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# Investigating the Effectiveness of Equine-assisted Therapy on Children Regardless of Their Mental Disorder

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**Abstract**

Equine-assisted therapy (EAT) is a common and popular complementary and alternative therapy among children with different mental disorders. In this study, the effectiveness of EAT was investigated on children with diverse mental disorders by analyzing their gait. Fifty-six children (age: 8.30 ± 3.77 years) were involved in the research who participated weekly in equine-assisted therapy during a school year. The gait of the children was measured twice with the GAITRite® pressure-sensing mat, before and after the therapy period. The participants did ten sections of walking on the pressure-sensing mat. Twenty-one spatial and temporal gait parameters were chosen and evaluated for further statistical analysis. To determine the normal distribution of the parameters, the Lilliefors normality test was carried out. Depending on the result, the paired t test or the Wilcoxon signed-rank test was used to compare the means of the results of the two measurements ($p < 0.05$). Significant differences were observed for eight out of the twenty-one parameters which investigation provides some promising results regarding the benefits of equine-assisted therapy for children's quality of life.

**Keywords**

equine-assisted therapy, gait analysis, GAITRite®, mental disorder

## 1 Introduction

Given the intricate nature and potential adverse effects associated with the majority of mental disorders and their therapeutic interventions, individuals frequently explore alternative or complementary therapeutic modalities to facilitate amelioration and recovery. Pharmacological treatments may entail significant side effects, imposing additional burdens on patients and their social environments, while the efficacy of conventional standardized treatments often yields suboptimal outcomes [1, 2]. Consequently, patients and their caregivers seek diverse alternative therapeutic approaches aimed at enhancing the condition of individuals grappling with mental or physical disorders. Complementary and alternative therapies hold significant importance in the rehabilitation process for children with mental disorders, contributing positively to their overall quality of life [3]. Complementary and alternative therapy may be acupuncture, biofeedback, chelation therapy, chiropractic or osteopathic manipulation, craniosacral therapy, energy healing therapy, hypnosis, massage, naturopathy, traditional healers, movement therapies, herbal and non-vitamin supplements, vitamins and minerals, homeopathy, special diets, yoga/tai chi/qi gong, and relaxation techniques (meditation/guided imagery/progressive relaxation) [4].

One of the most popular alternative and non-pharmacological treatments is equine-assisted therapy (EAT), an umbrella term for various forms of therapy such as physical therapy, occupational therapy, speech-language therapy, and psychotherapy where the horse is part of the treatment team [5]. Equine-assisted therapy finds application in the treatment of a spectrum of mental disorders, encompassing anxiety disorders, depression, post-traumatic stress disorder (PTSD), attention deficit hyperactivity disorder (ADHD) [6–8], cerebral palsy [9, 10], multiple sclerosis [11, 12] and autism spectrum disorder (ASD) [13], among others. The effectiveness of equine-assisted therapy is widely investigated. Its therapeutic efficacy in addressing the multifaceted needs of these populations has garnered increasing recognition, supported by empirical evidence demonstrating improvements in emotional regulation, social integration, and overall well-being [14, 15]. Therapeutic horse riding and

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equine-assisted therapy have emerged as popular alternative treatment modalities for individuals with mental disabilities, including children, aiming to enhance their health status and overall quality of life [16, 17]. These interventions require the expertise of well-trained instructors. Riding sessions have been associated with potential benefits such as improved head and trunk control [18], enhanced coordination, and improved gait [19].

The gait of children with different mental disorders may differ from their healthy piers. Children with ADHD seem to have specific patterns of gait variability compared to typically developing children, particularly in complex walking contexts and at faster paces [20, 21]. Previous research has highlighted a spectrum of motor skill and gait challenges associated with autism spectrum disorder (ASD), stemming from deficits in postural control, and stability, balance, and coordination difficulties [22–24]. Hypotonia, muscle stiffness, akinesia, bradykinesia, and impaired postural control can contribute to unstable and atypical movements during daily activities [25]. These abnormal gait patterns may result in discomfort, fatigue, and increased joint stress, consequently impacting the functional capacities of affected individuals, and diminishing overall quality of life [26].

Studies have indicated a resemblance between the gait patterns of older individuals and children with autism, characterized by wider step width, prolonged cycle time, double support time, and stance time. This similarity is attributed to a deficit in locomotor control, resulting in a common pattern of increased step width for enhanced stability in both groups [27]. Gait analysis serves as a valuable tool for evaluating the status of children with motor control impairments and for monitoring the efficacy of therapeutic interventions. Gait, being a complex and cyclical process, necessitates the integration of mental, spiritual, and physical health factors to maintain optimal movement patterns [28]. For children with mental disorders, the GAITRite® mat has emerged as an ideal assessment tool [29]. This system, which measures foot pressure, eliminates the need for marker placement on individuals being assessed, thereby minimizing discomfort. Instead, pressure values are utilized to compute various gait parameters [30].

The present study aims to declare the effectiveness of equine-assisted therapy as an effective complementary therapy on children regardless of their mental disorder on the gait parameters. In the present study, 56 children with different mental disorders were included and their gait parameters were examined before and after the EAT period with the GAITRite® pressure-sensing mat. We hypothesize that comparing the gait parameters of the pre- and posttherapy period shows statistically significant differences.

## 2 Methodology

### 2.1 Study population

56 children (23 girls, and 33 boys) were involved in the study with different mental disorders. Each participant's gait was examined twice, before and after the equine-assisted therapy period with the GAITRite® pressure-sensing mat. The participants' anthropometry data were as follows: pretherapy: age: 8.30 ± 3.77 years, height: 130.16 ± 19.06 cm, weight: 31.91 ± 14.92 kg; posttherapy: age: 8.68 ± 3.67 years, height: 130.89 ± 18.61 cm, weight: 32.14 ± 15.07 kg. The children of the study population had one or more mental disorders, as the following ones: autism spectrum disorder, sensory processing disorders, social-integration, learning, and behavior difficulty, attention deficit hyperactivity disorder, anxiety disorder, mental retardation, visual impairment, mixed specific developmental disorder, psychomotoric developmental disorder, hearing impairment, physical disability, specific developmental disorders of speech and language.

### 2.2 The equine-assisted therapy sessions

Throughout the rehabilitation program, each individuals participated in weekly equine-assisted therapy sessions spanning thirty minutes, conducted from October through May. Over this duration, children with mental disorders engaged in a total of 18–20 sessions, wherein activities were tailored to their individual abilities and specific challenges. These sessions encompassed a spectrum of exercises and tasks conducted on horseback, as well as activities focused on horse care and groundwork in proximity to the horse. The allocation and intensity of these therapeutic interventions were dynamically adjusted to accommodate the diverse needs and capabilities of the participating children, ensuring a personalized and responsive approach to their rehabilitation journey.

### 2.3 Instrumentation

For the measurements conducted, a GAITRite® pressure-sensing mat (CIR System Inc., Peekskill, NY, USA, version 4.8.5) served as the primary instrument. This standard device features eight sensor pads encapsulated in a roll-up carpet configuration, resulting in an active area spanning 488 cm in length and 61 cm in width. Within this layout, a precise 48 × 384 sensor grid is meticulously positioned [31]. During data acquisition, children traverse the mat at a self-selected walking speed, while the system meticulously captures pressure data and discerns the positioning and orientation of each step. Subsequently, the accompanying software meticulously archives each individual step and calculates a myriad of temporal and spatial gait parameters, providing comprehensive insights into the nuances of gait dynamics.

### 2.4 The measurement protocol

Participants were instructed to complete five consecutive rounds of walking back and forth, with each round comprising 10 sections, at their self-selected walking speed. To ensure consistency in velocity during measurements, participants initiated their gait at least one meter before stepping onto the pressure-sensing mat and concluded their stride a minimum of one meter after stepping off from the device. This protocol aimed to maintain a uniform walking pace throughout the assessment process. The testing procedure was repeated twice, both before and after the designated therapy period, to capture potential changes in gait parameters over time.

### 2.5 The chosen gait parameters

Given the GAITRite® software's capability to compute automatically a range of spatial and temporal gait parameters, twelve metrics have been selected to characterize movement patterns accurately: cycle time (s), double support time (s), stance time (s), cadence (step/min), normalized velocity (1/s), stride velocity (cm/s), step extremity ratio (-), toe in/out angle (°), mean step count (-), step length (cm), step time (s), and heel-to-heel base of support (cm). Table 1 shows all the parameters their units, and their definitions [32]. Fig. 1 and Fig. 2 are explanatory figures for the spatiotemporal parameters.

### 2.6 Statistical analysis

The mean and standard deviation of all the gait parameters before and after the therapy measurements were calculated. The normal distribution of the data set was carried out by the Lilliefors normality test. The mean values of the parameters of pre- and post-therapy period were compared. If both pre- and post-therapy data sets exhibited a normal distribution, a paired t-test was employed for comparison. Conversely, if the data did not meet the assumption of normality, the Wilcoxon signed-rank test was used to compare the means between groups. All statistical tests were conducted at a significance level of 5% ($p < 0.05$). All statistical analyses were performed using MATLAB R2023a (Mathworks, Natick, Massachusetts, USA).

## 3 Results

All 56 recruited children were retained for analysis. Table 2 provides the mean and standard deviation values for the 12 selected gait parameters. Given that cycle time, double support time, stance time, stride velocity, step extremity ratio, toe in/out angle, step length, step time, and heel-to-heel base of support are bilateral parameters, data for a total of 21 parameters are presented in Table 2. Additionally, the significance level between pre- and post-therapy period results is summarized in Table 2. Notably, eight out of the twenty-one parameters exhibit statistically significant differences ($p < 0.05$) between the two measurements. The eight parameters are the following ones: left cycle time ($p = 0.0270$), right cycle time ($p = 0.0354$), left stance time ($p = 0.0498$), right stance time ($p = 0.0367$), cadence ($p = 0.0003$), normalized velocity ($p = 0.0065$), left step time ($p = 0.0304$) and right step time ($p = 0.0388$).

## 4 Discussion

The purpose of the present study was to investigate the effectiveness and benefits of equine-assisted therapy on the health condition of children regardless of their mental disorders. Gait analysis was chosen due to its periodicity, complexity and also for its ease of implementation, facilitated by the GAITRite® pressure sensing mat, which eliminates the need for marker-based motion capture systems. Twelve spatial and temporal gait parameters were selected for evaluation. The study included 56 children with mental disorders, all of whom participated in equine-assisted therapy. Gait measurements were taken twice, before and after the therapy period. The obtained results were analyzed using statistical methods. To assess the normality of the data, a Lilliefors normality test was conducted. Subsequently, if the data followed a normal distribution, the one-sample t-test was applied to compare pre- and post-therapy results. Otherwise, the Wilcoxon test was used. The significance level for all tests was set at 5% ($p < 0.05$).

As Table 2 shows, eight parameters out of twenty-one – right and left cycle time, right and left stance time, cadence, normalized velocity, and right and left step time – show statistically different results between the pre- and post-therapy period measurements. As it can be observed, only temporal gait parameters demonstrate statistically different results. For these datasets, boxplots are used.

**Table 1** The chosen gait parameters and their definitions [32]

| Gait parameters | Unit | Definition |
|---|---|---|
| Cycle time | sec | It is the elapsed time between the first contacts of two consecutive footfalls of the same foot. |
| Double support time | sec | The two periods when both feet are on the floor are called initial double support and terminal double support. Initial double support occurs from heel contact of one footfall to toe-off of the opposite footfall. Terminal double support occurs from opposite footfall heel strike to support footfall toe-off. Total double support is the sum of the initial double support added to the terminal double support (Fig. 1). |
| Stance time | sec | The stance phase is the weight-bearing portion of each gait cycle. It is initiated by heel contact and ends with the toe off of the same foot. It is the time elapsed between the First Contact and the Last Contact of two consecutive footfalls on the same foot. |
| Cadence | step/min | It is defined as the total number of full steps taken within a given period of time. |
| Normalized velocity | 1/sec | It is obtained after dividing the Velocity by the Average Leg Length and it is expressed in Leg Length per second (LL/sec). The average Leg Length is computed (left leg length + right leg length)/2. |
| Stride velocity | cm/s | It is obtained after dividing the Stride Length by the Stride Time. |
| Step extremity ratio | - | It is defined as the Step Length divided by the Leg Length of the same leg. |
| Toe in/out angle | ° | It is the angle between the line of progression and the midline of the footprint. In Fig. 2, theta is the angle between the midline of the right footprint and the line of progression. Angle theta is zero if the geometric midline of the footprint is parallel to the line of progression; positive, toe-out, when the midline of the footprint is outside the line of progression and negative, toe-in, when inside the line of progression. |
| Mean step count | - | The number of steps taken by the examined person divided by the 10 sections. |
| Step length | cm | It is measured along the length of the walkway, from the heel center of the current footprint to the heel center of the previous footprint on the opposite foot. In Fig. 2, the length of line (AX) is the step length of the right foot, while the length of line (YG) is the step length of the second left foot. The step length can be a negative value if the subject fails to bring the landing foot heel point forward of the stationary foot heel point. |
| Step time | sec | It is the time elapsed from the first contact of one foot to the first contact of the opposite foot (Fig. 1). |
| Heel to heel base of support | cm | It is the vertical distance from the heel center of one footprint to the line of progression formed by two footprints of the opposite foot. In Fig. 2, the height of the triangle (ADG) is (DL), which is the base width of the right foot. |

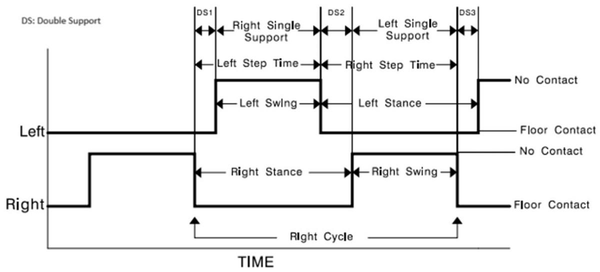


**Fig. 1** Explanatory figure for the temporal gait parameters [32]

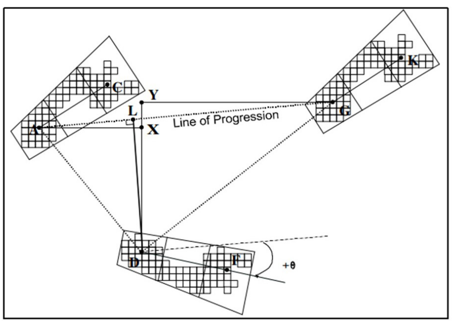


**Fig. 2** Explanatory figure for the spatial gait parameters measured by the GAITRite® mat [32]

Figs. 3–7 represent the boxplots of the parameters that show significant differences between the pre- and post-therapy period measurements.

Spatiotemporal parameters of children with different mental disorders were previously investigated and compared to the data of their healthy peers. Other studies confirmed that children with attention deficit and hyperactivity disorder performed worse in gait parameters such as velocity, step, and stride length [33].

Gait cycle time and double support time were significantly longer for the group of children with autism spectrum disorder compared to their healthy age-matched group [30, 34]. Our results show a significantly shorter cycle time and a non-significantly shorter double support time after the therapy period measurements; therefore, it can be stated that the equine-assisted therapy affected the children's gait.

As for the stance time, previous studies show controversial results. Vilensky et al. [35], Lim et al. [30] and Yang et al. [34] reported a significantly longer stance time for the group of children with autism spectrum disorder

**Table 2** The measured gait parameters (mean ± st. dev.), and significance level (significant values are highlighted), L – left, R - right.

| Gait parameters | Pre therapy | Post therapy | Significance |
|---|---|---|---|
| Cycle time L (s) | 1.03 ± 0.17 | 0.96 ± 0.13 | **0.0270** |
| Cycle time R (s) | 1.02 ± 0.17 | 0.96 ± 0.13 | **0.0354** |
| Double support time L (s) | 0.20 ± 0.08 | 0.19 ± 0.07 | 0.3624 |
| Double support time R (s) | 0.20 ± 0.08 | 0.19 ± 0.07 | 0.3748 |
| Stance time L (s) | 0.61 ± 0.12 | 0.57 ± 0.10 | **0.0498** |
| Stance time R (s) | 0.61 ± 0.12 | 0.57 ± 0.09 | **0.0367** |
| Cadence (step/min) | 119.96 ± 18.14 | 127.01 ± 17.06 | **0.0003** |
| Normalized velocity (1/s) | 1.39 ± 0.37 | 1.49 ± 0.41 | **0.0065** |
| Stride velocity L (cm/s) | 98.62 ± 24.93 | 101.88 ±21.66 | 0.4652 |
| Stride velocity R (cm/s) | 98.67 ± 24.89 | 101.82 ± 21.75 | 0.4723 |
| Step extremity ratio L (-) | 0.68 ± 0.12 | 0.69 ± 0.14 | 0.3621 |
| Step extremity ratio R (-) | 0.69 ± 0.11 | 0.70 ± 0.12 | 0.4066 |
| Toe in/out angle L (°) | 1.84 ± 8.08 | 0.89 ± 8.39 | 0.1354 |
| Toe in/out angle R (°) | 2.89 ± 8.85 | 1.51 ± 9.29 | 0.0983 |
| Mean step count (-) | 12.75 ± 3.95 | 12.80 ± 3.83 | 0.9275 |
| Step length L (cm) | 47.96 ±10.30 | 46.84 ± 10.18 | 0.5431 |
| Step length R (cm) | 47.97 ± 9.75 | 47.98 ± 9.29 | 0.1426 |
| Step time L (s) | 0.51 ± 0.09 | 0.48 ± 0.06 | **0.0304** |
| Step time R (s) | 0.51 ± 0.09 | 0.48 ± 0.07 | **0.0388** |
| Heel to heel base of support L (cm) | 9.35 ± 3.06 | 9.32 ± 3.07 | 0.8866 |
| Heel to heel base of support R (cm) | 9.67 ± 2.98 | 9.64 ± 2.98 | 0.9235 |

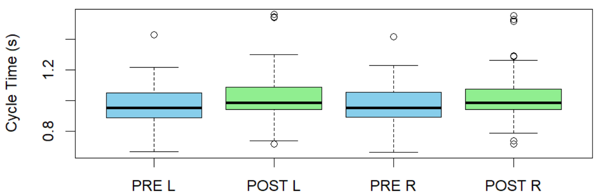


**Fig. 3** The boxplots of Cycle Time (s) before (PRE) and after (POST) the therapy period for both legs (L – left, R- right)

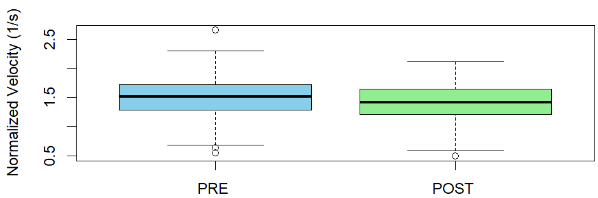


**Fig. 6** The boxplots of Normalized Velocity (1/s) before (PRE) and after (POST) the therapy period

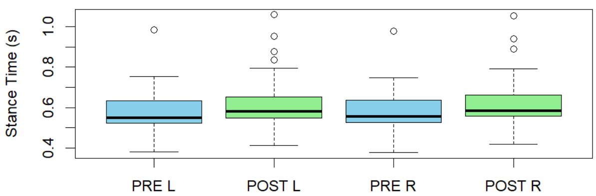


**Fig. 4** The boxplots of Stance Time (s) before (PRE) and after (POST) the therapy period for both legs (L – left, R- right)

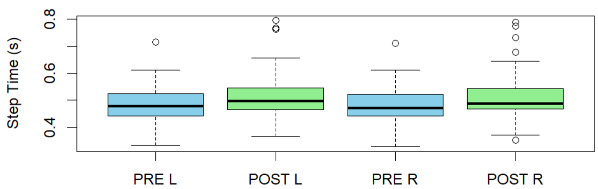


**Fig. 7** The boxplots of Step Time (s) before (PRE) and after (POST) the therapy period for both legs (L – left, R- right)

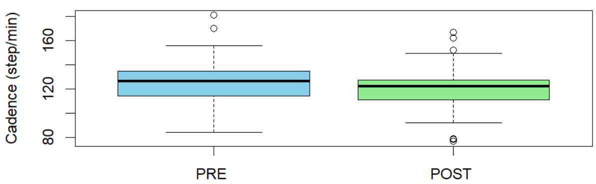


**Fig. 5** The boxplots of Cadence (step/min) before (PRE) and after (POST) the therapy period

compared to the control group, however, Calhoun et al. presented the opposite [26]. Our results shortened after the therapy period, so it agrees with the previous statement.

Cadence and normalized velocity parameters were significantly faster after the therapy period. Yang et al. [34] reported that cadence, stride velocity, and normalized velocity were lower for the group of children with autism, as our results are lower compared to the results of healthy age-matched children in the study of Dusing and Thorpe [29].

The step extremity ratio and the toe in/out angle do not present significant differences between the two measurements, although, previous studies show significantly lower step extremity ratio for children with autism compared to the healthy control group [34]. Mean step count does not show significant difference, although our results are higher than the mean step count in the group of healthy, age-matched children [29, 36]. In this study, the step lengths do not demonstrate significant differences, however, previous studies reported shorter results for the group of children with autism spectrum disorder compared to the healthy control group [35]. Heel to heel base of support shows lower values compared to the healthy piers as in the case of other studies [37]. Step width in this study was not investigated in this study, although previous studies showed that the step width was significantly wider for children with autism than for their healthy peers [34].

## 5 Study limitations

The human gait is subject to various influencing factors, including mood, weather conditions, and level of fatigue. Consequently, it would be premature to attribute observed progress solely to equine-assisted therapy. Moreover, it's plausible that the children involved may have participated in additional alternative or conventional therapies concurrently, potentially contributing to the outcomes observed. As such, while equine-assisted therapy may have played a role in the observed progress, the comprehensive understanding of its efficacy necessitates consideration of various contextual factors and potential confounding variables.

## 6 Conclusion

The present study demonstrates the positive effects of equine-assisted therapy sessions on spatiotemporal gait parameters in children regardless of their mental disorders. The novelty of our study lies in the demonstration of equine-assisted therapy as a valuable complementary method to enhance the health status and quality of life of these children. These findings contribute to our understanding of therapeutic approaches for mental disorders and advocate for the inclusion of equine-assisted therapy in comprehensive treatment plans for affected individuals. For further and more comprehensive statement, the clinical connection between the gait pattern and the mental assessment of the children will be investigated in depth in further research.

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