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The Study of the Effect of Treadmill Exercise on Spasticity of Lower Extremity of Cerebral Palsy Children of 3 to 10 years

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ABSTRACT
Weight bearing and gait are one of the main treatment methods for spastic cerebral palsy children. The aim of this study was to investigate the effect of treadmill exercise on spasticity of lower extremity of cerebral palsy children of 3 to 10 years old. To this end, 30 children with spastic cerebral palsy of age 3 to 10 years, who had not any other problems, were randomly selected and divided into control and test group. The first group of rehabilitation treatment performed treadmill exercises 3 days in a week and the second group performed 45 minutes of walking on treadmill for 6 weeks (60% of maximum heart rate in first two weeks, 65% in second two weeks and 70% in third two weeks) in addition to rehabilitation treatment. Before and after the start of exercise protocol, classification tests of gross movement, heart rate in minutes, body dimensions measurement, stiffness and active and passive range of ankle motion were taken. Data were analyzed by SPSS, variance analysis and ANOVA statistical method. The intergroup data analysis showed that in classification of gross movement, heart rate in minute, passive range of motion in ankle and active range of motion in ankle, no significance difference was observed in pre-test and post-test in subject group (p=0.05). While significant change was observed in reduction of ankle stiffness of the subject and the measurement of body dimensions (P=0.05). It seems that these changes are due to enhancement and training of child muscles on treadmill and increased muscular volume and consequently elevation of body dimensions in subject. Moreover, making motion control and the subject's obligation for active use of organs engaged in activity following reinforcement trend are the other reasons for change in subjects.

Keywords: Spasticity cerebral palsy, treadmill exercise, GMFCS classification

Introduction

Cerebral palsy is a motion disorder with prevalence of almost 2 in 1000 born children in most developed countries (1). The children with cerebral palsy constitute a great part of clients referring to rehabilitation clinics and the proper treatment interventions in these kids can lead to improvement of the child condition and development of his mental and motor skills. In cerebral palsy children, spastic (unnatural increase of muscle tension) is more frequently seen than other types and it is divided in itself to three categories of Hemiplegia, Diplegia and quadriplegia (2).

In children with spastic cerebral palsy, the natural growth would be disturbed due to neurological damage to different parts of cortex and usually lack of voluntary movement due to increase of muscles' tension is seen. The presence of spasticity is considered a great barrier on rehabilitation and improvement of patient (3).

For treatment and reduction of motor problems and performance of cerebral palsy children, various treatment interventions have been proposed so far. Weight bearing (4), performing active movements (5), stretching in joint motion range (6), use of BOBATH techniques (7), use of Rood technique (8), use of different orthosis (9) and gait training (10 and 11) are the best and most common treatment method.

The problems due to spasticity are due to the effect of cortex damage that is responsible for control of organs' movement. Thus, activities that lead to volunteering movement in spastic organs can have significant treatment effect on reduction of stiffness and high motor control on involved organs (12 and 13). Thus, some exercises such as ambulation leads to enhancement and training of gait in addition to weight bearing on the muscles in ambulation process. On the other hand, standing and ambulation lead to improvement of blood circulation, pulmonary ventilation and improvement of heart output compared to lying condition; thus, it

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organs due to ambulation that is an active performance and increase the control of brain on the involved seems that performing exercise on treadmill is effective for children with motor disorder. Schindl et al (2000) investigated the potential role of treadmill exercise in passive form with weight bearing in 10 children with cerebral palsy who had not the ability to move. Motor function scales, standing and ambulation were investigated through GMFM test. The results showed that at the beginning and end of program, the standing and ambulation rate didn't show certain change and reached from 1.1 to 1.9 ($P<0.05$) such that in total, the score of standing and ambulation increased up to 47% and ambulation showed 50% increase (14).

Karen et al (2007) studied the effect of supported treadmill exercise in a control clinical study on 14 children of age 5 to 14 with cerebral palsy. The comparison of two groups showed that the gait ability of 7 practitioners on treadmill increased more than 10 meter and the ambulation distance in exercise showed more than 10 minutes increase.

Furthermore, the researchers reported that it seems body weight-supported treadmill training (BWSTT) and ambulation on treadmill can improve the ambulation speed of children with cerebral palsy with average to extreme problems and increase ambulation rate and ambulation bearing in some children (15).

Cherng et al (2007) studied supported ambulation and the effect of such exercise on classification of gross movement procedures (GMFM) in children with spastic cerebral palsy. In this plan, 8 children with spastic cerebral palsy were studied and the parameters of temporal distance of ambulation, GMFM evaluation, muscular tune and voluntary motor control were measured for three times (two times during ordinary treatment and once after receiving the body weight-supported treadmill training in addition to general treatment). The results indicated that the body weight-supported treadmill training has meaningfully improved the kid's ambulation and GMFM evaluation. However, no considerable improvement was seen in muscular tone or motor control. The researchers concluded that weight bearing exercise on treadmill can improve some parameters of gross motion performance in children with spastic cerebral palsy (16).

In 2007, Begnoche and Pitetti studied the treatment effect of traditional physiotherapy methods along with supported treadmill exercise to specify what effect these exercises have on movement and the motor skills of cerebral palsy children. In this method, 5 children (2-3, 7 and 9 years old) with cerebral palsy problem took part in a 4-week training program (4 training sessions in a week, 2 hours in each session). Studies on determination of GMFM, Pedograph board test, disease evaluation questionnaire and 10-meter walking test were performed. The results indicate improvement in movement and motor skills of children who received physiotherapy treatment with body weight-supported treadmill training. Thus, the researchers argued that performing a physiotherapy program along with continuous body weight-supported treadmill training can be effective in improvement of motor skills of children with spastic cerebral palsy disorder (17).

Qarib et al (2011) studied the effect of ambulation on the performance of children with cerebral palsy of Hemiplegia. In this study, 30 children with Hemiplegia cerebral palsy of age 10 to 13 (19 girls and 11 boys) were randomly divided into two groups. Experimental group performed ambulation for 3 sessions in a week for three months. The mean step length, walking speed, the time of each foot's movement and movement index of kids were measured before and after therapeutic program. The results showed improvement of ambulation index in kids of experimental group (75.53 ± 7.36) compared to control group (66.06 ± 5.48) ($p=0.0001$). Furthermore, meaningful improvement was observed in ambulation of subject group (42.4 ± 3.37) compared to control group (38.06 ± 4.63) ($p=0.007$). A significant improvement was seen in the step length and walking speed in both groups. In this study, the researchers state that body weight-supported treadmill training along with traditional physiotherapy increases the chance for improvement of walking in the kids with Hemiplegia cerebral palsy (18).

Methodology

This is a semi-experimental and interventional study where 30 kids with spastic cerebral palsy of age 3 to 10, referring to rehabilitation centres, were randomly divided into experimental and control groups after parents' satisfaction and familiarization with performance and evaluation procedures. The control group received general rehabilitation treatment for 3 days in a week in rehabilitation centres and the other group performed ambulation for three days in a week, 45 minutes in each session for six consecutive weeks in addition to general rehabilitation therapy. In each training session, the kid was prepared ambulation in the first 15 minutes and this preparation included wearing comfort cloth for reduction of constrains in walking, if required, accessory instrument for ambulation was prepared for him. Then, the kid walks for 30 minutes continuously on treadmill with constant speed and zero steep in case of not showing exhaustion. The walking speed of the kid on treadmill was specified using the heart rate of kid such that 6 weeks of ambulation was divided into three programs of two weeks (the walking speed for the first two weeks was 60% of maximum heart rate, 65% for second two weeks and 70% for third two weeks). In each training session, the speed of

walking on treadmill with maximum heart rate in that training step could be increased or decreased to keep hear rate constant.

Since kids with cerebral palsy have mainly the problem of independent ambulation, to tackle this problem the invented instrument by the researcher was used for preventing the kid's falling and meanwhile preserving maximum autonomy of the kid in ambulation (figure 1).

At the beginning and end of 6-week training, evaluation of gross motor function classification (GMFCS), modified Ashworth scale, 10 sec beep test, anthropometric measurements, knee bending measurement and active and passive range of motion in knee and ankle was performed.

Figure1. The accessory instrument invented by researcher for kid's walking on treadmill

Table1.

Subjects	Mean age	Mean height (cm)	Mean weight (kg)	Gender
Test group	6.1	104.933	15.733	8 girls and 7 boys
Control group	6.4	107.010	16.080	8 boys and 7 girls

Results

Table2. The results and research findings

		Type III Sum of Squares	df	Mean Square	F	Sig.
(GMFCS)	Intragroup intergroup Error	1093500.000 0.000 0.000	1 1 28	1093500.000 0.000 0.000	**Re-investigate**	.
Heart rate (in every minute)	Intragroup intergroup Error	814801.067 1972.267 22254.667	1 1 28	814801.067 1972.267 794.810	1025.153 2.481	0.001• 0.126
Stiffness of left leg	Intragroup intergroup Error	63635.267 493.067 2446.917	1 1 28	63635.267 493.067 87.390	728.177 5.642	0.001• 0.025•
Stiffness of right leg	Intragroup intergroup Error	63342.504 501.704 2467.417	1 1 28	63342.504 501.704 88.122	718.804 5.693	0.001• 0.024•
Passive range of motion in left ankle	Intragroup intergroup Error	13771.350 33.750 1017.400	1 1 28	13771.350 33.750 36.336	379.003 0.929	0.001• 0.343
Passive range of motion in right ankle	Intragroup intergroup Error	13560.067 72.600 1000.333	1 1 28	13560.067 72.600 35.726	379.55 2.032	0.001• 0.165
Active range of motion in left ankle	Intragroup intergroup Error	1870.417 58.017 997.067	1 1 28	1870.417 58.017 35.610	52.526 1.629	0.001• 0.212
Active range of motion in right ankle	Intragroup intergroup Error	2018.400 13.067 1119.533	1 1 28	2018.400 13.067 39.983	50.481 0.327	0.001• 0.572
Body dimensions of left leg	Intragroup intergroup Error	29415.204 124.704 676.217	1 1 28	1217.991 124.704 24.151	1217.991 5.164	0.001• 0.031•
Body dimensions of right leg	Intragroup intergroup Error	29326.704 121.838 680.583	1 1 28	29326.704 121.838 24.307	1206.535 5.013	0.001• 0.033•

At the beginning and end of 6-week training, evaluation of gross motor function classification (GMFCS), modified Ashworth scale, 10 sec beep test, anthropometric measurements, knee bending measurement and active and passive range of motion in knee and ankle was performed.
The results of this study showed that although significant change has happened in GMFCS in pre-test and post-test of subjects (P=0.001), the statistical data showed no change between groups (P=0.878). In evaluation of the number of heart rate in pre-test and post-test, significant change happened in subject (P=0.001) and the heart rate during training on treadmill decreased after 6 weeks of training; however, no meaningful change was observed between test and control groups (P= 0.126).
Furthermore, significant change was observed in stiffness of left ankle of subject (P=0.001) and between control and test group in pre-test and post-test (P=0.333) and in control and test group in right leg (P=0.024) and in left leg (P=0.001). However, the passive range of motion in left ankle showed meaningful change between pre-test and post-test in subject group (P=0.001) and the investigation between control and subject group (left ankle, P=0.343 and right ankle, P=0.165) showed no significant change. In evaluation of body dimensions of left and right leg, significant change was observed in intragroup results (between pre-test and post-test, P=0.001), while, this change was not meaningful in comparison of control group and subject group (P=0.031 in left leg and P=0.33 in right leg).

Discussion

The results of this study showed no significant change in improvement of gross movement procedures, heart rate and passive range of motion of ankle between control and test group; however, meaningful change has happened in stiffness of left ankle and evaluation of body dimensions between test and control group. These results are not in line with Schindl et al in 2000 on 10 children with cerebral palsy where subjects showed meaningful progress in GMFCS, standing and walking rate (P<0.05). It seems that this difference has been due to difference in training period that Schindl et al performed this study on three months of training (14). While in this study, the training period was 6 months. Concerning the progress that happened in stiffness and measurement of body dimensions of kids in this study, it is likely that the continuance of this program for longer time could lead to progress in GMFCS.
In the controlled clinical study in 20007 by Karen et al on 14 children with cerebral palsy, the researchers investigated the effect of supported treadmill exercise. The results of comparison between two groups showed that the walking ability of 7 subjects on treadmill has increased above 10 meter and the walking distance in the exercises have increased above 10 minutes. The researchers reported that it seems body weight-supported treadmill training and ambulation can improve walking speed of children with cerebral palsy with average to extreme problems and increase the rate and bearing of ambulation in some kids (15). Concerning the finding on decreased spasticity and increased passive range of motion in this study, we obtained similar finding to improvement of relative weight of kids. Moreover, in this study, the variables of distance and ambulation speed have not been investigated.
In another study, Cherng et al (2007) studied 8 children with cerebral palsy. In this study, kids performed supported ambulation. The researchers in this study investigated the parameters of GMFCS, temporal walking distance, muscular stiffness and control of voluntary movement (16).
The results of study showed that GMFCS has meaningful progress and improvement in kids; however, it has not significant improvement in muscular stiffness. The results of this study are not in line with the present study and it seems that the reason for kids' progress in GMFCS is due to difference in duration of training compared to this study. The duration of training program was 8 weeks in Cherng et al study, while, it has been 6 weeks in this study.
In 2007, Begnoche and Pitetti studied the effect of traditional physiotherapy treatment along with supported treadmill training on 5 children with cerebral palsy. In this study, researchers tried to specify what changes this training makes in movement and motor skill of kids with cerebral palsy. Five children (2-3-7 and 9 years) with cerebral palsy disorder participated in a 4-week program (4 training sessions in a week and every session for 2 hours).
The investigations on measuring GMFCS, pedograph board and 10 sec beep test were performed. The results indicate improvement in movement and motor skills of kids who received physiotherapy treatment with body weight-supported treadmill training. Thus, the researchers proposed that performing physiotherapy along with continuous body weight-supported treadmill training can be effective in improvement of motor skills of kids with spastic cerebral palsy (17).
In the present study, the results obtained on improvement of stiffness and passive range of motion, improvement of motor skills and movement are in line with Begnoche and Pitetti results. However, in evaluation of the progress in GMFCS, there is some difference between the results of two studies; it seems that the reason is the intensity of training program in each session. In the training program in Begnoche and

Pitetti study, the treatment sessions were intense (4 training sessions in every week and 2 hours every session). While in the present study, the training sessions were performed in general form (three training sessions in every week, each lasting for 30 minutes). Thus, it seems that high intensity training can lead to development of GMFCS.

In another study in 2011 by Qarib et al, the effect of ambulation on the performance of children with Hemiplegia cerebral palsy was investigated. In this study, 30 children with Hemiplegia cerebral palsy of age 10 to 13 years (19 girls and 11 boys) were randomly divided into two groups. Experimental group performed ambulation for three sessions in a week for three months.

The mean step length, walking speed, the time of each foot's movement and kids' movement index were measured before and after treatment program. The results showed improvement of ambulation index in experimental group (75.53±7.36) compared to control group (66.06±5.48) (p=0.0001). Furthermore, meaningful improvement was seen in ambulation of test group (42.4±3.37) compared to control group (38.06±4.63) (p=0.007). Moreover, significant improvement was observed in the length of steps and ambulation speed of both groups (18).

In this study, the researchers claimed that body weight-supported treadmill training along with traditional physiotherapy treatment leads to improvement of walking in Hemiplegia cerebral palsy and this finding is consistent with our study; however, this consistency is not observed in other variables due to difference in the selection of variable.

Conclusion

Although the results of this study showed that treadmill exercise along with general rehabilitation treatment leads to rapid improvement in ambulation related factors and prevention of the side effects of muscular stiffness in lower extremity of kids with cerebral palsy, it still requires more investigations.

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