Towards a Motor Ability Training Table for Rehabilitating Children with Obstetric Brachial Plexus Lesion

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Abstract—Obstetric Brachial Plexus Lesion (OBPL) is an injury of the cervical spine and chest characterized by blockage of one or more brachial plexus nerves, usually during the child delivery procedure. Research indicates that the number of infant OBPL cases has been growing in a much faster rate than the population growth. Despite that, most of the equipment and electronic devices employed to help and accelerate the OBPL treatment are designed for adult use, treating kids as a miniaturized adult. This work proposes a simple yet efficient motor ability training table, specifically designed for infant use. The training table uses games, with light, sound and several complexity levels to arouse the child interesting and to make the treatment more challenging. On the top of that, a computer system that presents patient progress through graphical reports helps the professional to further analyzed the treatment result.

Keywords: OBPL, rehabilitation engineering, motor ability training table

1. Introduction

The OBPL - Obstetric Brachial Plexus Lesion - is caused by excessive traction of the neck, head and arm during the delivery procedure, exceeding the tolerance thresholds of the nerves [1], [2].

The rate of OBPL cases has been growing along with population growth, but in a much more considerable proportion, about 76 %, in Brazil. According to [3], children rehabilitation technology did not follow this growth, the technologies developed are still based on adults characteristics.

This project proposes the development of a motor ability training table to aid in the treatment of OBPL having as its main focus children rehabilitation. In the following sections, topics concerning the formation of OBPL lesion, treatment techniques, types of injury, the project development and its specifications are discussed.

2. Obstetrical Brachial Lesion

This section presents fundamental concepts such as the formation of Obstetric Brachial Plexus Lesion, its causes, residual deformities, and current treatment possibilities.

2.1 Lesion Formation

The Obstetric Brachial Lesion or Obstetric Brachial Plexus Lesion is an injury of the cervical spine and chest characterized by blockage of one or more nerves of the brachial plexus [4]. The lesion is usually the result of direct trauma caused during delivery. [2].

Research conducted in 2000 and 2010 shows that the rate of tocotraumatism cases (one should take into account the aggregation of all cases of various types of traumas) occurring during delivery, increased approximately 75.6 %, and mortality involving this type of injury accounts only to 0.6 cases per 100,000 births [5], [6]. It should be taken into account, when interpreting such data that, according to the Demographic Censo of 2000 and 2010, the Brazilian population grew by 12.3 % during this period [7].

Research indicates that the number of cases is incremented as the infant approaches the range between 4 and 5 kg, which can be seen from the graph of Figure 1.

Fig. 1: Relationship between number of cases of OBPL and weight (in grams) of the fetus at birth. Based on [8].

A study conducted by [9] relates, in 311 cases, the number of individuals affected by OBPL versus the type of delivery. This is depicted by Table 1. Note that the sum of births by forceps and suction exceeds the number of assisted births, this is due to the fact that births with the aid of forceps were performed after failure of Ventouse use and Caesarean section.
Table 1: Types of birth *versus* number of cases. Adapted from [9].

<table>
<thead>
<tr>
<th>Type of Birth</th>
<th>Studied Group</th>
<th>England 1994-1995</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N.</td>
<td>%</td>
</tr>
<tr>
<td>Spontaneous vertex delivery</td>
<td>183</td>
<td>59</td>
</tr>
<tr>
<td>Assisted delivery</td>
<td>113</td>
<td>36 *</td>
</tr>
<tr>
<td>Ventouse</td>
<td>87</td>
<td>28</td>
</tr>
<tr>
<td>Forceps</td>
<td>45</td>
<td>14.5</td>
</tr>
<tr>
<td>Breech</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>Caesarean section</td>
<td>5</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15.5</td>
</tr>
</tbody>
</table>

2.2 Types of Lesion

The OBPL is classified taking into account the gravity and the components involved in the lesion. Thus, the lesion can be split into three types: Erb-Duchenne Palsy, Total Brachial Plexus Lesion and Klumpke’s Palsy [4].

- **Erb-Duchene Palsy:** in this modality, the injury occurs between the C5 and C7 vertebrae. The arm is in a position called "waiter’s tip", with extension and pronation at the elbow and wrist and fingers flexed, as shown in Figure 2. In this case exists decrement of sensitivity, but the movement of grip is intact [6]. Note, when comparing photo A and B, how the arm position and the fingers flexion are characteristics of this type of injury.

![Fig. 2: Typical appearance of the newborn with Erb-Duchenne brachial plexus lesion. Adapted from [10], [11].](image)

- **Total Brachial Plexus Lesion:** in this case, all vertebrae from the C5 to T1 have their roots affected. The sensibility and all reflections are absent, the children does not move or lift the arm[6], [11], this can be observed by the Figure 3, note how the left arm of the patient is shown still.

![Fig. 3: Total Brachial Plexus Lesion, Clinical Case. Based in [12].](image)

- **Klumpke’s Palsy:** in this modality the vertebrae C7, C8 and T1 are envolved, paralyzing the hand muscles, arm flexors and wrist and fingers flexors [13]. The Klumpke’s Palsy is the most rare of all types of brachial plexus lesions and response to less than 1 % of the cases [5]. This type of paralysis may affect the cervical sympathetic fibers, taking ipsilaterally Horner’s syndrome, present on the same side of the affected limb [2], [14].

2.3 Residual Deformities

The limitations showed by the subjects affected by the OBPL may vary according with the type of the lesion. According to [15], the patient may present inability to understand and execute tasks requiring bilateral motor skills such as catching a ball or a large object. The residual deformities, according to [16], may be classified in 4 distinct types, taking into account the physiological/anatomical point of this deformity, being:

- **Shoulder:** the subjects affected by OBPL usually present difficulties in the movements of adduction and abduction of the arm, the main motor function of the shoulder [11]. Individuals may also present limitations of active abduction and lateral rotation, which can be seen from Figure 4. Note how the right upper limb movements are limited when compared to the left upper limb [11].

- **Elbow:** the residual deformity at elbow is often developed as a flexion of 45-90 degrees, which may be aesthetically disturbing. There is also a muscle imbalance summed with forced flexion of the elbow, resulting in abnormal bone growth caused by the use of very rigid immobilizing or splints during the recovery process [11].

- **Forearm and Hand:** residual deformities in the forearm and hand are determined by lot distribution, extension and type of the OBPL. While hand paralysis due to Klumpke lesion may be continuous, in the forearm, is common the appearance of deformities of pronation, as shown in Figure 5. Note the contraction of the forearm and elbow flexion [11].
2.4 Treatment

The Orthopedic Management or physical therapy, is the most appropriate treatment for the ones affected by OBPL and has as objective the early treatment in the newborn and child, in order to avoid deformities during the period of spontaneous recovery [15].

According to [11], the passive movements made during the exercise promotes the extension and flexion of the complete arc of all articulations.

Below are shown some of the exercises used during OBPL treatment. According to [15], each of the exercises should be performed repeatedly, several times per day.

2.4.1 Sensorial Development Exercises

The sensorial stimulus, in order to increase awareness that breastfeeding has on its own member, can be performed using a soft towel, gently massaging the arm, or using his/her own arm, massaging his/her own body [17].

Be aware of the affected limb is essential for the good progress of treatment as a patient who has no sensibility to the member can neglect it and continue to perform tasks only with the "normal" member.

2.4.2 Motor Ability Training Exercises

It is necessary to train grip and manipulate objects with both hands and also just the affected limb. To this end, the therapist can use objects of any kind. To encourage the active use of the atrophied member exercises that are used in everyday situations, such as tying shoes, draw and pick up objects may be strategies for the refinement of activities and for developing more accurate coordination for specific activities [17].

Exercises to gain motion amplitude or motion range are also important since by gaining motion amplitude one reduces the risk of contractures, mental and physical stress and improves blood circulation [18].

3. The Motor Ability Training Table: Specification

The training table proposed is a therapeutic device for the purpose of bringing the physiotherapist and the bearer of OBPL an alternative tool for qualitative and quantitative analysis of brachial plexus injury treatment.

According to [18], the therapist has tools for application of the exercises, but none of these are devoted exclusively or focuses on the OBPL treatment. The tools used by professionals are usually improvised materials such as toys, weights, pulleys and balls.

The development of rehabilitation technologies is occurring at a fast pace and the devices are becoming more individualized, when taken into consideration the type of disability or inability to move. In [3], published in 1996, the authors were concerned with enabling technologies exclusively for children. Current technologies are aimed at adults, eventually considering children as miniaturized adults. This is not enough, since the motor and cognitive functions of a child are in constant change during his/her growth.

The training table constructed consists of a module made of wood and glass, and divided into eight segments, as shown by the diagram of Figure 6. Each of the eight segments has an infrared touch sensor and LEDs in two colors, green and red, and play a note of a eight-note musical scale, from C to C.

These features together form a tool for dynamic exercises. The patient exercises by triggering the segments through touch, as soon as the training table asks for it. The physiotherapist has the ability to choose what will be the exercise performed. An example is to perform a sequence of ordered movements, i.e., the patient should operate with the OBPL affected member by all segments, one at a time, progressively. The table will temporarily turn on the leds of Red color in one segment to tell which should be activated, emits a musical note (for the segment) and wait for the
patient. If the patient triggers the correct thread it turns green again, otherwise the thread will flash symbolizing the error. Figure 7 shows step-by-step the training table basic operations.

During the exercise, the training table system sends data, related to the exercise, to the computer to which it is connected. The table is able to count time and errors during the exercise execution. Whenever the table system asks the patient to trigger a segment, the time between the actuation by the table itself and by the patient is accounted, this is called arrival time. Whenever a segment is triggered by the patient, the table accounts the duration of this actuation, this is called actuation time. Such measures are important to further analyze the progress of the patient response time according to the complexity of the exercise.

The system allows the physiotherapist to select the complexity of the exercise and stores the progress of each patient in each exercise performed. The exercise complexity is related to how fast each of the segments is trigger by the system, the shorter the time of drive, more attention and flexibility are required by the patient. There are 10 levels of complexity, which can be used in all exercises, ranging from one second apart (easy level) to 1/10th of a second (hardest level).

To monitor the exercise, a computer system was developed. The system controls/monitors the exercises, receives data regarding the patient movement and presents a graphical analysis of such information. The system is capable of registering patients and storing personal data progress of each registered patient, as shown in Figure 8. The physical therapist can also monitor and control the execution of the exercises through the computer system, as shown in Figure 9.

The system allows a temporal analysis of the exercise, through the construction of graphs with the data collected during the execution of the exercise. Figure 10 shows the history exercise screen. It is important highlight that the system, by itself, does not have any intelligence to perform data analysis at this moment. It only generates graphics to be analyzed by the responsible professional.


3.1 Related Work

The search for related work did not point out many items. As mentioned before, there is a bad habit of considering children as miniaturized adults, thus there is not many training devices for kids. This section presents the more relevant related work found.

The authors in [19] describe the development of a generic programmable platform to aid in patient care with physical disabilities, based on a set of non-invasive sensors that can track movements, touches and eye poking. The sensor signals are conditioned and processed in a computer system.

[20] describes the development of a multimedia workstation for children rehabilitation. Based on a cognitive/sensory system, one of the first ever developed, that works on neuromuscular functions. The proposed system uses EMG signals captured to study muscular information.

Finally, although there is not an equipment or device developed, it is important to mention that the authors in[21], [22] discuss about exercise techniques that can be applied during a motor dysfunction treatment.

3.2 Discussion and Results

Is it possible to train a carrier of obstetric paralysis through physical therapy methods? The literature states that it is. According to [15], [11], [23], the orthopedic management is highly recommended as an instrument of neuromuscular recovery and surgical treatment is indicated only in cases of delayed recovery or when there is no response to physiotherapy treatment. 

Although all the concepts discussed in the section 2.4, 2 and research using the methodology discussed in section 3.1, there were no positive results for the development of technologies for OBPL treatment, which allows the conclusion that professionals do not have specific devices for performing a focused OBPL physical therapy and that the development of these technologies could result in abbreviation of patient’s recovering time and also the reduction of residual deformities, these are the objectives that we hope to achieve by using the training table proposed in this work.

4. Conclusions

The training table, proposed in this project, is an alternative to conventional treatments that brings to a physical therapist and patient a ludic technique capable of arousing the interest of the child using a game as a treatment model. The presence of light and sound and the presence of several complexity levels make the exercise more interesting and challenging. By the other hand, the computerized system allows a better analysis of the patient’s progress throughout the exercise sessions. Thus, the professional can accurately assess the development of motor skills.

References


