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Robotic gait training in patients with cerebral palsy: a retrospective analysis

Treino de marcha robótica em pacientes com paralisia cerebral: uma análise retrospectiva

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ABSTRACT

Objective: The present study sought to retrospectively evaluate the efficacy of robotic gait training in children with cerebral palsy (CP) gross motor function classification system (GMFCS) levels II, III and IV. **Method:** The medical records from 69 patients with CP, who participated in the Lokomat® protocol, were analyzed using a retrospective approach. The results from the Gross Motor Function Measure (GMFM), 6-minute walk test (6MinWT), 10-meter walk test (10MWT) and Timed Up and Go (TUG) test were analyzed before and after the protocol was administered. **Results:** An improvement in GMFM was observed for all GMFCS levels. GMFCS level III patients showed a significant improvement in the 6MinWT (p= 0.01), and GMFCS level IV patients displayed a significant improvement in GMFM dimension B (p= 0.03). All tests showed a significant improvement when compared to their performance before the application of the protocol. **Conclusion:** The study suggests that all patients diagnosed with CP benefit from gait training, using the Lokomat® system, within their expected motor frame.

Keywords: Cerebral Palsy, Physical Therapy Modalities, Gait, Robotics, Rehabilitation

RESUMO

Objetivo: Verificar retrospectivamente a eficácia do treino de marcha com robótica (Lokomat®) em pacientes com Paralisia Cerebral (PC) níveis II, III e IV da Medida da Função Motora Grossa (GMFCS). **Método:** Análise retrospectiva descritiva do prontuário de 69 pacientes com PC que realizaram o protocolo da Lokomat®. Os resultados do teste de caminhada de 6 minutos (TC6M), teste de caminhada de 10 metros (TC10M), Timed Up and Go (TUG) e da Avaliação da Função Motora Grossa (GMFM) foram realizados e analisados pré e pós protocolo. **Resultados:** Foi observada uma melhora no GMFM para pacientes de todos os níveis do GMFCS. Pacientes GMFCS nível III apresentaram melhora significativa do TC6M (p= 0,01) e pacientes GMFCS nível IV apresentaram melhora significativa da dimensão B do GMFM (p= 0,03). Todos os testes mostraram melhoras significativas quando comparados aos resultados antes da aplicação do protocolo. **Conclusão:** O estudo sugere que todos os pacientes com diagnóstico de PC se beneficiaram do treino de marcha com uso da Lokomat® dentro de seu quadro motor esperado.

Palavras-chave: Paralisia Cerebral, Modalidades de Fisioterapia, Marcha, Robótica, Reabilitação

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Conflict of Interests
Nothing to declare

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INTRODUCTION

A Cerebral Palsy (CP) is defined as a group of permanent disorders of movement and posture attributed to non-progressive disturbances occurring during fetal development or in the brain of infants, resulting in functional limitations.[1] The average prevalence is about 2.4 for every 1000 live births, thus constituting one of the most common causes of physical disability during childhood, and throughout life.[2] Among its impairments, there is a delay in normal motor performance, hampering activities from rolling and sitting to ambulation.[3]

The gait of CP patients is of great concern for the family and caregivers, since it is linked to the independence in the activities of daily life and self-care, and has been correlated with autonomy.[4] Therefore, the development and maintenance of walking ability, in children with CP, is an important goal of rehabilitation, as it can promote physiological, functional and social benefits.[5]

Although CP is not a progressive condition, studies have indicated that the Gross Motor Function Classification System (GMFCS) levels and, consequently, the functionality of the individual, may change or deteriorate one decade after the transition from childhood to adulthood.[6] This situation is exacerbated by the fact that, in general, adolescents and young adults diagnosed with CP spend more time in a sedentary position than the general population, thus increasing the risk of developing diseases associated with this behavior.[7] It has also been shown that loss of motor function can be caused by overuse in some groups of CP due to chronic disablement.[8]

The gait parameters in children with CP are often characterized by low velocity, short stride length and poor balance, which increases the percentage of double support time during the gait cycle.[9] In recent decades, due to the high risk of deterioration of gait ability in children with CP as they age, several treatment modalities have been developed to complement conventional therapies and improve these parameters.[9] Based on the concept of motor learning, robotic assisted treadmill training conducted with a guided gait bracing requires less effort, allowing greater speed and displacement, which offers an improvement in specific aspects of gait rehabilitation, especially if combined with conventional physical therapy.[10,11] The Lokomat® system (Hocoma AG, Volketswil, Switzerland) consists of a treadmill with a load reducing body weight suspension system, coupled with an exoskeleton that enables the patient to perform repetitive walking cycles.[12,13]

The application of robotics in comparison to conventional therapies stands out for its precision and repeatability, facilitating the neural plasticity process and has been shown to be well tolerated by a majority of patients.[13-15]

Initially, robotic gait rehabilitation was only used with adult patients, and its use in pediatrics was disseminated later when it proved to be a safe and effective alternative. In fact, a previous study showed a functional improvement in the gait parameters of children with CP following robotic gait training.[8,16] However, the literature is inconsistent in elucidating the correct use of robotics in children with CP, and there are contradictions in the best applications and the most effective protocols with this type of treatment. Furthermore, there are few records on the use of robotics in evaluating the parameters of functionality.

The main indications of robotic gait training in our institution are improvement of specific gait parameters and endurance performance, speed gait improvement, increase weight transfer to lower limbs and provide a new motor engram for children who have never experienced a normal gait. The secondary indications are trunk control, improvement of self-esteem and orthostatism specifics benefits. The participation in a conventional physiotherapy program concomitant to training with the Lokomat® is one condition for the patient become eligible for the robotic gait training at AACD, given the importance of making Lokomat® training functional on activities of daily living.

The objective of the present study was to analyze the medical records of spastic diplegic CP patients with GMFCS levels II, III and IV, which represent CP patients that walk with limitations, need physical and/or manual assistance, have restricted mobility or use manual or motorized wheelchairs for travelling long or short distances, respectively,[17] who were undergone to robotic gait training therapy, and verify if there was a functional improvement in gait parameters, and to determine which GMFCS levels benefited the most from this type of therapy.

OBJECTIVE

This work sought to verify if there was any change in the results according to the GMFCS levels separately and if the assessment instruments routinely used are in fact sensitive for all GMFCS levels to assess the effect of this type of therapy.

METHOD

The present study employed a retrospective analysis of medical records of patients who were enrolled in the Lokomat® protocol administered by the Associação de Assistência a Criança Deficiente (AACD) Ibirapuera, São Paulo - Brazil, between June 2010 and March 2017. The project was approved by the research ethics committee of the institution (CAAE: 68189817.8.0000.0085).

CP patients who participated in Lokomat® gait training from June 2010 to March 2017 were selected from the child physiotherapy sector at the AACD rehabilitation center. These Patients were referred to robotic gait training through medical consultations, physiotherapy, team meetings or multiprofessional evaluations, and were enrolled in the treatment protocol following approval of the physiatrist.

The inclusion criteria for the patients were: diagnosis of CP with a GMFCS level of II, III or IV; prognosis of, at least, therapeutic gait, femur length of at least 21cm (measured from the trochanter to the knee joint line), ability to obey simple commands, ability to reliably signal pain, fear, or discomfort, and/or, in the case of postoperative situations, recovered for least six months from bone surgeries or less time for soft tissue surgeries.

The exclusion criteria included: incomplete medical records, patients who did not complete the treatment regimen, history of bone fractures, presence of deformities that made it impossible to fit in the machine, unhealed skin lesions on the extremities and/or severe cognitive deficits.

The robotic treadmill training was based on the original format of the Hocoma training center, using the Lokomat® V5.0 system and the NBR ISO 9001 standard of the institution. Prior to initiating the protocol, anthropometric data was collected, so that the machine could be adjusted to accommodate each patient. The evaluations were made through specific assessment system tools included in the Lokomat® (L-ROM, L-FORCE, L-STIFF).

The protocol consisted of a total of 28 sessions (24 training sessions plus the first two initial and final two evaluation sessions, and on the evaluation sessions the patient did not perform the training). Each session lasted one hour, but given the time of

placing the patient in machine, each patient performed gait training for 30–40 minutes, twice a week, in a continuous manner, for 12 weeks. Active participation by the patient was requested throughout the protocol. Gradually, the training evolved through the increase in speed combined with the decrease in suspension and driving force. Some patients were selected to undergo a second protocol, to compare motor gains with different number of sessions, starting immediately after the final evaluation of first protocol, with same length, periodicity, time, and conduction as the first protocol, with two sessions of evaluation at the end.

Specific motor function tests were performed before and after the Lokomat® protocol was initiated, being them:

a) Gross Motor Function Measure (GMFM): an instrument to evaluate the gross motor function of CP patients.[18] Currently, there are two versions of this clinical measure. The first version is GMFM-88, the most detailed version, which utilizes information according to neurodevelopmental milestones, and evaluates activities from lying down and rolling to walking, running and jumping.[18,19] The second version is GMFM-66, which was developed using 66 of the most predictive items. GMFM-66 displays reliability and responsiveness very similar to that of GMFM-88, but with a hierarchical structure that improves the interpretation of the GMFM.[18] Both instruments were used, and dimensions B and D were analyzed in isolation as well, for GMFCS level IV patients.

b) 6-minute walk test (6MinWT): a validated and reliable instrument used to evaluate the functional ability of CP patients capable of walking.[20] The result of this test is based on the total distance traveled in 6 minutes.[20] This evaluation is used to monitor changes in functional abilities, through repetition of the test during childhood and/or after new therapeutic procedures.[21]

c) 10-meter walk test (10MWT): a performance measure used to assess the time it takes to walk a short distance. As with the 6MinWT, this test has the potential to provide clinical information regarding gait.[22]

d) Timed Up and Go (TUG) test: a quick and practical screening tool that measures basic functional mobility as well as static and dynamic balance in CP patients (adults and children).[23] Briefly, from a sitting position, patients are instructed to get up from a chair (without help from the upper limbs), walk 3 meters, return to the chair and sit down.[24]

Treatment results for each GMFCS level, in all applied evaluations, were analyzed separately using a Wilcoxon signed rank test. To compare GMFCS levels II, III and IV and determine if there was a difference in the results in relation to the motor function level, a Mann-Whitney test was employed. The influence of a second protocol on the results was analyzed using Wilcoxon signed rank test comparing those who have reached a clinically significant improvement after the difference between first protocol (difference from initial and first protocol evaluation) and after second protocol (difference between initial and second protocol evaluation). The statistical analyses were performed using the IBM SPSS Statistics 26 program, and p values ≤0.05 were considered significant.

Minimum Clinically Important Difference (MCID) was calculated for all the tests performed, for each GMFCS levels, using medium and large effect sizes (0,5 and 0,8 respectively), according to the method described by Oeffinger et al.[25] The observed difference between evaluations for each patient was compared to the threshold calculated to establish the percentual of patients who saw an improvement over that limit. To evaluate the sample size adequacy, the software G*power version 3.1.9.3 was used to compute achieved power for a one-tailed Wilcoxon test and an alpha of 0.05. Effect size was set to reflect the relation between the mean and standard deviation of difference at each comparison, along with the N of individuals in each test performed.

RESULTS

Based on the medical records, 112 patients performed the Lokomat® protocol between June 2010 to March 2017, but only 69 who fit in inclusion criteria were selected for the retrospective analysis. All the patients were diagnosed with Spastic Diplegic CP. Of these, 17 patients had GMFCS level II, 36 level III and 16 level IV. The mean age of the patients was 10.70 ± 5.40 years, and 32% were female and 68% were male. The detailed data are described in Table 1.

Table 1. Population characteristics

GMFCS	N	FEMALE	MALE	AGE
II	17	10	7	7.94±3.43
III	36	9	27	12.17±6.46
IV	16	3	13	11.05±3.91
TOTAL	69	22	47	10.70±5.43

Data of gender and number of patients (N) expressed in absolute number; Data of age expressed in mean ± standard deviation

As expected, the pre- and post-protocol GMFM-88 and GMFM-66 values indicated that there was an improvement in both assessments at all levels (Table 2). Although in GMFM-66 all GMFCS levels improved, the extent of improvement in level II was greater than level III, which in turn was more substantial than level IV. This result comes as no surprise, since patients with lower level of GMFCS has better predictions of motor gains.

Table 2. Data analysis of pre- and post-protocol GMFM-88 and GMFM-66 in all GMFCS levels evaluated

	GMFM-88			GMFM-66		
GMFCS	II	III	IV	II	III	IV
Pre	85.11±10.61	63.43±1.11	42.38±11.57	67.35±7.54	56.08±8.08	44.58±6.07
Post	86.1±9.59	66.71±14.9	45.94±10.28	68.57±7.35	57.76±7.89	45.64±44.89
p	0.14	0.01	0.003	0.0007	0.0002	0.07

Data expressed in mean ± standard deviation

The 6MinWT, 10MWT and TUG test results were analyzed, and it was possible to observe in Figure 1 a statistically significant improvement in the post-protocol TUG in all GMFCS levels (II – p =0.002; III – p= 0.00003; IV – p= 0.008). The 6MinWT and 10MWT did not show a statistically significant improvement, although 34/52 and 22/61 patients have reached MCID in those tests. In the TUG 10/41 have reached MCID (Table 3). The Minimum Clinically Important Difference (MCID) was calculated for medium and large effect sizes, for each GMFCS group, and can be observed in Table 4.

The overall percentage of patients over MCID in TC6M, GMFM-66 and GMFM-88 is high, with some variation between groups. GMFCS IV patients had better outcomes in TUG and GMFM-88, while GMFCS II performed well in other tests but had little improvement in TUG (Table 4).

Table 3. Patients that reached MCID threshold for each evaluation test and GMFCS group

	Large MCID		Medium MCID		Lower than MCID		Total
	N	%	N	%	N	%	N
TC6M							
GMFCS II	10	67%	-		5	33%	15
GMFCS III	21	70%	-		9	30%	30
GMFCS IV	3	43%	-		4	57%	7
Total	34	65%	-		18*	35%	52
TC10M							
GMFCS II	9	53%		0%	8	47%	17
GMFCS III	9	26%	2	6%	23	68%	34
GMFCS IV	1	10%	1	10%	8	80%	10
Total	19	31%	3	5%	39	64%	61
TUG							
GMFCS II	1	9%	1	9%	9	82%	11
GMFCS III	1	5%	1	5%	20	91%	22
GMFCS IV	6	75%		0%	2	25%	8
Total	8	20%	2	5%	31	76%	41
GMFM-66							
GMFCS II	15	88%		0%	2	12%	17
GMFCS III	22	63%	1	3%	12	34%	35
GMFCS IV	6	38%	2	13%	8	50%	16
Total	43	63%	3	4%	22	32%	68
GMFM-88							
GMFCS II	11	79%		0%	3	21%	14
GMFCS III	30	86%	1	3%	4	11%	35
GMFCS IV	12	80%		0%	3	20%	15
Total	53	83%	1	2%	10	16%	64
GMFM-B							
GMFCS IV	4	29%	3	21%	7	50%	14
Total	4		3		7		14
GMFM-D							
GMFCS IV	2	14%	-	0%	12	86%	14
Total	2				12		14

**One patient present lower than this study MCID, but Medium MCID in the literature reference*

Table 4. Calculation of MCID for each GMFCS group with this study data

Test	Effect size	GMFCS II	GMFCS III	GMFCS IV	Total
TC6M	Medium	6.7	9.8	21.0	7.9
	Large	10.7	15.6	33.6	12.7
TC10M	Medium	0.5	4.5	46.5	20.3
	Large	0.9	7.2	74.4	32.5
TUG	Medium	3.7	73.7	6.4	46.4
	Large	5.9	118.0	10.2	74.3
GMFM-66	Medium	0.0	0.3	0.5	0.2
	Large	0.1	0.4	0.8	0.3
GMFM-88	Medium	0.1	0.5	0.5	0.3
	Large	0.1	0.9	0.8	0.5
GMFM-B	Medium	-	-	2.8	2.8
	Large	-	-	4.5	4.5
GMFM-D	Medium	-	-	3.0	3.0
	Large	-	-	4.8	4.8

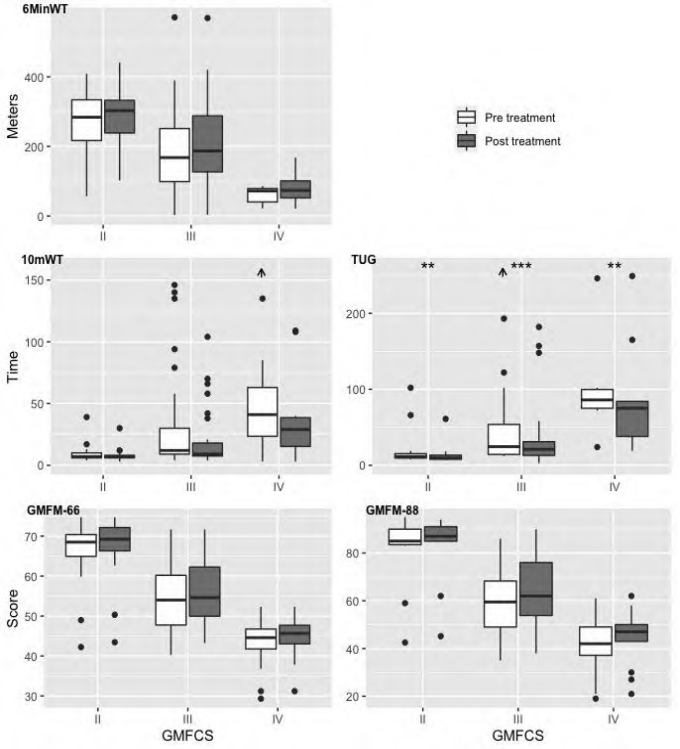

Figure 1. Analysis of 6MinWT, 10mWT, TUG, GMFM-66 and GMFM-88 pre and post treatment with Lokomat® protocol in each GMFCS levels

Patients with GMFCS level IV were assessed according to two GMFM dimensions separately, dimensions B (sitting) and D (standing). These tests did not result in a statistically significant difference, although 13/14 patients achieved large MCID in dimension B and 6/11 in dimension D (Table 3).

There were 16 patients who performed the Lokomat® protocol administered by the institution twice, as they did not obtain the expected evolution with only 24 sessions, thus representing a double protocol. Five of these patients were diagnosed with Spastic Diparesia CP GMFCS level II, 10 patients were level III, and 1 patient was level IV. The mean age of the patients, in this case, was 8.6 ± 3.6 years, and 40% were female and 60% were male. Were analyzed 6MinWT, GMFM-66 and 10mWT due to the low number of patients that performed Lokomat® protocol twice. There was no statistical significance detected, in any test, when compared to the evaluation after the end of the first protocol and the last evaluation at the end of the 48 sessions (Figure 2).

The GMFM-66 test was applied in all 16 patients that received the second protocol, showing that 2 patients achieved large MCID after this second protocol, 7 kept large MCID, 5 kept lower results than MCID and 2 went from large to lower MCID.

According to the TC6M test (applied in 15 from 16 patients), 2 achieved the large MCID after the second protocol, 8 kept the large MCDI, 3 kept lower than MCID and 2 went from large to lower than MCID. The TC10M revealed that out of 15 evaluated patients, 11 patients kept lower than MDIC (one of them achieved large MCID after the first protocol, but came down to lower after the second), only 1 achieved large MCID, 3 went to medium or large to lower than MCID.

Statistically significant difference was found for patients who achieved medium or large MCID between the first and second protocol in the TC6M test with p= 0.001. The TC10M and GMFM-66 tests did not show a statistical difference between the 2 protocols.

The achieved power varied between 29.3 and 99.9%. The GMFM-66 test did not achieve adequate power (over 80%) only among GMFCS IV. The power of the analysis among GMFCS IV was sufficient only in GMFM-88. GMFCS III group also has sufficient power in the TC6M test. The result from the power analysis is detailed in the Table 5.

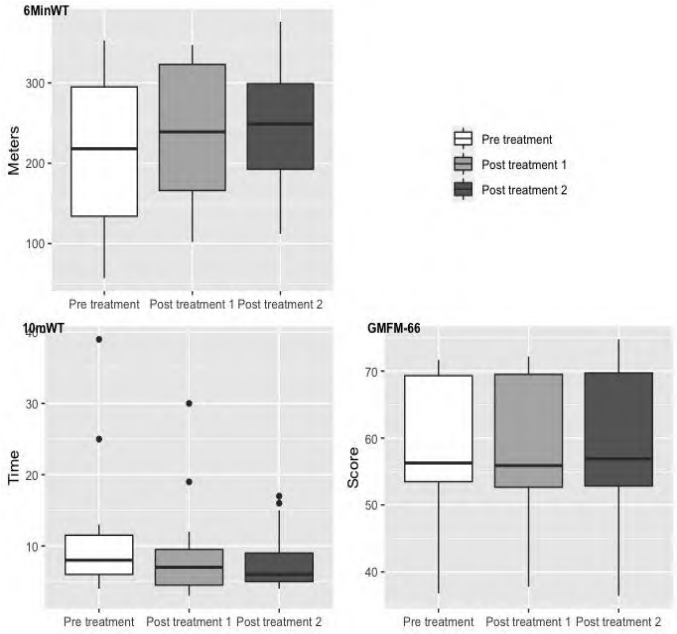

Figure 2. Analysis of 6MinWT, 10mWT and GMFM-66 pre and post treatment with Lokomat® protocol (post treatment 1) and after the second Lokomat® protocol (post treatment 2)

DISCUSSÃO

CP is described as a group of posture and movement disorders that cause changes in neuropsychomotor development, but gait is nevertheless described as a priority of the families of these children.[26] Approximately 90% of children with CP have gait limitations,[27] and robotic gait training with partial weight-bearing suspension has been shown to be an effective tool for improving gait capacity.[16,28]

All the patients, independent of GMFCS level, submitted to gait training with the Lokomat® system showed an improvement in the conventional physiotherapy motor tests. With regards to gait parameters, there was an observed reduction in the 10MWT time after application of the Lokomat® treatment protocol. While this improvement in performance was not statistically significant, it does indicate an improvement in gait speed in patients with GMFCS levels II and III.

Furthermore, this finding is consistent with a previous study that showed an improvement of up to 15% in gait speed after robotic gait training.[10] The 6MinWT showed an improvement in level II and III patients, further indicating an increase in gait velocity in these two groups, but with no statistical significance.

The study of Beretta et al showed a significant improvement in 6MinWT in patients with CP levels III and IV after robotic gait training combined with conventional physical therapy.[29] This finding probably differs from our study due to the larger N of sample.

The TUG test present a statistically significant result in all GMFCS levels indicating a gain in balance for these patients. This is consistent with a previous study that showed Lokomat® training has a positive influence on the balance of children with CP.[30]

Table 5. Power analysis of statistical tests performed in this study

	Power analysis (Wilcoxson one tailed)			
Test	**GMFCS II**	**GMFCS III**	**GMFCS IV**	**Total**
TC6M	81.5%*	98.8%*	29.3%	99.9%*
TC10M	57.3%	79.1%	32.1%	58.2%
TUG	49.9%	34.1%	93.6%*	57.0%
GMFM-66	99.9%*	96.4%*	61.6%	99.9%*
GMFM-88	57.6%	57.6%	97.0%*	99.9%*

**statistically satisfactory level*

GMFM-66 showed a significant improvement in patients with GMFCS levels II and III, and although it was not shown to be significant at level IV, there was still an improvement. This result is in accordance with the test formulation, since the GMFM-66 is punctuated by items with greater difficulty of execution.

The GMFM-88 was shown to be a more sensitive indicator for functional improvement in patients with GMFCS levels III and IV. This is in accordance with the study of Cherng et al.[12] which showed an improvement in total GMFM after applying the robotic gait training protocol with partial body weight suspension to 8 children with Spastic Diplegic CP GMFCS levels II and III. The study of Beretta et al.[29] showed an improvement in Dimension D of GMFM in patients with GMFCS level III and analyzing all levels together after robotic gait training combined with conventional physical therapy, indicating a functional improvement in orthostatic posture in this group of patients.[29]

In contrast to the results from this study, which, according to the GMFM-66 and GMFM-88, showed that CP patients less affected (GMFCS I and II) presented greater evolution compared to those most affected (GMFCS III and IV), a study by Klobucká et al.[19] showed that the patients most affected benefited more from robotic gait training than those less affected. This is probably due to the fact that the aforementioned study analyzed the GMFM dimensions separately, showing greater evolution in the dimensions A (lying down and rolling), B (sitting) and C (crawling and kneeling).

Consistent with this result, a significant improvement was also observed in the study of Aurich et al, in which the GMFM dimension B after Lokomat® protocol in patients with GMFCS level IV, where an improvement in trunk control for nonambulatory patients is expected after application of the Lokomat® protocol, which is the objective of this type treatment in these cases, together with the improvement of resistance, range of motion and specific benefits of orthostatism.[31]

Nevertheless, it was possible to observe that patients, at all GMFCS levels, showed a functional improvement within the specific motor frame, that is, the less compromised patients started the therapy with better a GMFM and, consequently, they ended the protocol with a higher GMFM than those more compromised. However, it should be pointed out that the GMFM of more compromised patients also increased after completing the treatment.

Thus, it was concluded that, all levels benefited from gait training using robotics, but each one within its expected motor frame. This finding is in agreement with a study by Schroeder et al.[15] who evaluated the usefulness of robotic gait training in 18 patients with CP and found an inverse relationship between GMFCS and GMFM improvement.

All the tests that did not reach a power of 80% could benefit from a bigger sample size to be able to determine the non-existence of a difference between pre and post treatment scores. This means that many trends observed that did not confirm a statistically significant result might be due to the difficulty of obtaining data on this type of training for some groups of patients.

The conventional physiotherapy motor tests showed a great limitation in its application to patients with GMFCS level IV, even if they were ambulant. This is because the 6MinW and 10MWT require minimal motor control for cornering and the TUG test requires the patient to stand up from the chair, attributes which are often absent in GMFCS level IV patients. In addition, these tests need to be performed without help from third parties, making it even more difficult to carry out.

The number of sessions required to achieve the benefits of gait training with Lokomat® is still very controversial, in the literature. For example, Borggraefe et al.[32] investigated the benefits achieved by robotic gait training, in children, and showed that a 12 session protocol was sufficient for the improvement of motor performance, which was sustained for up to six months. On the other hand, the study by Druzbicki et al.[9] compared the functional improvement parameters in patients with CP who only performed conventional physiotherapy and patients who performed the Lokomat® protocol, and concluded that 20 to 45 minutes, sessions distributed over 4 weeks was not sufficient for improving gait parameters.

Hedel et al.[33] shortly thereafter reported a positive correlation between training dose and functional changes. In the present study, 24 sessions, lasting 1 hour, over 12 weeks were applied, and this regimen was effective in improving all motor tests performed. When the protocol was doubled to 48 sessions, the analysis showed that there was no statistical significance when comparing the second and third evaluation moments, thus demonstrating that more extensive protocols do not provide any additional therapeutic value.

The MCID values were very close to the ones presented in the literature for TC6M in GMFCS II and III groups, and lower for GMFCS IV. In the GMFM-88 evaluation, the MCID for GMFCS II was very similar, while groups III and IV had much bigger MCID.[25] Some tests like GMFM-66 and TUG presented great variation among groups. This means that probably these tests are not ideal for the group of children with major motor commitment, especially level IV of the GMFCS.

The overall result, considering all tests, point toward the benefits of the therapy for all levels of GMFCS, with special attention to the tests that are better suited to evaluate one or other group. Comparing this data to regular physiotherapy intervention is the nest step to determine if this therapy has further benefit to the patient, along with the improvement in the well-being and utilization of human resources providing therapy. The study therefore suggests that all patients diagnosed with CP benefit from gait training using Lokomat® within their expected motor frame.

CONCLUSÃO

GMFCS level II and III patients benefited from improvements in walking speed and balance, while GMFCS level IV patients showed a marked improvement in trunk control. In this study, no parameters were found that justify the use of more than 24 sessions of robotic gait training. It is necessary to review the most appropriate evaluations for patients with GMCS level IV using trunk scales or scales describing the need for walking aid, such as the Functional Ambulation Classification. Nevertheless, further studies are needed to standardize the application of the Lokomat® protocol for patients with CP and to employ differentiated protocols for patients with increased motor impairment.

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