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Biodex balance system training versus treadmill training on balance in children with lower limb burns

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Abstract

Purpose: The purpose of this research is to compare the effectiveness of Biodex Balance System training against treadmill training in helping children with lower limb burns regain their balance. **Methods:** Forty children (both boys and girls) who were suffering from second degree burns of their lower limb with ≥30% of their total body surface area (TBSA) were took part in this research, they were between the ages of 8 to 16, moreover, they were split equally between two groups (A and B). While both Group A and Group B participated in conventional physical therapy, Group A trained with the Biodex Balancing Device while Group B used treadmill training. The children participated in this study were assessed by Biodex Balance System and they were evaluated before and after the treatment program that applied three sessions per week for eight consecutive weeks. **Results:** The results showed that there was a statistically significant difference between the groups before and after treatment on all outcome measures assessed. Post-test mean values for all assessed variables also revealed substantially significant differences favoring the group (B) ($P< 0.05$). **Conclusion:** Children with lower limb burns improved their balance more effectively with treadmill training than with Biodex Balance System training; however, both are valuable additions to the physiotherapy program.

Keywords: Balance, Biodex Balance System Training, Burn, Children, Lower Limb, Treadmill training.

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1. INTRODUCTION

Burn injuries have occurred ever since the discovery of fire. It primarily involves a destruction and disruption of the normal anatomical and physiological function of the skin. Among all injuries, burns are among of the most dramatic and difficult to treat. The early effects are localized tissue damage and injury. Moreover, excessive burn wounds continue to destroy tissue or progress for up to 48 hours **(1).**

In contrast to pharmaceutical interventions, exercise training may slow the muscle breakdown that happens with ageing process and living with a chronic illness. Physical therapy for burn patients begins at 6 months post-injury (usually 2–3 months following discharge), and it helps these children greatly when it comes to rebuilding their muscle power **(2).**

To maintain balance, the brain must process information from a wide variety of sensory systems, such as the vestibular, visual, auditory, proprioceptive, as well as higher-level premotor processes. Preserving a specific postural alignment, whether while seated or standing, stimulation of voluntary movement, such as the movement transitions between postures, recovering equilibrium following external disruptions, such as a trip, slide, or shove, are intended outcomes of the balancing system **(3).**

Children's burn injuries are a serious global health problem, especially in low-income regions. Contractures caused by burn injuries in children may be very disabling and producing contractures, increasing the child's risk of permanent impairment if not treated. Recovery from a burn injury in a child is not complete without rehabilitation **(4).**

Burn survivors have difficulty keeping their balance. Tactile perception, muscular strength, proprioception, range of motion, and cognition are all important components of overall balance. Extreme burns may have an impact on all of these areas. The ultimate objective of burn rehabilitation is to help people who have suffered burns return to their normal lives in the community **(5).**

Balance training for children using the Biodex technology and the more traditional balance training **(6).** Treadmill training encourages the patient to walk in rhythmic steps whilst standing with their lower bodies supported. An weakness in balance is associated with a weaker lower body. Having weak trunk control also has a bad impact on one's stability **(7).**

The primary objectives of the recent research were to detect the efficacy of Biodex Balance System (BBS) training on balance and to compare the efficacy of treadmill training against training used BBS on the effects of lower limb burns on a child's balance.

2. MATERIALS AND METHODS

2.1. Study design

This research was a randomized controlled trial. Before having children participate in the study, the authors obtained written informed consent from the children's parents by explaining the study's objective, prospective benefits, and protocol. After establishing trust, the equipment were given to the children, and the parents of the children were assured their children's privacy would be respected. The Physical Therapy Department at Modern University for Technology and Information in Cairo, Egypt, approved this study between April and August 2022.

2.2. Participants

Forty children (both boys and girls) who were suffering from second degree burns of their lower limb with ≥30% of their TBSA were took part in this research. All of children met the requirements, were recruited from the General Embaba Hospital in Giza, Egypt and were carried out at the outpatient clinics, Modern University of Technology and Information, Department of Physical Therapy, Cairo, Egypt. Using G*POWER statistical software (version 3.1.9.2; Franz Faul, Universitat Kiel, Germany), F-test MANOVA within as well as among interaction effects was chosen. Considering Alpha=0.05, G*Power = 80% and effect size = .038, A minimum of 20 subjects per group and a maximum of 40 subjects were needed to generate a valid sample size.

The following were used as criteria for inclusion: a) children ranging in age from 8 to 16 **(8)**, b) they suffering from second degree burns of their lower limb with ≥30 % of their TBSA **(8)**, c) they were capable of standing and walking independently, d) they were clinically and medically stable, e) they had sufficient cognition demonstrating understanding the requirements of the study and f) they had no history of lower extremity surgery. Children with i) visual and/or auditory defects, ii) significant shortening and/or deformity of lower extremities, iii) other neurological problems that affect balance or mentality (e.g. epilepsy), iv) advanced radiographic alterations comprise (bone destruction, bony ankylosis, knee joint sublaxation as well as epiphysial fracture), v) lower extremity skeletal abnormalities (whether congenital or acquired) and vi) cardiopulmonary dysfunction were excluded.

The children who were chosen were divided into two groups of equal size at random. Both Group A and Group B participated in conventional physical therapy, while Group A trained with the Biodex Balancing Device while Group B used treadmill training.

According to the flowchart in Figure 1, 52 children were qualified to participate in this study, but 12 children withdrew out due to their remote location. Using the Block Stratified Randomized Software program (windows version 6.0 of randomization program (Rand.exe), block sizes 4, 2, and 6), the residual forty children were put into two groups at random. It is hard to put the same number of samples into two groups with the same numbers when there are multiple stratified variables **[9]**).

2.3. Outcome measures

The evaluation of each child took about 40 minutes and was done before as well as after the eight weeks of the training program. Before starting the evaluation, all procedures were explained to the participating children. An evaluation sheet was maintained for each child who took part in the study, including the variables assessed before and after the treatment program.

2.3.1. Biodex Balance System (BBS):

This device is the first of its type to evaluate and train for dynamic postural control. Stability during dynamic stress may be accurately measured and recorded using this multi-axial apparatus. It's cheaper, lighter, and portable, and it comes with a platform that can be moved to give different levels of stability and computer-based information. It is utilized to analyze balance concerning Overall stability index (OSI), Anteroposterior stability index (APSI) as well as Mediolateral stability index (MLSI) **(10).**

It is used as a stable method, consisted of force plate which is suspended circularly in shape. This platform included of 20 degrees tilting as a maximum in all direction when unstabilization is completed and detect the participant's stability that based on the difference from the center of the platform **(11).** Also, it is considered as an objective method and reliable for the measurement of balance (the reliability of OASI, APSI as well as MLSI are 0.43, 0.80, and 0.82, respectively) **(12).**

2.4. Intervention

The conventional physical therapy program applied for 30 min aiming **(13)** to improve balance posture and control (Table 1) and BBS training and treadmill training for 30 min. Tools were used in conventional physical therapy program include vestibular board, blocks, rolls, and wedges of variance sizes. The treatment session was performed three sessions weekly for eight consecutive weeks.

Table (1): Conventional exercise program utilized for both groups:

Exercise	Description
-Standing with feet closer to each other.	- The therapist sat on a stool behind the child then manually secured the child's knees before carefully tilting him or her forward, backward, as well as toward the side.
-Step-standing: standing with one step of the foot forward.	- The therapist took a position behind the child and instructed him or her to lean back and forwards.
-High step-standing: standing with one foot resting on a block.	- The therapist asked the child to maintain the balance of his/her body while the child was standing one foot on a block.
-Stoop and recovery.	- The therapist sat behind of the child, manually secured both knees of the child, and then had the child stoop and then do active recovery.
-Dynamic balance: Walking exercises.	- The child walked across obstacles (wedges, rolls and blocks of variance sizes) in forwards, backwards, and side to side directions without support.

In BBS training (group A), every child was told to stand while putting 2 feet on the "locked" platform. While encouraging the child to keep their attention on the visual feedback screen, the examiner pushed the platform to an increasingly unstable condition. Children were not holding onto any handles and their arms were resting at their sides. They have started their training at a stability level six. Balance improvement was used as a measure for level advancement **(6).**

While in treadmill training (group B), each child was asked to walk on the motorized treadmill (ENTRED, Enraf–Nonius) at speed about 75 percent of over-ground and the child walking independently at 0 percent incline for twenty minutes. Before the walking on the treadmill, each child warmed up in 5-min by active progressive and prolonged stretching exercises of the quadriceps, Achilles' tendon, and hamstrings muscles **(14).** When each child was standing on the treadmill, should be ensure that this standing in an upright position, and according to each child, the therapist corrected the height of the handrails. Ask the child to keep looking forwards along the walking on the treadmill aiming to encourage the setting of walking free. The treadmill training would be completed for each child when the child completes three stages in 1-min training cycles. First stage: the child grasped on to the rails with both hands in first 15 s of every 1-min. Second stage: the child grasped on to the railings with one hand in the second 15 s. And final stage: the child didn't grasp on to the railings in last 30 s. Every child performed this procedure twenty times **(15).** At the end of the program, there was cooldown about 5-min to prevent any spasm that may be presented. Every child had flexible clothes and comfortable shoes during the program **(7).**

Statistical analysis:

The gender distribution was determined using the Chi-square test. Means as well as standard deviations were utilized to display all of the study's data. The Shapiro-Wilk test was used to verify that the data followed a normal distribution. To examine whether or not there was homogeneity in the variances between groups, Levene's test was carried out. Unpaired t-tests were used to compare study variables among groups, while paired t-tests were used to examine study variables before and after treatment within each group. In this study, a p-value of less than 0.05 is considered significant. All statistical analysis was carried out using the statistical package for social studies (SPSS) version 22 for windows (IBM SPSS, Chicago, IL, USA).

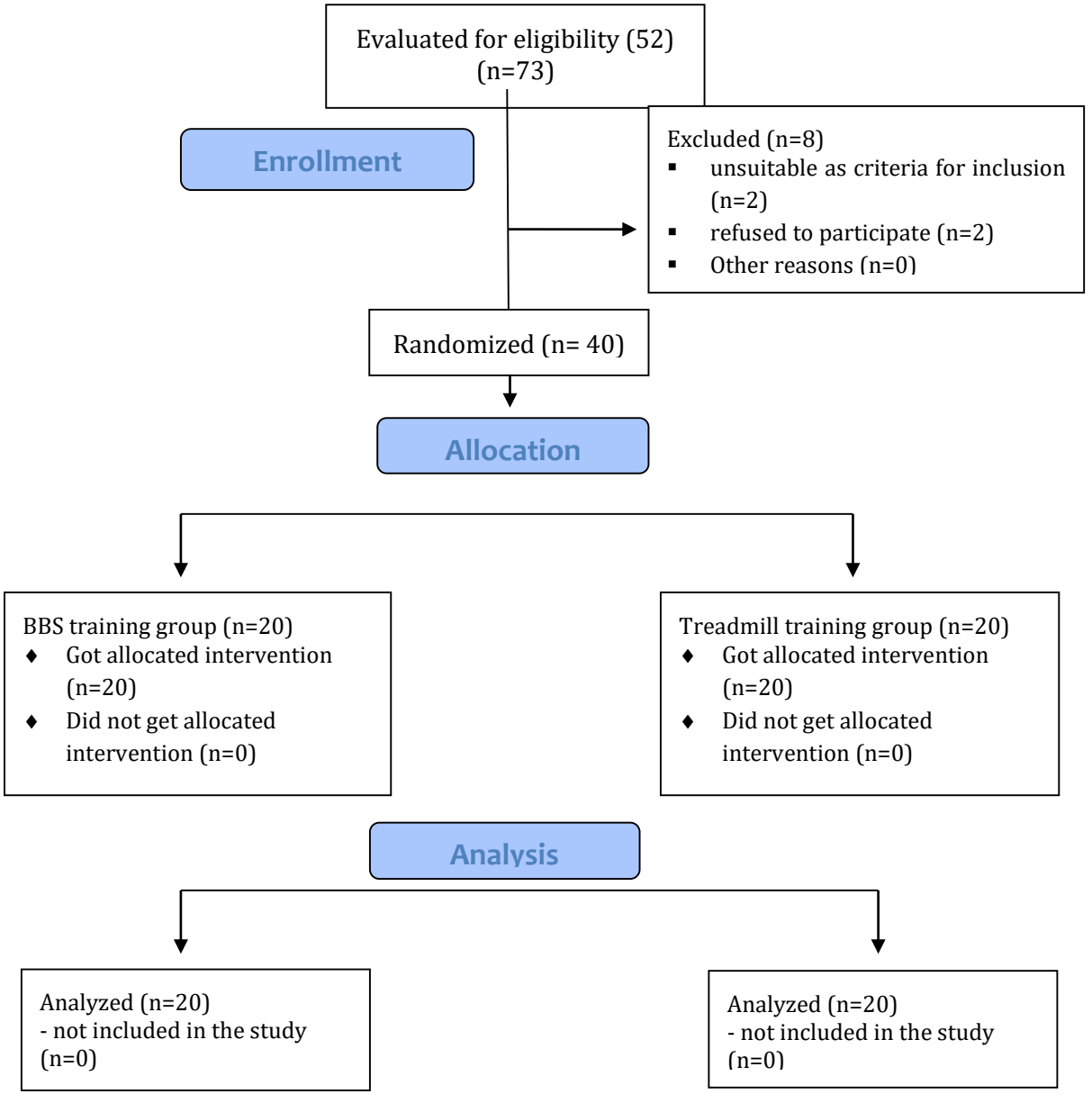

Figure (1): The flow chart of the study.

3. RESULTS

A) Demographic data:

There was no statistically substantial difference among groups A as well as B in their respective mean ages, height as well as weight ($p > 0.05$) (Table 2).

Table (2): Comparison of age between the three groups (A and B).

	Group (A) $\overline{X}$ ± SD	Group (B) $\overline{X}$ ± SD	t-value	p-value	Level of significant
Age (years)	12.6 ± 2.19	11.9 ± 2.49	0.94	0.351	N.S
Height (m)	1.44 ± 0.09	1.43 ± 0.1	0.22	0.831	N.S
Weight (kg)	38.5 ± 8.04	39.05 ± 9.11	0.2	0.841	N.S

$\overline{X}$: Mean. SD: Standard Deviation. t-value: Unpaired t-test value. p-value: Probability value. NS: Non-Significant.

The gender distribution of group (A) showed that there were 11 (55%) girls and 9 (45%) boys while gender distribution of group (B) showed that there were10 (50%) girls and 10 (50%) boys. There was no substantial difference among the two groups (A and B) ($p > 0.05$) as in (Table 3).

Table (3): Comparison of gender distribution between the two groups (A and B).

	Gender distribution N (%)		X^2	p-value	Level of significant
	Group (A)	Group (B)			
Girls	11 (55%)	10 (50%)	0.1	0.75	NS
Boys	9 (45%)	10 (50%)			

$\overline{X}$: Mean. SD: Standard Deviation. X^2: Chi squared value. p-value: Probability value. NS: Non-Significant.

B) Measured variables:

1) Before treatment comparison among the two groups (A as well as B):

When contrasting before treatment $\overline{X}$ ± SD of OASI, APSI as well as MLSI values among groups (A as well as B), non-significant differences were showed ($p > 0.05$) among the two groups (Table 4).

2) Before as well as after- treatment comparison regarding group (A):

When contrasting before as well as after treatment $\overline{X}$ ± SD of OASI, APSI as well as MLSI values regarding group (A), substantial differences were found ($p < 0.05$) respectively (Table 4).

3) Before as well as after- treatment comparison regarding group (B):

When contrasting before as well as after treatment $\overline{X} \pm$ SD of OASI, APSI as well as MLSI values regarding group (B), significant differences were found ($p < 0.05$) respectively (Table 4).

4) After treatment comparison among the two groups (A as well as B):

When contrasting after treatment $\overline{X} \pm$ SD of OASI, APSI as well as MLSI values among groups (A and B), substantial differences were found ($p < 0.05$) respectively among the two groups respectively (Table 4).

Table (4): Comparison of OASI, APSI and MLSI for the two groups (A and B).

		Group (A) $\overline{X} \pm$ SD	Group (B) $\overline{X} \pm$ SD	p-value
OASI	Before treatment	5.09 ± 0.46	4.92 ± 0.44	0.249^{NS}
	After treatment	3.91 ±0.32	3.26 ± 0.47	0.001^{S}
	p-value	0.0001^{S}	0.0001^{S}	
APSI	Before treatment	5.11 ± 0.52	4.9 ± 0.38	0.154^{NS}
	After treatment	4.03 ± 0.36	3.39 ± 0.47	0.001^{S}
	p-value	0.0001^{S}	0.0001^{S}	
MLSI	Before-treatment	4.91 ± 0.3	4.87 ± 0.55	0.75^{NS}
	After-treatment	3.81 ± 0.32	3.18 ± 0.82	0.004^{S}
	p-value	0.0001^{S}	0.0001^{S}	

$\overline{X}$: Mean. SD: Standard Deviation. P-value: Probability value.
NS: Non-Significant. S: Significant.

4. DISCUSSION

The target of the current research was to evaluate the efficacy of training used BBS and to compare the impact of the BBS training against treadmill training on balance among children suffering from burns on their lower limb. As far as the literature review is concerned, there is no enough available information to conclude the effectiveness of BBS training on balance and to contrast the efficacy of treadmill training as well as BBS training on balance in children having lower extremity burns. The current study showed that training with the BBS had no substantial impact on balance in children having lower extremity burns, also there was no substantial difference in balance advancement among BBS training as well as treadmill training in the children of both groups (A and B) before treatment, Nonetheless, there was a marked improvement in outcomes for Group (B).

In the current study, selection of the children with lower limb burn could be accepted with **Khalaf and El-Okby, (16)** who applied their study to evaluate the effectiveness of treadmill training program on correcting gait abnormalities in children who've had a lower extremity burn injury. Forty children (male and female) participated in the study; twenty children (study group) underwent

treadmill training as well as the conventional physical therapy program, while the other 20 children (control group) got the conventional physical therapy program only.

Children who have been severely burned benefit from exercise because it enhances their pulmonary function as well as cardiorespiratory efficiency. Exercising as a means to speed up recovery in severely burnt people is another method that has been investigated **(17).**

According to **El-gohary et al., (6)** BBS may have subtly regulated the recruitment pattern as well as the anticipatory adaptation mechanisms by focusing on the somatosensory as well as neuromuscular elements of balance control, corroborating the substantial results among before and after-treatment of group (A). The unstable supporting surface makes the child to keep his or her centre of gravity close to the ground. The biodex system's instantaneous feedback during training not only allows the child to regain kinesthetic sense for optimal body placement to maintain balance, but also to link body parts then repeats the activity.

Group (A) findings were consistent with those reported by **El-gohary et al., (18)** and **Elangovan et al., (19)** who suggested that the BBS training may have altered the integration of the central and peripheral nerve systems.

Through correcting postural misalignment and enhancing spinal kinematics, training using the BBS may have enhanced neuromusculoskeletal functional skills. Relaxation and control may be responsible for the enhanced passive movement replication **(6).**

Cho et al., (20) who found a substantially significant variance between before and after treatment scores for group (B), concluded that treadmill gait training is useful for improving balance and strengthening the muscles that extend and bend the knee. As a result, it's an essential factor in helping children become more independent in their daily lives.

The after treatment outcomes regarding group (B) are consistent with those of **Matsuno et al., (21)** who discovered that since the treadmill is treated as a moving surface, children using it had to put more weight on each foot throughout the gait cycle than they would if they were walking on solid ground. As a result, they have one foot off the ground less often while walking on a treadmill than when walking outside. He went on to say that increasing base of support is a key to better stability and balance.

Tulchin et al., (22) who expanded on group B's results to conclude that treadmill training contributed to substantial enhancementsin walking endurance, gait stability, muscular functioning, cardiorespiratory fitness, balance, as well as regular activity levels of individuals. Moreover, **Dal et al., (23)** found that treadmill training offered a number of options for improving balance, building lower limb muscular strength, and stimulating neural connections that aid in the development of independent, well-balanced walking.

These findings are consistent with those of **Khalaf and El-Okby, (16)** who conducted a similar study on 40 children (boys and girls) and found that treadmill training in addition to conventional physiotherapy had a significant impact on gait patterns when compared with conventional physical therapy program alone.

Supporting the present findings is a research by **Suman et al., (24)** that found that a 12-week exercising program increased by aerobic treadmill exercising capacity in children suffering from severe burns when started six months after injury. Our findings are in line with those of **De Lateur et al., (25)** who discovered that a 12-week aerobic treadmill training program improved the aerobic

capacity among burn survivors if initiated between 9 as well as 122 days following injury.

Treadmill training, as proven by **Ulrich et al., (26)** makes strength and stabilizes the neural network responsible for creating this pattern and enhances the unique postural control mechanism required to keep one's balance while shifting one's weight from one foot to the other. Thus, treadmill training, which is an example of stepping practice, enables and strengthens the neural pathways that emerge from the coupling of multi - modal sensory information generated by the child via inadequate motor control.

Our findings are at contradiction with **Carmeli et al., (27)** study, who evaluated subjects' balance after participating in ball exercises as well as treadmill training. Both postural control and balance did not improve after 6 months of treatment with those patients.

Treadmill training, in comparison to BBS training, was shown to have a greater impact on cardiovascular fitness and endurance in the after-treatment comparison among groups (A as well as B), which is consistent with the findings of **Clayton et al., (28)** when applied to pediatric burn patients, the study found that a 6-week rehabilitation exercise program that included treadmill training was adequate for increasing muscular strength, body composition, and cardiovascular fitness. Cardiopulmonary exercise should be continued after inpatient therapy ends, but if possible, at home or at a nearby facility.

The after-treatment differences among groups (A and B) are also in line with the outcomes of **Cambiaso-Daniel et al., (29)** who verified that while the impacts of rehabilitation exercise in the type of treadmill training upon strength as well as cardiorespiratory capabilities are still present nearly four years after the burn.

The sensory and neuromuscular elements of balance regulation were specifically targeted by BBS training and the unstable supporting footing forces the child to keep his or her centre of gravity close to the ground **(6).**

In a study with burn children, **Pena et al., (30)** discovered that after 12 weeks of progressive resistance as well as aerobic training, there was a reduction in body fat, there was a substantial increase of lean muscle mass, muscular strength, and maximum aerobic capacity with treadmill training.

Limitations:
A few limitations exist in this investigation. First, the sample size was small, which may have limited the generalizability of the results. Second, after eight weeks of the intervention, the impact of interventions was measured immediately. Consequently, the findings of this research need for long term effects for more beneficial results.

Strength:
The present study's use of an objective, valid, as well as trust worthy measurement tool could be viewed as a strength in our approach to find out the combined impact of BBS training versus treadmill training in helping children experiencing burns on their lower limbs to regain their balance which previously did not report.

Weakness:
There is no research that compares the effectiveness of BBS training vs treadmill training in helping children with lower limb burns regain their balance.

Conclusion:
Treadmill training and BBS training should be added to a designed physical therapy program for children with lower limb burns, due to its significant impact on their balance. Children experiencing lower limb burns who participated in treadmill training had greater gains in balance than those who participated in BBS training which might be a reason to support its implementation more.

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Conflicts of interest:
No conflict of interest has been declared by the authors of this academic work.

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