knee | | | | | | | |
| | Flexion Rt. | EAT | 75.2 ± 33.94 | 62.8 ± 11.71 | 57.3 ± 12.75 | $p = 0.28$ | $p = 0.14$ | $p = 0.20$ |
| | | ExEd | 89.9 ± 22.40 | 83 ± 23.39 | 66.3 ± 16.81 | $p = 0.49$ | $p = 0.02$* | $p = 0.097$ |
| | | Between groups | $p = 0.24$ | $p = 0.03$* | $p = 0.21$ | | | |
| | Flexion Lt. | EAT | 80.2 ± 28.11 | 61.9 ± 8.41 | 59.3 ± 12.49 | $p = 0.046$* | $p = 0.31$ | $p = 0.052$ |
| | | ExEd | 82.8 ± 19.96 | 91.4 ± 22.18 | 68.3 ± 17.27 | $p = 0.374$ | $p = 0.004$* | $p = 0.105$ |
| | | Between groups | $p = 0.40$ | $p = 0.00$* | $p = 0.18$ | | | |
| | Shoulder | | | | | | | |
| | Abduction Rt. | EAT | 126.5 ± | 151.7 ± 12.20 | 154.4 ± 22.28 | $p = 0.04$* | $p = 0.51$ | $p = 0.01$* |
| | | ExEd | 128.6 ± 23.74 | 123.8 ± 17.15 | 113.9 ± 21.50 | $p = 0.51$ | $p = 0.49$ | $p = 0.24$ |
| | | Between groups | $p = 0.85$ | $p = 0.001$* | $p = 0.005$* | | | |
| | Abduction Lt. | EAT | 123.2 ± 35.70 | 142.5 ± 24.33 | 146.1 ± 24.35 | $p = 0.126$ | $p = 0.11$ | $p = 0.03$* |
| | | ExEd | 117.2 ± 18.83 | 106.4 ± 25.67 | 106.8 ± 21.65 | $p = 0.43$ | $p = 0.47$ | $p = 0.28$ |
| | | Between groups | $p = 0.91$ | $p = 0.012$* | $p = 0.006$* | | | |
| | Flexion Rt. | EAT | 135.2 ± 34.15 | 159 ± 13.44 | 159.5 ± 21.4 | $p = 0.11$ | $p = 0.79$ | $p = 0.03$* |
| | | ExEd | 117.4 ± 21.71 | 116.7 ± 23.57 | 127.2 ± 15.39 | $p = 0.91$ | $p = 0.41$ | $p = 0.61$ |
| | | Between groups | $p = 0.24$ | $p = 0.00$* | $p = 0.00$* | | | |
| | Flexion Lt. | EAT | 133.8 ± 33.19 | 149 ± 19.40 | 141.9 ± 25.74 | $p = 0.03$* | $p = 0.36$ | $p = 0.54$ |
| | | ExEd | 123.1 ± 34.27 | 113.8 ± 31.30 | 126.2 ± 11.68 | $p = 0.72$ | $p = 0.88$ | $p = 0.23$ |
| | | Between groups | $p = 0.6$ | $p = 0.00$* | $p = 0.057$ | | | |

term maintenance of participant's exercise regimes (Resnick et al., 2014). In this HEAT study the decrease in pain was due to increased ROM and possibly muscle strength which was not measured in this study. To identify the muscles which were affected, further research would need to be conducted.

Although, no other equine-assisted therapy studies have specifically targeted arthritis and joint pain and ROM, there is documentation of improvements in muscle strength (Aranda-Garcia et al., 2015; de Araújo et al., 2013; Lechner et al., 2003), balance (Aranda-Garcia et al., 2015; Araujo et al., 2011; de Araújo et al., 2013; Homnick et al., 2012; Homnick et al., 2013; Homnick, Henning, Swain, & Homnick, 2015; Kim et al., 2014), and stress hormones (Cho, Kim, Kim, & Cho, 2015) in older adults with EAT intervention. Aranda-Garcia et al. (2015) study of 38 participants found statistically significant improvement in knee extensors in contrast to our results with knee ROM not improved. Aranda-Garcia et al. (2015) included trotting and rode three times a week in contrast to our walking only and dose of 1 time per week. Trotting would increase movement of the knee accounting for the difference in results. Weight bearing with the two-point exercise or bracing in the stirrups would increase chondral stressors in the knees and may have contributed to non-significant findings in the experimental group. When a horse is trotting and the rider is posting (standing and sitting with each trot step of the horse) the knees are engaged in increased activity. The control group's improvement in knee ROM is accounted for with their attendance at the education sessions. Any movement would cause improvements. But stress from 2 point could result in the non-significant results chondral stressors.

In reviewing other exercise studies targeting knees, eight weeks of hydrotherapy exercise did produce significant pain decrease for fifteen adult patients with arthritis (Karimi & Rahnema, 2016). The hydrotherapy exercise provides non weight bearing exercise on the participant's knees unlike the horse riding in two point (standing in the saddle while the horse is moving) that could have placed stress on the knee joint. Future research could study the differences in knee pain outcomes comparing trotting to walking EAT.

EAT's ability to relax the participant's hips and back with the rhythmic motion of the horses may have accounted for the significant changes in ROM. One EAT participant at baseline reported she could not walk more than ten steps due to hip pain and stiffness. After two EAT sessions she claimed she could go to the store, completed shopping for food, and had resumed activities of daily living that she had not been able to for years. Strengthening the girdle muscles of the shoulder by grooming a large horse, with its resultant external rotation and elevated circular motion, would have increased support to the gleno-humeral joint, accounting for the shoulder ROM improvements. Other interventions have documented conflicting results. Bieler, Siersma, Magnusson, Kjaer, and Beyer (2018) conducted an observer blinded RCT on three groups with 50 older adults afflicted with hip osteoarthritis. In contrast to our findings, their 4-month interventions of walking on a Nordic machine, physiotherapy and home exercise found no differences in improvement for ROM. The superior stretching of the hip joint when riding along with the movement of the horse may explain the improvements in our study. One participant suffered hip soreness after the first EAT session. She discontinued the study after consulting her physician.

Improvements in QOL by the EAT intervention were found at weeks three and six in upper limbs, shoulders at three weeks, and affect at six weeks. Comparatively, QOL also measured by the AIMS 2, was considered in a four week RCT for arthritis in adult participants in their 50's and 60's, that measured dynamic exercise compared to conventional joint treatment (Baillet et al., 2009). At four weeks these authors found no significant improvement in the AIMS 2 scores. The HEAT study found significant improvement for upper limb, and affect QOL outcomes for the EAT group. The additional two weeks EAT could have produced a more measurable effect resulting in improved AIMS2 scores.

The improvements in affect found in this study were similar to the findings of (Pretty et al., 2007) who studied 263 participants with ten activities including horse riding. Their results include significant improvement in mood. This could be attributed to the effect of the human-animal bond. Bachi, Terkel, and Teichman (2012) assert that horses provide affect mirroring due to their instantaneous non-verbal feedback to humans. In a critical review of human-animal interaction literature, Hosey (2014) related human-equine relationships as similar to cats and dogs with the subsequent positive effects of companion animals. Separation anxiety after the human-equine bond was formed occurred with three participants with two participants visiting the study horses frequently after their intervention was concluded.

## 6. Limitations

Although threats to internal and external validity were partially mitigated with blinding, randomization, and consistency in horses and personnel, cautious interpretation of the results is warranted. Threats to external validity include a small sample, fewer males in the control group, and underrepresentation of African Americans and Hispanic arthritis sufferers. Threats to internal validity include an inability to control for extraneous exercise in participants over the six-week period. Moderate or vigorous exercise confounds the accuracy of the results and was not accounted for. Potentially confounding variables such as participant illnesses and differences in diet were not accounted for. Previous horse-riding experience and the participant views of human-animal relationships were not measured. The horses' welfare was monitored by the PATH instructor before, during, and after sessions. They were limited to two therapeutic rides per day. No indication of stress from the horses was noted which is consistent with. Johnson et al.'s study with therapy horses working two sessions a day for a six week (Johnson et al., 2018).

## 7. Conclusion

The study's findings inform the science of human-animal interactions and contributes to the growing evidence of the benefits of EAT in adults with arthritis. The significant exploratory results reported here needs to be interpreted cautiously due to the limited sample and lack of sample diversity, and longitudinal measurement to identify how long positive effects of EAT may last. Future research should include large multi-center trials, increased sample diversity. Comparison of different doses and duration of riding would inform the EAT science and future study designs. A cost benefit analysis study would be useful to identify whether or not EAT may be a valid therapy for clinical use and third-party insurance reimbursement.

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