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

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Abstract---Purpose: The current study is aimed to determine the effect of biodex balance system training against treadmill training in improving balance in children having lower limb burns. Methods: Forty children from both genders (boys and girls) who were complaining from 2nd degree lower limb burns with ≥30 percent of their total body surface area (TBSA) were participated in this study, their ages ranged from 8 to 16 years and they were randomized into 2 groups of same number (A and B). Both groups (A and B) received the same conventional physical therapy programs, however group (A) trained to use 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 three sessions per week for eight consecutive weeks. Results: All evaluated outcome measures pre and post treatment were significantly variance between 2 groups, as shown by the findings. Post-test mean values for all assessed variables also showed substantially significant differences in favor of group (B). Conclusion: Treadmill training proved more beneficial than biodex balance system training in improving balance in children with lower limb burns, thus both are important addition into the physiotherapy programs.
**Keywords**---Biodex balance system training, Treadmill training, Balance, Lower limb burn, Children.

**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. More ever, excessive burn wounds continue to destroy tissue or progress for up to 48 hours (Porter et al., 2015).

In contrast to pharmaceutical interventions, exercise training may slow the muscle breakdown that happens with aging 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 (Hardee et al., 2014).

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. (1) Maintaining of a given postural alignment, including sitting or standing; (2) Stimulation of voluntary movement, like the movement transitions among postures; (3) Recovering equilibrium following external disruptions, such as a trip, slide, or shove, are all functional goals of the balance system (Mancini and Horak, 2010).

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 (Ohgi and Gu, 2013).

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 (Ali et al., 2015).

Balance training for children using the Biodex technology and the more traditional balance training (El-gohary et al., 2017). Treadmill training encourages the patient to walk in a 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 (El Meniawy et al., 2012).

The primary objectives of the current study were to detect the efficacy of biodex balance system training on balance and to compare the efficacy of treadmill training versus training used biodex balance system on balance in children with lower limb burns.
Subjects and Methods

Study design and participants:

Forty children from both genders (boys and girls) who were complaining from 2nd degree lower limb burns (≥30 % of their TBSA) were involved in this study. All of children met the requirements and were recruited from the General Embaba Hospital in Giza, Egypt and were conducted at the outpatient clinics, Faculty of physical therapy, Modern University for Technology and Information, Cairo, Egypt. Utilizing G*POWER statistical software (version 3.1.9.2; Franz Faul, Universität Kiel, Germany), the minimum proper sample size for the current study was determined to be 20 children in each group. Allocation ratio N2/N1 = 1 and significance levels =0.05 and =0.2 and effect size =0.4 were used in these calculations.

The current study was as a randomized controlled trial. Treatment sessions were conducted three sessions weekly for a total of 8 consecutive weeks, and children were assessed using biodex balance system parameters; Overall stability index (OASI), Antero-posterior stability index (APSI) as well as Medio-lateral stability index (MLSI). Children were randomized into 2 groups: Twenty children were assigned to group (A), where they participated in conventional physical therapy sessions and trained to use the biodex balancing device. Twenty children were assigned to group (B), which underwent treadmill training in addition to the conventional physiotherapy program as used on group (A).

The inclusion criteria were as follows: a) the children aged between 8 to 16 years (Benjamin et al., 2015), b) they were complaining from 2nd degree lower limb burns (≥30 % of their TBSA) (Benjamin et al., 2015), 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 changes include (bone destruction, bony ankylosis, knee joint subluxation and epiphysial fracture), v) congenital or acquired skeletal deformities in the lower limbs and vi) cardiopulmonary dysfunction were excluded.

After all baseline criteria were met, the eligible children were allocated randomly to the group (A) or group (B). Each child was asked to choose one of forty sealed preset envelopes which was opened by the researcher after completing the baseline evaluation testing.

This study was conducted from April to July 2022 and it was approved by the Research Ethical Committee, Faculty of physical therapy, Modern University for Technology and Information, Cairo, Egypt. Parents as well as legal guardians of prospective participants were given a consent form that included extensive details about the study’s methods and goals. 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.

- **Methods:**

  **A) Evaluation:**

  - **Biodex balance system:**

    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 OASI, APSI as well as MLSI *(Hinman, 2010)*.

    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 *(Cachupe et al., 2001)*. 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) *(Schmitz and Arnold, 1998)*.

    The biodex balance system parameters are used to examine the additional benefits of whole-body vibration therapy on balance control, postural stability, as well as mobility following thermal burn injuries as part of a conventional physical treatment program *(Abdel-Aal et al., 2021)*.

  **B) Treatment:**

    The participated children in the current study were randomized into 2 groups of equal number (A and B) based on the following:

    **Group (A):**

    It consisted of twenty children who received conventional physical therapy program for 30 min aiming *(Alsakhawi and Elshafey, 2019)* to improve balance posture and control (Table 1) and biodex balance system training for 30 min. Tools were used in conventional physical therapy program include vestibular board, blocks, rolls, and wedges of variance sizes and training for 30 min. The treatment session was performed three sessions weekly for eight consecutive weeks.

    In biodex balance system training, 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 (El-gohary et al., 2017).

Table 1  
Conventional exercise program utilized for both groups

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standing with feet closer to each other.</td>
<td>- 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.</td>
</tr>
<tr>
<td>Step-standing: standing with one step of the foot forward.</td>
<td>- The therapist took a position behind the child and instructed him or her to lean back and forwards.</td>
</tr>
<tr>
<td>High step-standing: standing with one foot resting on a block.</td>
<td>- The therapist asked the child to maintain the balance of his/her body while the child was standing one foot on a block.</td>
</tr>
<tr>
<td>Stoop and recovery.</td>
<td>- 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.</td>
</tr>
<tr>
<td>Dynamic balance: Walking exercises.</td>
<td>- The child walked across obstacles (wedges, rolls and blocks of variance sizes) in forwards, backwards, and side to side directions without support.</td>
</tr>
</tbody>
</table>

Group (B):

It is involved of twenty children who received the same conventional physical therapy program that was applied on group (A) for 30 min aiming (Alsakhawi and Elshafey, 2019) to improve balance posture and control and treadmill training for 30 min. The treatment session was performed three sessions weekly for eight consecutive weeks.

The 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 (Combs et al., 2010).

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 (Smith et al., 2007). 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 (El Meniawy et al., 2012).

Statistical analysis:
Statistical analysis was performed in Windows Version 23 of the Statistical Software for the Social Sciences (SPSS, Inc., Chicago, IL, USA). The interaction between group as well as time was the dependent variable, with an a priori alpha of 0.05 as well as a 95% confidence range. The analysis was conducted statistically using an intention-to-treat approach.

Results
A) Children demographic data:
Group (A) consisted of 20 children with \( \bar{X} \pm SD 12.6 \pm 2.19 \) years and group (B) consisted of 20 children with \( \bar{X} \pm SD 11.9 \pm 2.49 \) years, there was no significant difference among the two groups (A and B) \( p = 0.351 \) as in (Table 2).

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 were 10 (50%) girls and 10 (50%) boys. There was no significant difference between the two groups (A and B) \( p = 0.75 \) as in (Table 2).

<table>
<thead>
<tr>
<th></th>
<th>Group (A) ( \bar{X} \pm SD )</th>
<th>Group (B) ( \bar{X} \pm SD )</th>
<th>t-value</th>
<th>p-value</th>
<th>Level of significant</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (years)</strong></td>
<td>12.6 ± 2.19</td>
<td>11.9 ± 2.49</td>
<td>0.94</td>
<td>0.351</td>
<td>N.S</td>
</tr>
<tr>
<td><strong>Gender distribution N (%)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td>11 (55%)</td>
<td>10 (50%)</td>
<td>( X^2 )</td>
<td>p-value</td>
<td>Level of significant</td>
</tr>
<tr>
<td>Boys</td>
<td>9 (45%)</td>
<td>10 (50%)</td>
<td>0.1</td>
<td>0.75</td>
<td>NS</td>
</tr>
</tbody>
</table>

\( \bar{X} \): Mean. \ SD: Standard Deviation. t-value: Unpaired test value.

\( X^2 \): Chi squared value. \ p-value: Probability value. NS: Non-Significant.
B) Measured variables:

1) Pre- treatment comparison between the two groups (A and B):

When comparing the pre- treatment \( \overline{X} \pm SD \) of OASI, APSI and MLSI values between groups (A and B), non significant differences were revealed \( (p= 0.466) \), \( (p= 0.345) \) and \( (p= 0.113) \) among the two groups respectively (Table 3).

2) Pre and post- treatment comparison for group (A):

When comparing the pre and post- treatment \( \overline{X} \pm SD \) of OASI, APSI and MLSI values for group (A), significant differences were revealed \( (p= 0.0001) \), \( (p= 0.0001) \) and \( (p= 0.0001) \) respectively (Table 3).

3) Pre and post- treatment comparison for group (B):

When comparing the pre and post- treatment \( \overline{X} \pm SD \) of OASI, APSI and MLSI values for group (B), significant differences were revealed \( (p= 0.0001) \), \( (p= 0.0001) \) and \( (p= 0.0001) \) respectively (Table 3).

4) Post- treatment comparison between the two groups (A and B):

When comparing the post- treatment \( \overline{X} \pm SD \) of OASI, APSI and MLSI values between groups (A and B), significant differences were revealed \( (p= 0.002) \), \( (p= 0.012) \) and \( (p= 0.007) \) between the two groups respectively (Table 3).

<table>
<thead>
<tr>
<th>Table (3)</th>
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<tbody>
<tr>
<td>Comparison of Overall stability index (OASI), Antero-posterior stability index (APSI) and Medio-lateral stability index (MLSI) for the two groups (A and B).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Overall stability index (OASI)</th>
<th>Group (A) ( \overline{X} \pm SD )</th>
<th>Group (B) ( \overline{X} \pm SD )</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-treatment</td>
<td>3.84 ± 0.28</td>
<td>3.91 ± 0.32</td>
<td>0.466&lt;sup&gt;NS&lt;/sup&gt;</td>
</tr>
<tr>
<td>Post-treatment</td>
<td>4.67±0.32</td>
<td>5.09±0.46</td>
<td>0.002&lt;sup&gt;S&lt;/sup&gt;</td>
</tr>
<tr>
<td>p-value</td>
<td>0.0001&lt;sup&gt;S&lt;/sup&gt;</td>
<td>0.0001&lt;sup&gt;S&lt;/sup&gt;</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Antero-posterior stability index (APSI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-treatment</td>
</tr>
<tr>
<td>Post-treatment</td>
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<tr>
<td>p-value</td>
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<table>
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<tr>
<th>Medio-lateral stability index (MLSI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-treatment</td>
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<tr>
<td>Post-treatment</td>
</tr>
<tr>
<td>p-value</td>
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</tbody>
</table>

\( \overline{X} \): Mean. \( SD \): Standard Deviation. p-value: Probability value.

Discussion

The target of the current study was to evaluate the efficacy of training used biodex balance system and to compare the impact of the biodex balance system training against treadmill training on balance in children with lower limb burns. As far as the literature review is concerned, there is no enough available information to conclude the effectiveness of biodex balance system training on balance and to compare the efficacy of treadmill training and biodex balance system training on balance in children having lower extremity burns. The current study showed that training with the biodex balance system had no substantial impact on balance in children having lower extremity burns, also there was no substantial difference in balance advancement among biodex balance system training as well as treadmill training in the children of both groups (A and B) pre treatment, but the results of both groups improved post treatment, in favor of group (B).

In the current study, selection of the children with lower limb burn could be accepted with Khalaf and El-Okby, (2006) 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 in addition to the conventional physiotherapy program, while the other 20 children (control group) received the conventional physiotherapy 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 (Chao et al., 2018).

According to El-gohary et al. (2017), biodex balance training 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 pre and post-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., (2016 and Elangovan et al., (2014) who suggested that the biodex balance system training may have altered the integration of the central and peripheral nerve systems.

Through correcting postural misalignment and enhancing spinal kinematics, training using the biodex balance system may have enhanced neuromusculoskeletal functional skills. Relaxation and control may be responsible for the enhanced passive movement replication (El-gohary et al., 2017).
Cho et al. (2016), 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.

Group B's post-treatment findings are consistent with those of Matsuno et al. (2010), who found 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., (2010), who added on the findings of group (B), also found that treadmill training led to significant improvements in walking endurance, gait stability, muscular functioning, aerobic fitness, balance, and individuals' usual levels of physical activity. In addition, Dal et al. (2010) found that treadmill training provided several possibilities to enhance balance, develop lower extremity muscular strength, and activate neural connections that contribute to the formation of independent, well-balanced walking.

These findings are consistent with those of Khalaf and El-Okby (2006), 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., (2002) 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. (2007), who found that a 12-week aerobic treadmill exercise regime enhanced aerobic capacity in adult's burn survivors when started between 9 and 122 days after injury.

Treadmill training, as proven by Ulrich et al. (2001), 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. (2003) 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 biodex balancing system training, was shown to have a greater impact on cardiovascular fitness and endurance in the post-treatment comparison between groups (A and B), which is consistent with the findings of Clayton et al (2017) when applied to paediatric 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 post-treatment differences between groups (A and B) are also consistent with the findings of Daniel et al. (2018), who verified that while the effects of rehabilitation exercise in the type of treadmill training on strength and cardiorespiratory capabilities are still present nearly 4 years after the burn.

The sensory and neuromuscular elements of balance regulation were specifically targeted by biodex balance training and the unstable supporting footing forces the child to keep his or her centre of gravity close to the ground (El-gohary et al., 2017).

In a study with burn children, Pena et al. (2016) found that following 12 weeks of progressive resistive as well as aerobic exercise, there was a substantial increase of lean muscle mass, muscular strength, and maximum aerobic capacity with treadmill training.

**Conclusion**

Biodex balance system training and treadmill training should be added to a designed physical therapy program for children with lower limb burns, due to its significant impact on their balance. Treadmill training was more effective than biodex balance system training in improving balance in children with lower limb burns which might be a reason to support its implementation more.

**References**


