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Electromyographic evaluation of the lower limbs of patients with Down syndrome in hippotherapy

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ABSTRACT. Hippotherapy is a therapeutic method that uses the horse's movement to achieve functional results in practitioners with Down syndrome (DS), who present motor and neurophysiological changes that affect the musculoskeletal system. Evaluating the motor behavior related to the control and the improvement of muscle activation in practitioners with Down syndrome subjected to hippotherapy. 10 practitioners were divided into two groups: Down Group (DG) – practitioners with DS, and Healthy Group (HG) – practitioners with no physical impairment. The muscles gluteus medius, tensor fasciae latae, rectus femoris, vastus medialis, vastus lateralis, biceps femoris, tibialis anterior and gastrocnemius were evaluated by electromyography using gross RMS values, which correspond to muscle activation; the evaluations were performed on the 1st and 10th hippotherapy sessions (frequency: once a week), and after 2 months interval without treatment, they were performed on the 1st and 10th hippotherapy sessions (frequency: twice a week). It was noted that activation of the studied muscles increased with the passing of sessions, regardless the weekly frequency of attendance; however, the period without treatment resulted in reduction of this effect. Practitioners with DS presented satisfactory changes in muscle activation pattern, in learning and in motor behavior during hippotherapy sessions.

Keywords: muscle activation, electromyography, hippotherapy, Down syndrome, equine assisted therapy.

Avaliação eletromiográfica dos membros inferiores de pacientes com síndrome de Down na equoterapia

RESUMO. Equoterapia é um método terapêutico que utiliza o movimento do cavalo para alcançar resultados funcionais, realizada em praticantes com síndrome de Down (SD), que apresentam alterações neurofisiológicas e motoras que afetam o sistema musculoesquelético. Avaliar o comportamento motor relacionado ao controle e melhora a ativação muscular em praticantes com SD submetidos ao tratamento equoterapêutico. Participaram dez praticantes divididos em dois grupos: grupo Down (GD) - praticantes com SD, e grupo Saudável (GS) - praticantes sem comprometimento físico. Os músculos glúteo médio, tensor da fáscia lata, reto femoral, vasto medial, vasto lateral, bíceps femoral, tibial anterior e gastrocnêmio foram avaliados por meio da eletromiografia, utilizando o valor de RMS bruto que corresponde à ativação muscular, e as avaliações foram realizadas na primeira e décima sessões de equoterapia (frequência: 01 vez por semana); e após intervalo de dois meses sem tratamento, foi realizada na primeira e décima sessões de equoterapia (frequência: 02 vezes por semana). Observou-se que a ativação muscular dos músculos estudados aumentou com o passar das sessões, independente da frequência semanal de atendimento; mas o período sem tratamento resultou em redução deste efeito. Os praticantes com SD apresentaram mudanças satisfatórias no padrão de ativação muscular, na aprendizagem e no comportamento motor no decorrer das sessões de equoterapia.

Palavras-chave: ativação muscular, eletromiografia, equoterapia, síndrome de Down, terapia assistida por cavalos.

Introduction

One of the few human aneuploidies compatible with postnatal survival is a genetic condition caused by trisomy of chromosome 21 (an extra 21 chromosome, or part of it) that affects autosomal chromosomes, known as Down syndrome (DS). This is the most common cause of mental impairment and determines the trend to pathological expression of brain structure and function in people with this syndrome (Agulló & González, 2006; Sommer & Henrique-Silva, 2008; Torquato, Lança, Pereira, Carvalho, & Silva, 2013). This information is also regulated by other genes of the individual, so that the variability observed between people with DS is notable. At the same time, the brain is not a fixed and unchanging structure, but highly plastic, so the environment and therapeutic intervention can exert decisive influence in the development of the individual (Agulló & González, 2006).

The neuropathological basis for the motor dysfunction present in DS is not yet well established, but it is suggested that the cerebellar dysfunction, the delayed myelination, as well as proprioceptive and vestibular deficits, can be considered as possible causes (Galli, Rigoldi, Brunner, Virji-Babul, & Giorgio, 2008).

The early motor repertoire is adversely affected in individuals with DS, and a delay in motor development is expected (Torquato et al., 2013; Cardoso, Campos, Santos, Santos, & Rocha, 2015). There is a difference in age of acquisition of motor skills between children with typical development and children with DS, which is often delayed in the later for skills in prone/supine, sitting and vertical positions (Pereira, Basso, Lindquist, Silva, & Tudella, 2013). In addition, there is a delay in gross motor performance, as the acquisition of walking and running movements, when compared with typical children (Palisano et al., 2001; Cardoso et al., 2015).

In fact, there is no treatment for people with this syndrome; however, the measures that structure the rehabilitation process through physiotherapy and speech therapy techniques for motor delays and severe mental damage are of the utmost importance, enabling proper social reintegration (Guerrero, Clark, & Sisto, 2015). Motor training can contribute to improve the performance of voluntary control of postural balance, promoting the ability of movement to perform activities such as walking, running and jumping in children and adolescents with DS (Wang, Long, & Liu, 2012).

Although it is similar to the use of therapeutic devices in a clinic, such as swing or Swiss ball, hippotherapy offers more sensory-motor stimulation and a link between rider and horse that cannot be artificially simulated in clinics or with a lifeless horse. In this context, this therapeutic method provides sensory-motor experiences to the disabled practitioner that contribute to the development, maintenance, rehabilitation and improvement of several sensory and motor skills (Sterba, Rogers, France, & Vokes, 2002). Hippotherapy, as therapeutic resource for individuals with DS, promotes better biomechanical alignment, with more efficient muscle control through appropriate muscle activation and synergy, optimizing the balance (Meneghetti, Porto, Iwabe, & Poletti, 2009). The activities developed in hippotherapy may also contribute to a greater control of movement and quality of walking, resulting in a walking pattern of DS children more similar to the normal pattern described in literature (Copetti, Mota, Graup, Menezes, & Venturini, 2007).

When a person is mounted in a horse at walking speed, the three-dimensional movement implies in constant diverting from the midline, thus contributing to muscle strengthening, since a continuous contraction of torso and lower limbs is demanded, as well as constant postural adjustments due to the displacement of the center of gravity (Medeiros & Dias, 2002). A previous study showed that the therapy performed with blanket and feet off the stirrups can provide the recruitment of motor units in torso muscles, being a good choice of riding material in hippotherapy for practitioners with DS, as these patients present hypotonia. The use of this type of riding equipment, with feet off the stirrups, probably can result in a more efficient muscle control, conferring improvement in tone and, consequently, in balance (Espindula et al., 2014).

The hypothesis of this study is that the type of mount used in hippotherapy can generate a combination of stimuli that satisfactorily influence muscle activity, providing better control and motor learning, resulting in improvement of muscle activation of lower limbs in hippotherapy patients/practitioners through the enhanced muscle activity during a single session, as well as a gradual improvement over the course of the sessions. Therefore, the objective was to evaluate the behavior of lower limb muscle activity in practitioners with Down syndrome and without physical commitment, during Hippotherapy treatment.

Methods

This research was evaluated and approved by the Research Ethics Committee of the Federal University of Triângulo Mineiro, under protocol number 1502, and those responsible for the individuals included in the study read and heard the Term for Clarification, signing the Consent Form afterwards.

The present study is a case-control cross-sectional research, in which students from a special education institution were selected. The sample was composed by children diagnosed with Down syndrome, as well as by children without the syndrome, with mild intellectual impairment (learning disability) that did not present any physical impairment. The children who participated in the study were divided into two groups: Down Group (DG), which corresponded to children with Down syndrome, and Healthy Group (HG) with children who did not present the syndrome. After the analysis of medical records and assessment of data such as age, gender, medicine in use and therapies applied, individuals with consent of parents or guardians who did not have previous experience with hippotherapy and were not being treated with conventional physiotherapy were included in the study. Those with uncontrolled epilepsy, hip dislocation, scoliosis in evolution at 30 degrees or more, no pairing of age, those who had not completed the number of sessions planned, and those that did not allow the placement of the equipment, or were afraid of the horse, were excluded.

Initially, the treatment with hippotherapy was composed by 10 sessions for both DG and HG, performed once a week, with 30 minutes each, which constituted the first part of the treatment. The electromyographic record was performed in the 1st session (1st evaluation) and in the 10th session (2nd evaluation). Then, after an interval of two months without treatment, which corresponded to the holiday period, the same practitioners have been subjected again to hippotherapy, performing ten 30-minute session, this time twice a week. The same process of electromyographic record was repeated in the 1st (3rd evaluation) and in the 10th (4th evaluation) treatment session. These evaluations are specified in Table 1. The route sequence was standardized during the 30-minute attendance with three types of terrain, based on the uses in clinical practice, as follows: in Task 1 (T1) the horse walked for 10 minutes to the right side of the roundabout on a dirt track; in Task 2 (T2) the horse walked for 10 minutes in straight line on a gravel and cement track; in Task 3 (T3) the horse walked for 10 minutes to the left side of the roundabout on a dirt track. During the sessions, there were no activities with the practitioner on the horse, being the three-dimensional movement of the walking horse the only stimulus applied, and a blanket with feet off the stirrups was used as mount apparatus, since this type of mount is the most stimulating for torso muscles in individuals with DS (Espindula et al., 2014).

Table 1. Electromyographic evaluation sequence.

	Session	Nº of sessions per week
A1	1ª	1
A2	10ª	1
A3	1ª	2
A4	10ª	2

Captions: (A1) Evaluation 1; (A2) Evaluation 2; (A3) Evaluation 3; (A4) Evaluation 4

An 8-channel portable Surface Electromyography device by EMG System of Brazil® was used for the record of muscle activity, with 14 bits of resolution at acquisition of signals, electrical insulation of 5000 volts, ability to obtain 1000 samples/second/channel, connected to a Positivo® computer (notebook) via USB port, powered by rechargeable Li-ION 11 battery, 1V, 2.2 mA H^{-1}. After shaving and cleaning the skin of the patient with cotton and 70% alcohol, 1 cm disc shaped bipolar surface electrodes (Ag $AgCl^{-1}$ surface with foam and solid gel) connected to the preamps in center-to-center interelectrode distance of 2 cm (Malek et al., 2006; Espindula et al., 2012) were placed on the following left lower limb muscles: Gluteus Medius, Tensor Fasciae Latae, Rectus Femoris, Vastus medialis, Vastus lateralis, Biceps Femoris, Tibialis Anterior and Gastrocnemius (Lateral Subdivision), and the reference electrode was placed on the left lateral malleolus. All electrodes were positioned in accordance with the recommendations of SENIAM Project (Surface ElectroMyoGraphy for Non-invasive Assessment of Muscles [Seniam], 2012) (Hermens, Freriks, Klug, & Rau, 2000), available for access in http://www.seniam.org/. Every session in which the electromyographic evaluation was performed, records of muscle activity were conducted at 5 times (Table 2): Initial Rest (IR): practitioner sitting on the back of the standing horse before the start of the session; during the session at the 10th (end of T1), 20th (end of T2) and 30th (end of T3) minutes with the horse in motion; Final Rest (FR): practitioner still sitting on the standing horse, after the 30-minute session.

Table 2. Electromyographic evaluation times in a same session.

	Time	Terrain	Direction
RI	0’	-	Standing horse
T1	10'	Dirt track	Right side of roundabout
T2	10'	Gravel and cement	Straight line
T3	10'	Dirt track	Left side of roundabout
RF	30’	-	Standing horse

Captions: (RI) Initial Rest; (T1) Task 1; (T2) Task 2; (T3) Task 3; (RF) Final Rest.

The values obtained by the electromyography were presented in RMS (Root Mean Square) microvolts as raw data, because RMS was used to compare an individual to himself throughout all the sessions (Espindula, Ribeiro, Souza, Ferreira, & Teixeira, 2015).

For the statistical analysis, data were analyzed with the software *Statistica* 7®. The normality of data was checked with the *Shapiro-Wilk* test and the homogeneity of variances with the *Bartlett* test. The statistical tests was applied in accordance with the objectives described in this study, and the comparative analysis was performed between the times of evaluation, considering changes in the variables along the treatment in the same group, and not between groups. As the distribution was not normal, the *Kruskal-Wallis* test for repeated measures was used. The differences in which the probability (p) was less than 5% ($p < 0.05$) were considered statistically significant.

Results

Initially, 20 patients with Down syndrome were selected; however, in accordance with the exclusion criteria adopted, 10 male subjects participated in this study, divided into 2 groups: Down Group (DG) (all with simple Trisomy), composed by five subjects with an average age of 12.60 years (± 3.21); and the Healthy Group (HG), composed of children with mild intellectual disability, with no physical impairment, paired to DG, consisting of five subjects, with average age of 11 years (± 2.28).

There were significant difference in muscle activation at time IR between the four evaluations for gluteus medius (DG p = 0.0095; HG p = 0.0064) and tensor fasciae latae (DG p = 0.0393; HG p = 0.0157). At IR, both muscles behaved in similarly, and, for HG, the 10th session presented more activation than the 1st, with hippotherapy sessions at first once a week; and, after the period without treatment, there was less activation at IR in the 1st session, with further increase in the 10th session, although the activation was still less than that of the 10th session of the first stage. For DG, the activation pattern occurred in the same way as in HG, though with more activation in the 10th session of the second stage than in the 10th session of the first stage. At FR, for both muscles, there were significant differences between the evaluations of DG and no significant differences for HG. In DG, there was more activation in the 1st session than in the last one of the first stage; the same was observed in the second part of the treatment after the interval.

The analysis of rectus femoris showed statistically significant difference at T2 between the 4 sessions evaluated for DG (p = 0.0211), and at T3 for (p = 0.045), with a more expressive activation during the 10th session of the first stage. At time IR, there was significant difference between sessions for DG (p = 0.0161) and a tendency to significance for HG (p = 0.0734). At FR, there was no significant difference between the four sessions for both groups.

Vastus medialis showed significant difference in muscle activation between sessions at T3 (p = 0.0177) for HG, and statistically significant difference was found for DG (p = 0.0252) and HG (p = 0.0140) at FR. For both groups, the stimuli presented similar behaviors; the muscle was more activated in the 1st session than in the 10th session of the first stage, and in the sessions after the interval without treatment, there was also more activation in the 1st than in the 10th session.

Comparing muscle activation between the moments of a session, for the muscles vastus lateralis and tibialis anterior, there was statistically significant difference between times T1, T2 and T3 of the 1st hippotherapy session of the first stage of treatment for DG (p = 0.0455 and p = 0.0059, respectively) (Figures 1 and 2), with increase of the stimuli during the session, presenting a peak at T3. At time FR, HG presented significant difference in muscle activation between the evaluated sessions (p = 0.0149). Still considering the tibialis anterior, a significant difference was observed in HG between the four evaluations at time T1 (p = 0.0153).

The analysis of the gastrocnemius presented no statistically significant difference between the evaluations at times T1 (p = 0.0188), T2 (p = 0.0094) and T3 (p = 0.0118) for HG. At IR, DG presented statistically significant difference between the evaluations (p = 0.0277).

Biceps femoris showed no significant difference at times T1, T2 and T3, as well as at times IR and FR of the four sessions, both for DG and HG.

The mean values and standard deviation of RMS (mV), relative to the analysis of muscle activation, are presented in Tables 3 and 4, as well as the statistical values of p.

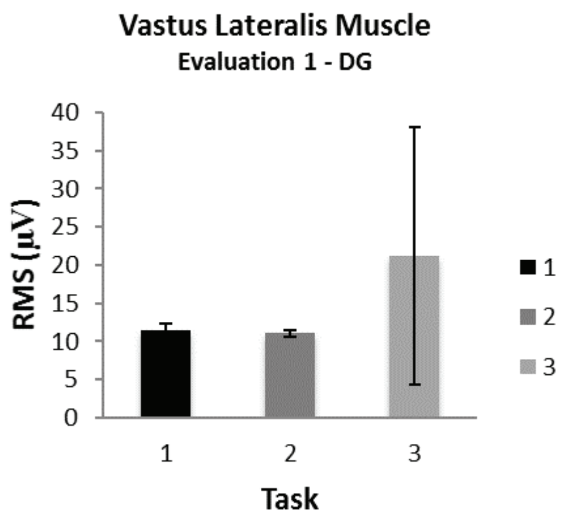

Figure 1. RMS of Vastus Lateralis in the first Hippotherapy session for the Down Group in three different times T1, T2 and T3. Statistical tests:* *Kruskal-Wallis* (p = 0.0455).

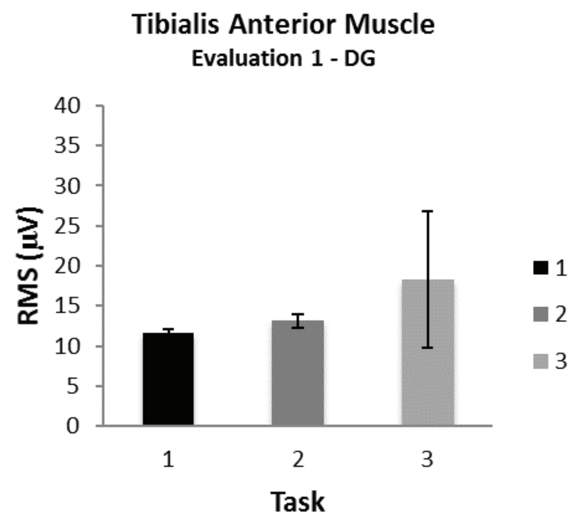

Figure 2. RMS of Tibialis Anterior in the first Hippotherapy session for the Down Group in three different times T1, T2 and T3. Statistical tests:* *Kruskal-Wallis* (p = 0.0059).

Table 3. Analysis of EMG - RMS Comparison (in mV) and standard deviation between the four evaluations for the Down Group, relative to the muscle and evaluation time during the session.

Muscles		IR	T1	T2	T3	FR
Gluteus medius	A1	11.16 (± 1.08)	13.48 (±4.35)	22.55 (±23.16)	18.84 (±13.87)	12.07 (±0.55)
	A2	16.38 (±3.13)	13.24 (±3.51)	13.49 (±6.59)	11.99 (±4.06)	10.33 (±1.07)
	A3	11.86 (±0.87)	12.86 (±1.23)	12.23 (±0.80)	12.95 (±0.52)	12.54 (±0.28)
	A4	18.77 (±2.77)	22.25 (±15.58)	12.92 (±4.37)	13.19 (±1.91)	11.56 (±2.46)
p value		p = 0.0095*	p = 0.4282	p = 0.6893	p = 0.4556	p = 0.0255*
Tensor fasciae latae	A1	12.33 (±4.9)	12.97 (±4.66)	11.81 (±1.02)	24.27 (±27.76)	11.41 (±0.47)
	A2	17.94 (±2.01)	15.36 (±4.83)	16.34 (±13.1)	14.19 (±6.93)	10.12 (±0.77)
	A3	11.2 (±0.91)	14.92 (±3.97)	16.40 (±10.52)	13.49 (±1.19)	12.06 (±0.39)
	A4	23.22 (±14.64)	14.71 (±4.36)	10.82 (±2.7)	11.34 (±2.28)	11.15 (±2.48)
p value		p = 0.0393*	p = 0.7819	p = 0.3791	p = 0.3953	p = 0.0232*
Rectus femoris	A1	11.14 (±1.1)	15.57 (±8.07)	23.35 (±22.69)	28.30 (±35.87)	12.37 (±0.59)
	A2	18.4 (±2.23)	21.93 (±14.94)	35.01 (±15.55)	21.34 (±9.65)	12.54 (±3.76)
	A3	11.93 (±1.02)	13.14 (±3.24)	16.40 (±9.41)	13.02 (±0.86)	12.82 (±0.46)
	A4	23.46 (±16.88)	13.23 (±3.7)	11.06 (±1.97)	12.14 (±2.32)	11.89 (±2.87)
p value		p = 0.0161*	p = 0.8425	p = 0.0211*	p = 0.1338	p = 0.2350
Vastus medialis	A1	11.18 (±1.1)	12.15 (±1.63)	13.98 (±4.44)	31.00 (±31.94)	12.31 (±0.49)
	A2	15.67 (±4.21)	15.4 (±7.72)	37.24 (±51.11)	15.23 (±7.09)	10.19 (±1.07)
	A3	11.92 (±0.66)	15.68 (±6.97)	13.22 (±1.57)	14.99 (±3.83)	12.59 (±0.39)
	A4	14.74 (±4.26)	15.08 (±4.32)	10.93 (±2.24)	11.65 (±2.46)	11.66 (±2.76)
p value		p = 0.2760	p = 0.6224	p = 0.1866	p = 0.1726	p = 0.0252*
Vastus lateralis	A1	12.88 (±6.39)	11.44 (±0.93)	11.04 (±0.55)	21.18 (±18.8)	11.68 (±0.56)
	A2	14.87 (±4.02)	11.85 (±3.73)	18.92 (±16.87)	18.29 (±18.38)	10.29 (±1.78)
	A3	11.12 (±1.05)	11.71 (±0.62)	12.04 (±0.65)	13.46 (±3.45)	12.06 (±0.57)
	A4	17.64 (±2.21)	14.05 (±4.45)	10.01 (±2.43)	10.80 (±2.49)	10.78 (±2.99)
p value		p = 0.0690	p = 0.7736	p = 0.2709	p = 0.2295	p = 0.1452
Biceps femoris	A1	11.62 (±4.06)	13.21 (±5.72)	13.92 (±4.98)	22.35 (±11.48)	12.55 (±3.19)
	A2	23.86 (±17.52)	21.73 (±12.78)	15.92 (±8.88)	33.74 (±33.42)	18.87 (±19.98)
	A3	20.67 (±16.33)	23.62 (±17.95)	15.56 (±4.68)	18.49 (±6.98)	18.84 (±10.77)
	A4	23.18 (±16.03)	18.04 (±6.86)	28.73 (±34.01)	28.86 (±33.07)	12.58 (±2.84)
p value		p = 0.1718	p = 0.4397	p = 0.8806	p = 0.9343	p = 0.4883
Tibialis anterior	A1	14.04 (±6.71)	11.62 (±0.48)	13.10 (±0.98)	18.31 (±9.46)	18.17 (±10.19)
	A2	15.58 (±4.21)	15.00 (±3.94)	14.96 (±4.73)	13.49 (±8.05)	21.49 (±9.48)
	A3	12.95 (±1.8)	14.97 (±6.33)	12.72 (±0.66)	14.15 (±2.77)	12.73 (±0.32)
	A4	16.39 (±3.91)	11.56 (±2.36)	12.80 (±3.95)	19.96 (±16.28)	18.09 (±11.82)
p value		p = 0.4096	p = 0.3102	p = 0.8261	p = 0.2328	p = 0.5011
Gastrocnemius	A1	11.49 (±1.64)	21.69 (±8.36)	28.25 (±26.93)	38.84 (±31.63)	12.96 (±0.39)
	A2	17.51 (±4.64)	24.54 (±16.14)	44.92 (±41.55)	37.26 (±27.81)	18.81 (±13.02)
	A3	12.53 (±1.63)	12.25 (±0.6)	12.26 (±0.72)	14.09 (±2.7)	12.86 (±0.38)
	A4	18.39 (±2.04)	12.1 (±1.85)	12.44 (±2.92)	15.76 (±8.35)	12.06 (±2.84)
p value		p = 0.0277*	p = 0.0683	p = 0.1338	p = 0.0804	p = 0.3592

Captions: A1 - Evaluation 1, A2 - Evaluation 2, A3 - Evaluation 3, A4 - Evaluation 4; IR- Initial Rest, T1 - Task 1, T2 - Task 2, T3- Task 3, FR – Final Rest. Statistical tests: Kruskal-Wallis, $p < 0.05$*.

Table 4. Analysis of EMG - RMS Comparison (in mV) and standard deviation between the four evaluations for the Healthy Group, relative to the muscle and evaluation time during the session.

Muscles		RI	T1	T2	T3	RF
Gluteus medius	A1	10.90 (±0.6)	13.77 (±7.15)	11.56 (±1.43)	12.46 (±2.05)	11.33 (±0.55)
	A2	25.08 (±9.96)	36.67 (±47.65)	14.72 (±5.48)	17.61 (±10.53)	11.13 (±1.27)
	A3	12.83 (±1.78)	13.58 (±3.19)	16.78 (±7.5)	13.06 (±1.23)	12.27 (±0.29)
	A4	14.88 (±3.66)	14.13 (±3.13)	14.64 (±5.13)	13.95 (±3.28)	11.19 (±0.65)
p value		p = 0.0064*	p = 0.2464	p = 0.3275	p = 0.8289	p = 0.1738
Tensor fasciae latae	A1	11.43 (±2.03)	12.49 (±2.56)	17.76 (±6.72)	11.86 (±1.85)	11.04 (±0.91)
	A2	30.78 (±10.01)	18.75 (±5.81)	17.15 (±8.63)	21.62 (±19.6)	10.02 (±1.19)
	A3	11.51 (±1.25)	11.72 (±1.03)	30.14 (±38.69)	14.84 (±3.58)	11.90 (±0.44)
	A4	19.76 (±10.35)	19.13 (±12.98)	21.91 (±21.24)	13.81 (±4.96)	12.63 (±3.99)
p value		p = 0.0157*	p = 0.1505	p = 0.9016	p = 0.4615	p = 0.0696
Rectus femoris	A1	13.24 (±6.28)	12.82 (±3.77)	19.49 (±14.86)	16.02 (±4.81)	11.75 (±0.86)
	A2	31.62 (±24.44)	45.91 (±41.04)	66.26 (±116.69)	129.61 (±108.01)	22.92 (±17.4)
	A3	12.04 (±1.03)	12.26 (±0.75)	14.60 (±3.40)	13.38 (±0.6)	12.70 (±0.13)
	A4	12.67 (±3.78)	11.5 (±1.24)	11.38 (±0.79)	11.35 (±0.25)	11.53 (±0.35)
p value		p = 0.0734	p = 0.0675	p = 0.0749	p = 0.045*	p = 0.1361
Vastus medialis	A1	12.13 (±2.2)	22.84 (±20.87)	34.29 (±39.82)	28.28 (±18.85)	12.27 (±0.09)
	A2	14.71 (±3.38)	14.73 (±3.51)	32.44 (±39.18)	45.34 (±41.34)	10.49 (±1.25)
	A3	11.62 (±1.17)	11.50 (±0.85)	14.08 (±3.52)	13.00 (±1.46)	12.96 (±2.95)
	A4	14.04 (±4.79)	12.58 (±4.04)	12.54 (±3.65)	12.34 (±2.45)	11.16 (±0.3)
p value		p = 0.6624	p = 0.2971	p = 0.1505	p = 0.0177*	p = 0.0140*
Vastus lateralis	A1	10.61 (±2.45)	16.15 (±13.63)	10.57 (±0.68)	11.58 (±2.02)	10.84 (±0.66)
	A2	11.25 (±2.59)	32.77 (±50.39)	41.84 (±44.94)	83.69 (±61.64)	10.18 (±0.28)
	A3	11.02 (±1.32)	10.86 (±1.04)	13.10 (±3.83)	11.8 (±0.82)	11.58 (±0.07)
	A4	13.49 (±4.88)	11.87 (±3.94)	9.96 (±0.37)	10.17 (±0.33)	10.11 (±1.28)
p value		p = 0.7113	p = 0.9616	p = 0.1097	p = 0.1612	p = 0.0149*
Biceps femoris	A1	11.77 (±2.72)	11.92 (±2.09)	19.15 (±15.72)	12.61 (±1.87)	11.51 (±1.66)
	A2	13.08 (±4.17)	14.16 (±4.68)	14.90 (±5.66)	17.71 (±6.21)	10.45 (±2.31)
	A3	15.56 (±7.06)	16.84 (±8.42)	15.42 (±5.34)	33.70 (±45.42)	13.89 (±3.78)
	A4	13.36 (±4.86)	13.97 (±4.14)	14.57 (±5.25)	14.01 (±5.26)	12.48 (±3.47)
p value		p = 0.8677	p = 0.8636	p = 0.9506	p = 0.6869	p = 0.2893
Tibialis anterior	A1	11.89 (±1.37)	18.72 (±7.01)	14.63 (±2.76)	14.09 (±2.98)	12.67 (±2.93)
	A2	29.06 (±25.27)	28.86 (±13.91)	16.68 (±4.50)	16.33 (±4.44)	11.35 (±2.0)
	A3	13.74 (±3.61)	11.54 (±0.73)	17.59 (±10.40)	16.77 (±8.99)	12.38 (±0.07)
	A4	16.00 (±6.29)	11.71 (±1.32)	12.40 (±3.73)	13.61 (±3.27)	17.59 (±11.79)
p value		p = 0.3690	p = 0.0153*	p = 0.1378	p = 0.6843	p = 0.6633
Gastrocnemius	A1	22.16 (±25.14)	28.34 (±19.29)	71.63 (±63.19)	130.46 (±112.3)	12.43 (±1.2)
	A2	26.75 (±18.26)	171.64(±99.06)	153.69 (±100.74)	136.12 (±77.7)	15.13 (±8.19)
	A3	18.93 (±15.56)	13.75 (±3.23)	15.04 (±2.57)	13.45 (±1.09)	14.41 (±3.99)
	A4	13.41 (±4.44)	14.51 (±7.20)	17.33 (±12.69)	14.35 (±4.21)	12.16 (±1.03)
p value		p = 0.4397	p = 0.0188*	p = 0.0094*	p = 0.0118*	p = 0.4515

Captions: A1 - Evaluation 1, A2 - Evaluation 2, A3 - Evaluation 3, A4 - Evaluation 4; IR- Initial Rest, T1 - Task 1, T2 - Task 2, T3- Task 3, FR – Final Rest. Statistical tests: Kruskal-Wallis, $p < 0.05$*.

Discussion

From the objective proposed in this study, which was to evaluate muscle activation of lower limbs during hippotherapy sessions performed with different attendance frequencies in individuals without physical impairment and individuals with DS, we found favorable results confirming the initial hypothesis, and it can be noted that the treatment influenced on muscle activation and provided favorable changes in motor learning of these individuals.

It is known that children with DS feature changes that affect the musculoskeletal system, which can contribute to a subsequent misalignment of the lower limbs. Hypotonia, ligament laxity and muscle weakness are some of the changes that lead to a delay in motor development, resulting in the acquisition of abnormal patterns (Gokce, Purushottam, David, Roger, & Daniel, 2008).

Physiologically, hypotonia is characterized as a decrease of segmental excitability of the motoneuron pool; thus, the compromised stretch reflex mechanism results in reduction of sensory-motor control. Since hypotonia is present in individuals with DS, this causes the muscle to perform a slow and/or ineffective contraction (Corrêa, Oliveira, Oliveira, & Corrêa, 2011). Electromyographic data of this study demonstrate that gluteus medius and tensor fascia latae, who behaved in a similar way considering muscle activation, showed significant difference at time IR between the evaluated sessions for DG and HG, and at time FR for DG. In hippotherapy, even with the horse standing, there were stimuli that required important muscle activation for the practitioner to stay in balance, justified by the muscular action of hip abduction, which is the position the rider holds on the back of the horse. However, for individuals with DS, RMS values were lower at most of the evaluated times than for individuals without physical impairment, who presented greater variation with higher values of muscle activation in different moments of stimulation.

With the difference in muscle activation at time IR between the evaluated sessions, it was verified an increase in stimulation with 10 hippotherapy sessions, regardless of whether they were conducted once or twice a week, which was significant for the muscles gluteus medius, tensor fascia latae, rectus femoris and gastrocnemius in DG, and gluteus medius and tensor fascia latae in HG. In addition, it is worth noting that the muscles behaved differently between the groups, because the difference in muscle activation between the evaluations of the 1st and the 10th sessions was greater after two weekly sessions for GD, and for HG it was higher after one session a week. This suggests that individuals without physical impairment had better adapted to the starting position of the hippotherapy session, controlling their muscle activation during the treatment, while individuals with DS used more their muscles to remain in this position over the sessions, requiring a larger weekly frequency to improve muscle activation. With training, individuals with DS are able to increase the intensity with which they activate their motoneurons, recruiting a larger number of motor units and generating more force, showing that they can improve certain aspects in their motor performance with practice and therapeutic intervention. Therefore, a stimulating environment must be offered, where they can learn how to perform their motor skills (Almeida, Corcos, & Latash, 1994).

Changes in muscle activation at FR for DG were significant and positive in relation to the improvement of motor performance, because at the end of 30 minutes of the 10th session, there was less muscle use than at the end of the 1st session in both stages. This learning was noted due to the significance between the evaluations of the muscles gluteus medius, tensor fascia latae and vastus medialis. This is even more relevant when we observe that the same occurred with vastus medialis and vastus lateralis of individuals without physical impairment. The data of the present study corroborate Horak et al. (apud Carvalho & Almeida, 2008), who said that motor control strategies emerge from a neural processing, triggering an effective action that balances the disturbance, based on objectives, tasks and environmental context. Considering that individuals without neurological impairment modulate the magnitude of their automatic postural response with the magnitude of the disturbance, if such a response is initially performed with excessive muscle activation, the repetition can lead to a reduction in the magnitude of the activation.

Motor control can be obtained by central commands to the lower motor neurons, and the central stimulation is adjusted to the environmental context by sensory stimuli. Significant activities that provide sensory experiences, resulting in adaptive responses, will promote sensory integration and strengthen the motor learning. The stimulation with swinging movements is a way of offering sensory stimuli, which contributes to the modulation of responses necessary for motor control of the task (Bonfim & Barela, 2007; Carvalho & Almeida, 2009; Godzicki, Silva, & Blume, 2010). In this sense, it can be compared to hippotherapy, in which the oscillations of the practitioner's body, caused by the three-dimensional movement, lead to stimuli responsible for promoting sensory integration and body awareness, thus improving the balance (stimulating vestibular apparatus) and modulation of muscle tone (Pierobon & Galetti, 2008). Opposing the data relative to this research, were our initial hypothesis was of an increased activity in all evaluated sessions, is the fact that, when analyzing muscle activation during ride in hippotherapy, at times there was less muscle activity required even when keeping the three-dimensional motion stimuli, which indicates a better control of muscles and, consequently, motor learning, used to keep up the position on the horseback.

Individuals with DS have great potential for improving their motor development (Latash, 2007). They sometimes require longer practice time and experience of a task, and so are able to improve their performance, developing learning skills and autonomy/self-control, which is based on concepts of neural plasticity and motor learning principles (Chiviacowsky, Wulf, Machado, & Rydberg, 2012; Berg, Becker, Martian, Primrose, & Wingen, 2012; Gimenez, Manoel, & Basso, 2006). According to this study, the intervention with hippotherapy sessions, in which they were subjected to the movement of the horse for 30 minutes per session, generating postural adjustments in practitioners with DS and no physical impairment led to the acquisition of motor skills through practice, resulting in better control of muscle activation of lower limbs.

A consistent motor performance requires development time and practice, and generating confidence and safety apparently plays a much larger role for individuals with DS than for normal individuals. A soothing environment that offers satisfaction and is favorable to the development of the activity helps the motor performance in DS to become qualitatively and quantitatively indistinguishable from the 'normal'. Therefore, one of the goals of the practice of hippotherapy by individuals with DS should be the establishment of a feeling of confidence during the activity, so that they understand what kind of action is suitable for the motor task (Latash, 1992). The same applies to individuals with DS submitted to hippotherapy in this study when we evaluate the three different tasks during the session, which correspond to different types of soil (dirt track and gravel). Therefore, we observed that, for the muscles vastus lateralis and tibialis anterior, there was significant difference in activation between times T1, T2 and T3 only in the 1st evaluation and only for DG. This may indicate that, in a first moment, practitioners with DS perceived the difference in the tasks; in subsequent evaluations, they behaved as healthy individuals, showing an adaptation of all muscles, regardless of the task. Additionally, to lower limb muscles, the type of terrain used in hippotherapy does not seem to influence changes in activation, and it is noted that the practice of hippotherapy provided a better adaptation of muscular responses to different tasks.

At IR, there was loss of the gains in muscle activation for both groups, with ten hippotherapy sessions after the two months interval without treatment, since the activation decreased from the 10th session of the first stage to the 1st session of the second stage. Therefore, it is believed that the effects of hippotherapy can be lessened if the practitioner remains without treatment for some time. In a study by Berg et al. (2012), who evaluated motor control of a child with DS throughout the intervention with interactive games and Nintendo Wii, it was verified that the child presented gains in motor control areas with increased practice time, suggesting that high levels of intense practice result in the acquisition of skills and mastery, based on concepts of neural plasticity and motor learning principles. Children with DS get used to the activity after developing some motor skills, even if they are not yet fully mature, requiring different stimuli that motivate new interests in the search of new acquisitions, thus improving maturation (Araújo, Scartezini, & Krebs, 2007). On this account, we suggest that the treatment for individuals with DS, who require more encouragement, should be maintained for a longer time, and that in case of discharge, the practitioner's functional activities and motor performance should be evaluated.

Conclusion

By means of electromiographic analises of lower limbs in individuals with DS and without physical impairment, it is concluded that hippotherapy, through the three-dimensional movement of the horse associated with the use of blanket and feet off the stirrups, provided a series of stimuli able to generate activation of the studied muscles. In the course of the sessions, through the practice of hippotherapy, there is an increase in muscle activation, regardless of weekly frequency of attendance; however, individuals without physical impairment have adapted to the movement of the horse, controlling their muscle activation during the treatment. Individuals with DS used more their muscles to stay in this position over the sessions, requiring a higher weekly frequency to promote more muscle activation, though they improved their muscular control, indicating motor learning. The practice of Hippotherapy provided a better adaptation of the muscular responses to different tasks, although the type of soil did not appear to affect muscle activation of lower limbs. In addition, we noted that a period without treatment might result in decreased muscle activation; therefore, we suggest that hippotherapy intervention is maintained for as long as possible.

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