

# Effect of Treadmill Training with Supramalleolar Orthosis on Balance in Children with Down Syndrome

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## ABSTRACT

**Background:** Children with Down syndrome (DS) often display delayed onset of independent walking. Treadmill training is an effective intervention that leads to an earlier walking onset. In addition, orthoses often are provided to children with DS to increase stability and promote earlier independent walking. The purpose of this study was to provide insight into the developmental outcomes of early orthosis use in combination with treadmill training in children with DS compared with treadmill training alone. **Subjects:** Thirty patients in with Down syndrome (age ranges from 7 to 11) years were equally divided into two groups; control group (A) and study group (B). The control group received selected physical therapy program to facilitate balance during walking for one hour, while the study group receiving treadmill exercise with supramalleolar orthosis for twenty five minutes in addition to the same program which given to the control group for thirty five minutes were used for treatment in the out-patient clinic of the Faculty of Physical Therapy, Cairo University. The subjects were evaluated and scored functionally, using Peabody developmental motor scale II), and objectively, using an balance Master System device utilized to obtain the step width, step length and speed, at different time intervals; pretreatment and three months later during which they underwent the treatment program. **Results:** the results revealed statistically significant improvement in the measuring variables of both groups when comparing their pre and post treatment mean values. Comparing the two groups' post-treatment variables, significant difference is revealed in favor of the study group (B). **Conclusion:** The obtained results strongly support the introduction of treadmill exercise with supramalleolar orthosis as an additional procedure to the treatment program of Down syndrome children.

**Key words:** Down syndrome, Balance. Orthosis, Treadmill.

## INTRODUCTION

Down syndrome (DS) is a genetic disorder that occurs in 13.65 out of every 10,000 live births<sup>2</sup>. Though DS is most commonly known for its effects on cognitive ability, children with DS also have delayed and atypical motor development. On average, children with DS sit independently at 11 months, pull themselves to a standing position at 17 months, and walk independently at 24 months<sup>6</sup>. These delays, separately and in combination, lead to difficulties with function and social interaction.

Difficulties with functional skills and social interaction also arise from atypical movement patterns. Children with DS display atypical antigravity control in the legs and neck<sup>12</sup>; more specifically, they have atypical kicking patterns<sup>14</sup>. Although these delayed and atypical movements are the focus of physical therapy interventions in children with DS, there is little evidence of the effectiveness of specific interventions in this population.

One specific intervention that has been studied in children with DS is orthosis use. Lower-extremity orthosis, specifically foot orthosis and supramalleolar orthosis (SMOs), often are provided to young children with DS to improve functional gait. These orthosis are external devices that stabilize the subtler joint, thus maintaining the calcaneus in an upright position. An upright calcaneus improves the bony alignment of the foot and ankle and influences postural and gait characteristics. Selby-Silverstein and colleagues<sup>13</sup> examined orthotic use in 3- to 6-year-old children with DS. They found that foot orthosis led to decreased ankle eversion while the children remained in a static standing position. In addition, there were a decrease in foot progression angle and variability in this angle, a change in the initial contact site from flat

foot to heel-strike, and an increase in walking speed during the stance phase of gait. Martin<sup>8</sup> studied orthosis use in 3- to 8-year-old children with DS.

Walking is an important milestone. Like other motor skills, walking in children with DS is not only delayed, but also abnormal<sup>3,7,10,11,15</sup>. Although children with DS walk, on average, 1 year later than children who are developing typically, they are able to step when supported on a treadmill at a much earlier age<sup>9,19</sup>. About 13 months before they walk, children with DS respond to the treadmill with alternating steps<sup>17</sup>. This preference for alternating steps while being supported on a treadmill begins to emerge by 11 months, about the time when children with DS begin to sit independently<sup>16</sup>.

Ulrich and colleagues<sup>19</sup> trained this stepping behavior in children with DS before they were able to walk independently. Children who received treadmill training as a supplement to physical therapy walked independently 101 days earlier than a control group of children with DS who did not receive the treadmill intervention but continued to receive physical therapy. A subsequent treadmill intervention study showed that a higher-intensity, individualized training protocol led to improved outcomes<sup>1,22</sup>.

This study is an extension of the previous treadmill training research involving children with DS. The intent was to incorporate orthosis use into the lower-intensity treadmill training protocol of Ulrich and colleagues<sup>19</sup>.

## SUBJECTS, INSTRUMENTATION AND PROCEDURE

### I- Subjects

The study was conducted in the out-patient clinic of the Faculty of Physical Therapy, Cairo University. Thirty DS children with age ranged from 7 to 11 years participated in this study and assigned into two groups of equal number as control and study groups. Both groups were received three successive months of training program and assessed before and after treatment program. The control group received selected physical therapy program to facilitate balance during

walking for one hour, while the study group receiving treadmill exercise with (SMOs) for twenty five minutes in addition to the same program which given to the control group for thirty five minutes were used for treatment in the out-patient clinic of the Faculty of Physical Therapy, Cairo University.

## II- Instrumentation

### A) *Evaluation of children:*

#### Balance Master System:

According to the manual of Balance Master System (NeuroCom® International Inc., 2004), Balance Master System was used for evaluation of each child of two groups and conducted before and after three months of treatment. Peabody developmental motor scale (PDMS-2): It is used for determining gross and fine motor skills<sup>5</sup>.

### B) *For Treatment:*

#### Treadmill:

Motorized treadmill Make (EN-TRED, Enraf Nonius). The walking area of these treadmill are made of heavy steel of minimum 8 inch thickness and are available with cushioning to absorb impact load. Treadmill and tools of selected physical therapy exercises were used.

## III- Procedure

### A) *For Evaluation:*

#### Balance Master System:

The total time required for evaluation of each child was average 20 minutes and the evaluation was conducted before and after three successive months of training program. The assessment of the study and control children by using of Balance Master System was done through the following tests:

#### Walk Across:

- The TW test measured the following parameters:

- a) Step Width: is the lateral distance in centimeters between the left and right feet on successive steps.
- b) Speed: is the velocity in centimeters per second of the forward progression.
- c) End Sway: is the velocity in degrees per second of the anterior/ posterior component of COG sway for 5 seconds beginning when the patient terminates walking.

B) *For Treatment:*

The control group received selected physical therapy program to facilitate balance during walking for one hour, while the study group receiving treadmill exercise with (SMOs) for twenty five minutes in addition to the same program which given to the control group for thirty five minutes were used for treatment.

## RESULTS

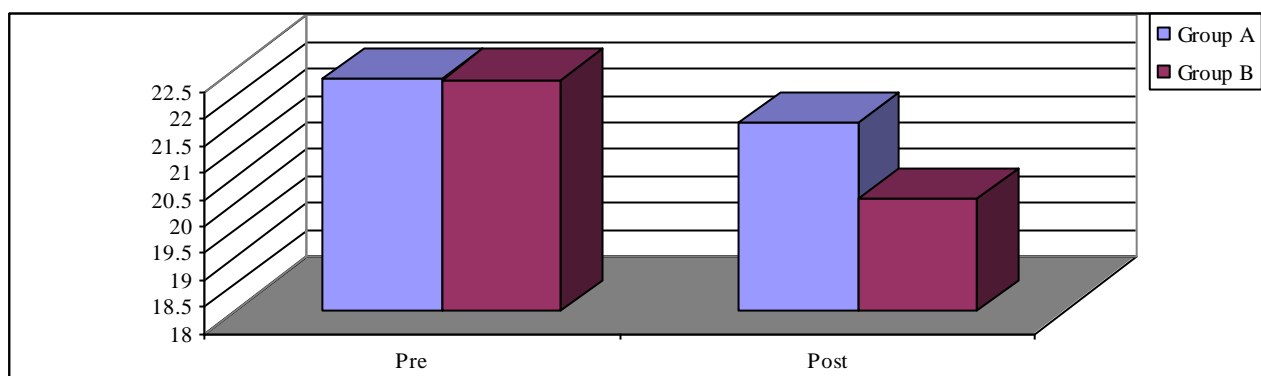
The results of pre and post treatment values were compared with each group .The results revealed significant improvement in both groups.

A) **Balance Master system**1- **Step width:**

As revealed from table (1) and Fig. (1) was observed in mean values of step width measured in both groups at the end of treatment as compared with the responding mean values before treatment ( $P < 0.01$ ).

**Table (1): Pre and post treatment mean values of step width in both groups.**

Test	Mean $\pm$ SD	MD	% of Diff	t-value	P-value
Pre (control)	22.327 $\pm$ 1.066	0.027	0.12	0.25	0.808*
Pre (study)	22.3 $\pm$ 1.145				
Post (control)	21.507 $\pm$ 1.174	1.414	6.57	3.18	0.004**
Post (study)	20.093 $\pm$ 1.261				



**Fig. (1): Pre and post treatment mean values of step width in both groups.**

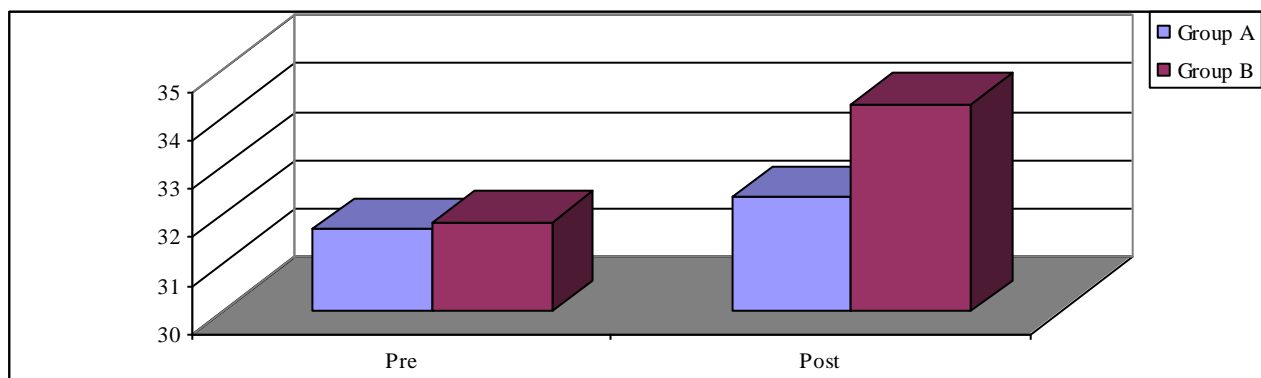
2- **Step Length (cm)**

As revealed from table (2) and Fig. (2) was observed in mean values of step length

measured in both groups at the end of treatment as compared with the responding mean values before treatment ( $P < 0.01$ ).

**Table (2): Pre and post treatment mean values of Step Length (cm) in both groups.**

Test	Mean $\pm$ SD	MD	% of Diff	t-value	P-value
Pre (Control)	31.693 $\pm$ 1.627	0.14	0.44	0.25	0.808*
Pre (Study)	31.833 $\pm$ 1.497				
Post (Control)	32.353 $\pm$ 1.455	1.927	5.95	3.77	0.001**
Post (Study)	34.28 $\pm$ 1.338				



**Fig. (2): Pre and post treatment mean values of Step Length (cm) in both groups.**

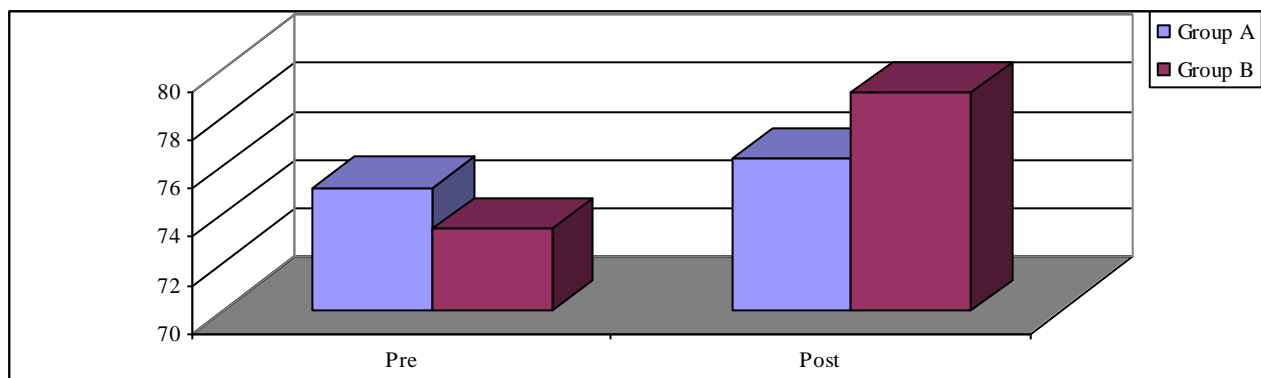
### 3- Speed (cm/sec.):

As revealed from table (3) and fig. (3) was observed in mean values of speed

measured in both groups at the end of treatment as compared with the responding mean values before treatment ( $P < 0.01$ ).

**Table (3): Pre and post treatment mean values of speed (cm/sec.) in both groups.**

Test	Two Groups	Mean±SD	MD	% of Diff	t-value	P-value
Pre (Control)		75.067±2.717	1.65	2.19	1.53	0.138*
Pre (Study)		73.414±3.201				
Post (Control)		76.267±2.473	2.72	3.56	2.89	0.007**
Post (Study)		78.987±2.473				



**Fig. (3): Pre and post treatment mean values of speed (cm/sec.) in both groups.**

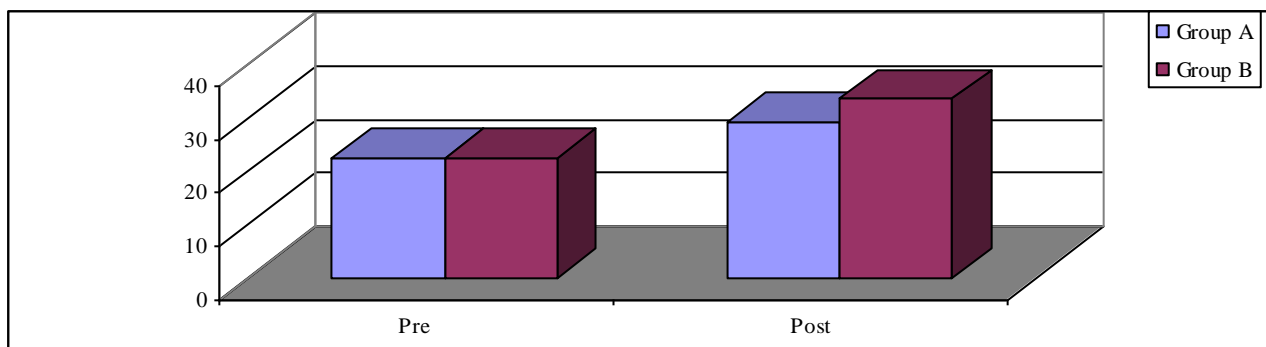
### B) Peabody (locomotion subtest)

As revealed from table (4) and Fig. (4) was observed in mean values of locomotive motor system Peabody developmental motor

scale II measured in both groups at the end of treatment as compared with the responding mean values before treatment ( $P > 0.01$ ).

**Table (4): Pre and post treatment mean values of Peabody (locomotion subtest) in both groups.**

Test	Two Groups	Mean±SD	MD	% of Diff	t-value	P-value
Pre (Control)		22.5±1.05	1.65	2.19	1.53	0.138*
Pre (Study)		22.44±1.01				
Post (Control)		29.267±1.473	2.72	3.56	2.89	0.007**
Post (Study)		33.587±2.473				



**Fig. (4): Pre and post treatment mean values of Peabody (locomotion subtest) in both groups.**

## DISCUSSION

The purpose of this study was to determine whether the addition of SMOs to a treadmill training protocol for children with DS would lead to improved developmental outcomes. The hypothesis was that the addition of SMOs would lead to improved developmental test scores and balance abilities for DS children.

In studies by Ulrich and colleagues<sup>20</sup>, traditional treadmill training led to a large decrease in time to independent walking onset and to improved gait at walking onset compared with no treadmill training. In the current study, children with DS who received treadmill training as well as early orthotic use indicates that there may have been a moderate treatment effect in favor of the group that received SMOs. This finding suggests that the SMOs may positively affect the rate of walking development; however, although the major difference between this study and control on children with DS is the addition of orthosis, another large difference in this study is the time at which treadmill training was initiated. Previous studies began the treadmill training protocol when children could sit independently<sup>4</sup> or take 6 to 10 supported steps on the treadmill<sup>18</sup>. Because the current study focused on SMO use, the intervention did not begin until the children were able to pull themselves to a standing position and bear weight on their feet. This method corresponds to that of Ulrich et al.,<sup>16</sup> who found that children with DS began to prefer alternating stepping patterns on the treadmill when they could pull themselves to a standing position and make forward progress in a prone position. On average, the children in this study pulled themselves to a standing position at 20.5

months, or about 2 weeks after the children who received treadmill training in the original study began to walk.

Perhaps a better experimental combination of treadmill training and orthosis would include treadmill training, beginning at 10 months of age, and use of SMOs when the children can pull themselves to a standing position independently. This combination would allow the children to derive the maximal benefits from the treadmill training while still introducing the orthosis at a developmentally appropriate point.

The effect of orthosis on GMFM scores is complex. As expected, all children in the study showed improvement in their gross motor skills during the course of the intervention. In addition, there was no group difference over the course of the intervention in the overall (PDMS-2) score. This finding was expected because all of the children entered the study at the same gross motor level (ie, ability to pull themselves to a standing position) and ended the intervention at the same gross motor level (ie, ability to take 3 independent steps without support). The use of orthosis while learning these skills may have limited the available solutions to solving the problem by limiting the amount of movement at the foot and ankle. In turn, the initial rate of increase in the standing scale scores was not as large in the experimental group as it was in the control group.

During the development of a skill, children experiment with and explore multiple solutions to solving movement tasks. Through this process, they learn how to perform a skill and how to adapt that skill to new or differing circumstances. Perhaps the SMOs externally impose limits in ankle and foot alignment and range of motion during this important

developmental period that detract from the variability of practice and thus the adaptability of the learned skills. Although the children in the experimental group were limited by the SMOs during the development of walking, the children in the control group had the opportunity to engage in this process of exploration before they received the orthosis. They were able to use the skills that they developed during the attainment of walking in addition to the stability gained from the SMOs to improve their gross motor skills.

### Conclusion

Use of SMOs appears to have a detrimental effect on overall motor skill development in children and new walkers who have learned to walk while wearing the orthoses. Based on this information, health care professionals may want to postpone the use of SMOs in children with DS until they have learned to walk independently.

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### الملخص العربي

#### دراسة تأثير السير على جهاز السير الكهربائي مع جبيرة القدم على الاتزان للأطفال المصابين بمتلازمة داون

**الخلفية والهدف من الدراسة :** ضعف الاتزان عند الأطفال المصابين بمتلازمة داون هو مشكلة شائعة ومعيقة يتميز هذا المرض بالعديد من الأعراض ألا وهي عدم القدرة على الحركة والتأخر في جميع الأنشطة اليومية . **الهدف من الدراسة :** يهدف هذا البحث إلى دراسة السير على جهاز السير الكهربائي مع جبيرة القدم على الاتزان للأطفال المصابين بمرض متلازمة داون . **طريقة البحث :** شملت الدراسة 30 طفلاً مصاباً بمرض بمتلازمة داون تتراوح أعمارهم ما بين سبع إلى إحدى عشر عاماً وتم تقسيمهم عشوائياً إلى مجموعتين مجموعة مشاركة في التمارين ومجموعة غير مشاركة. كانت مدة برنامج ثلاثة أشهر (ثلاث جلسات في الأسبوع)، الجلسة لمدة 60 دقيقة تم استخدام مقياس جهاز الاتزان ومقياس (Peabody developmental motor scale II) قبل وبعد الانتهاء من البرنامج ( أي بعد ثلاثة أشهر) . **نتائج الدراسة :** أظهرت النتائج وجود تأثيرات ايجابية ذات دلالة إحصائية بين القياس قبل وبعد للمجموعة المشاركة . **الاستنتاج :** استنتج من الدراسة أن هناك تأثير ايجابي السير على جهاز السير الكهربائي مع جبيرة القدم على الاتزان للأطفال المصابين بمرض متلازمة داون .