Bioclimatic design of therapeutic gardens for children with Down syndrome

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ABSTRACT: The research realized to design a bioclimatic garden with therapeutic purposes for children presenting Down syndrome is described. Vegetation characteristics and environmental conditions were the main elements studied in order to obtain comfort indices, and to evaluate the effect of these spaces for the development of cognitive skills, additionally to the therapies commonly used.

The experimental period lasted six months, divided in five stages, during which the study groups were evaluated in three aspects:

1.Environmental conditions and vegetation preferences: Using surveys applied to subject groups, therapists and relatives.

2. Bioclimatic analysis, the physical environmental characteristics that impact thermal comfort. The variables considered were: air temperature, wind speed, heat index, humidity, surface temperature index and cloudiness.

3.Experimental stimulation and data analysis. It was analysed how the vegetation and environmental conditions influenced the development of cognitive skills, evaluating the abilities acquired with and without the experimental stimulation, using a control group.

The results allowed determining the indices of outdoor thermal comfort for children with Down syndrome. Design guidelines were finally obtained for using colours, textures, or contrasts between shadow and light, among others. Therapeutic gardens could have a great effect as an adjunct treatment for people with Down syndrome.

Keywords: Outdoors thermal comfort; therapeutic garden; Down syndrome.

INTRODUCTION

One of the prime aspects of bioclimatic architecture is to uphold the respect to the ecological environment by developing alternatives for the design of the spaces, optimizing the physical nature of the surroundings. At the same time it deepens the study of different aspects: thermal, acoustical, lighting and psychological comfort, to achieve harmonic, healthy and comfortable spaces [6].

For some people the concept of comfort is subjective, and it depends on age, gender, on cultural and social aspects [10]. The most complete definition of comfort is the physical and mental state in which and individual expresses well being and/or satisfaction with the environment [2], including aspects such as social well being. For practical proposes, comfort is classified according to the different sensorial perception channels involved; thermal, hygrometric, lighting, acoustical, olfactory and psychological comforts [6].

In the design of spaces, the designers try to create conditions that result acceptable for most of the users. The conventional standards for comfort are based on the studies performed in laboratories with controlled environment. This standards are usually of great utility for closed spaces, however, they are not always applicable for outdoor spaces, since they do not consider the adaptation capabilities of the individual or the variability of the environment [10]. In despite that it has been shown that outdoor spaces provided with vegetation produce positive effects on human psyque and sensorial relaxation [12], and that they have been used for therapeutically proposes [9], as well as for medication reduction and recuperation improvement of surgeries subjects in hospitals [8], if such spaces are not comfortable, they will be not utilized and therefore the benefits will not be reached. Thus, in the design of outdoor spaces, the analysis and creation of physical and psychological comfort are very important [7].

The thermal comfort is one of the aspects more relevant to outdoor design. Outdoors spaces should be conceived according to the activities to be developed in these spaces and should consider ambient variables such as air temperature, wind speed, solar radiation, humidity, physical activities, clothing insulation [3], and natural elements such as vegetation that can have effect on thermal perception of the users, since they are determinant in the environment variables of a micro-clime to be developed [4].

In the case of psychological comfort, this is an aspect that has been less explored, but it is not less important. It addresses the global perception that the brain has of all information that receives from the environment: Spatial, visual, and acoustical perceptions. This information is analyzed and processed in the context of others in the subject memory.

In the particular case of Down Syndrome (DS), there is not enough information for bioclimatic design. Individuals with DS require a consideration for their general health state and their particular physical and sensorial handicaps. All these aspects affect the cognitive development of these individuals, since they require stimulation of all their senses, and to develop the capacity to acknowledge the relation between space and time [11]. In case of thermal perception it must be consider that 40% of the DS population presents hypothyroidism that can appear at any moment in their life and some of the symptoms of this illness are: intolerance to cold or heat, motor incapacity, regression of skills previously acquired and introversive behavior among others [1]. Considering these aspects and with the goal of giving alternative approaches that could help in the rehabilitation process for people with DS, a bioclimatic design of a therapeutic garden in which the vegetation and the thermal comfort are the main elements, was proposed and enabled and the results were analyzed as follows.

DESIGN PROCESS METHOD

Study case: A search for a training center for people with DS in Mexico D.F and metropolitan area that have the infrastructure to carry out tests in an outdoor space was conducted. The CEDAC Foundation (Centre of Down education, A.C.), located in Naucalpan, Estado de Mexico, was chosen. This Foundation is dedicated to the training and education of children and young people with DS. The Foundation serves a population of 110 students and has training programs for early intervention, pre-school, special elementary and secondary education and employment training.

Experimental design: Considering that while younger the people with DS begin stimulation therapies the best results are obtained in the development of the cognitive area, and also, considered that individuals should be old enough to be able to interact and respond to the stimulations applied; the selected test population was 10 students at special elementary education stage, with an age range of 5 to 7 years. The degree of stimulation was evaluated in a format of presence-absence of the variable, splitting the test population in a control group and a group with experimental stimulus. The skills of groups were analyzed before and after the stimulation in the therapeutic garden. The assignment of the subjects to either group was conducted at random. Most members were males.

Climate analysis: Regional data such as temperature, wind, relative humidity, and solar radiation in the CEDAC area were obtained from the nearest weather station located at 4.3 km from the study site; the time period for the data was 1971-2000, the most recent record available. For climate analysis, the model developed by Freixanet [6] was used, climatic parameters such as solar radiation, temperature, relative humidity, wind and analysis of minimum and maximum neutral thermal comfort indices, were obtained. The local climatic conditions of the site were measured with 2 dataloggers. Temperature, relative humidity, and wind speed data were collected along one week in March 2011. One datalogger was placed in sunlight and the other one in shadow, both at 1.10 m. above ground, considering the average height of the experimental group.

Design of the therapeutic garden: Designing an outdoors space becomes even more complex when it is consider how environmental variables influence the comfort of people with DS; therefore it was decided to execute a design of the therapeutic garden to assess the impact of the vegetation on the thermal comfort and in the development of cognitive area of individuals.
The guidelines to design this garden were taken from Healing Gardens by Roger Urlich [9], by Cooper and Barnes [5], and the suggestions of design for a Recreational Center for people with various disabilities including DS, conducted in 1997 by the team of Enlace Integral of the UAM- Azc, were used as reference**.** The resources for the execution of the therapeutic garden were obtained through donations of teachers, parents and students of CEDAC, as well as from various organizations and institutions who were interested in the project.

Analysis of the study group: In parallel to the execution of the therapeutic garden the study group was analyzed considering three approaches:

1. Environmental preferences: surveys were applied to the study groups, parents and therapists. These surveys were previously designed with the orientation and supervision of psychologists and therapists of the Foundation. The information obtained allowed to know the characteristics of the vegetation and environmental conditions that were preferred by the study group. Visual, acoustical and tactile support materials were used to evaluate students. The sections considered in the survey were: General information about the student, level of support required, and level of acquired skills in the cognitive area, frequency and type of interaction of the students with the vegetation, preferences of the student in relation to factors of comfort according to environmental and climatic conditions.

2. Bioclimatic analysis: the objective was to determine the characteristics of the physical environment in the presence of vegetation through sessions in the enabled therapeutic garden and how these factors impact on the sense of thermal comfort in the experimental group. The variables considered for analysis were: air temperature, heat index, and relative

humidity, as well as other variables such as cloudiness. It was also considered physical activity and type of clothing used. The data for the analysis was collected trough seven sessions, from August to October 2011. The instruments used for collection of climate data were: 2 datologgers, a bulb thermometer and a light sensor. Also, the data of the conditions inside the control group classroom was collected.

3. Skill analysis: a program of activities was designed focused on the cognitive area for the group with experimental stimulation, with the aim of analyzing how the natural environment and environmental conditions influence the development of cognitive skills.

RESULTS AND DISCUSSION

Climatological site analysis: CEDAC is located at 19 °29' 48.63 " N, 99º15' 22.19" W with an elevation 2288m above sea level with semi-cold bioclimate. According to bioclimatic analysis the average values over a year are: Prevailing wind comes from the North with a speed of 2.4 m/s, with a direct radiation of 461.6 w/m^2 and a diffuse radiation of 204.2 w/m^2, a temperature high of 24°C and minimum of 9.7 ° C, calculated neutral temperature is 22.9 ° C. The coldest months are December and January, and the warmest from April to June. The average annual relative humidity is 60%, being March month showing minimum value of 46% and during August and September showing the maximum value with 71%.

Considering the schedules of activities of the Foundation, the analysis indicates that the hours below the thermal comfort in the area are between 7 a.m. and 12 a.m. in the months of October-December and 7 a.m. to 11 a.m., in January-February. From 12 a.m. to 8 p.m. the temperature was within comfort levels all over the year with exception of March, the hottest month of the year, in which the temperature exceed thermal comfort between 1 p.m. and 6 p.m**.** In relation to the urban context, the Foundation is within a residential area, the height of the buildings are between 6 to 10 m, which could act as a wind barrier, as well as a wooded area located north of the of the site location (Fig. 1).

The site assigned for the design of the therapeutic garden is of 457 m^2, rectangular, and without vegetation (Fig 2). Microclimate analysis was considered between 8:40 a.m. to 9:40 a.m., scheduled for the sessions of the experimental group. The data of the instrument located in sunlight indicated a maximum temperature of 34.2 °C, minimum temperature of 26.7 °C and a relative humidity of 36.8 %. In shadow, the maximum temperature is 26.4 ºC and 19.0 °C minimum, relative humidity of 33.4 %. The wind speed was 0.3 m/s and the airflow of 0.03 m/s; both instruments were placed at a height of 1.10 m height, being the average height of the experimental group. According to climate analysis, temperature values on site were out of range of comfort levels, 25.4 ° C maximum and 20.4 ° C minimum. These data were collected in the month of March 2011 in one week.

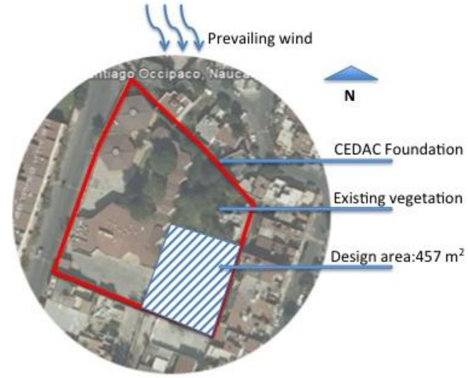


Figure 1: Satellite image of Foundation CEDAC the facility ground Image de Google Earth

Figure 2: Site assigned for therapeutic garden.

Design and execution of Therapeutic Garden:
According to previous investigations, the following guidelines were established for the design of the therapeutic garden for people with DS:

Conclusions of preferences of people with SD according to previous studies [9], [5], and Enlace Integral of the UAM-azc.		Solutions of elements and features for the therapeutic garden.
Vegetation	Flowers and fruit trees	Species without thorns, non-toxic, odor, perennial with sun requirements. Species obtained: Lavanda, hydrangea, jasmine, malvón, daisys, genariums chamomile, mint, basil, rosemary, bugambilia, orange, lemon.
Elements	Vegetation and water	Carpet grass, fountain
Colours	Red, Green, yellow, blue	Flowers, change of textures in ground like grass, gravel, volcanic coarse soil, and trunks.
Textures	Rugged	
Shapes	Circle	Circular shapes
Spaces	Open	

The donations were requested as possible with the characteristics of the proposed species. The considerations for the design were (Fig. 3)

1. Elements that generate shadow and barriers against wind.

2. Composition of plants and flowers, with different heights.
3. Fountain or pond.
4. Open spaces inside the garden, the vegetation such as border of the space will be used.
5. Difference of textures on pavement.
6. Sunlight throughout the day.
7. Barrier for predominant winds.

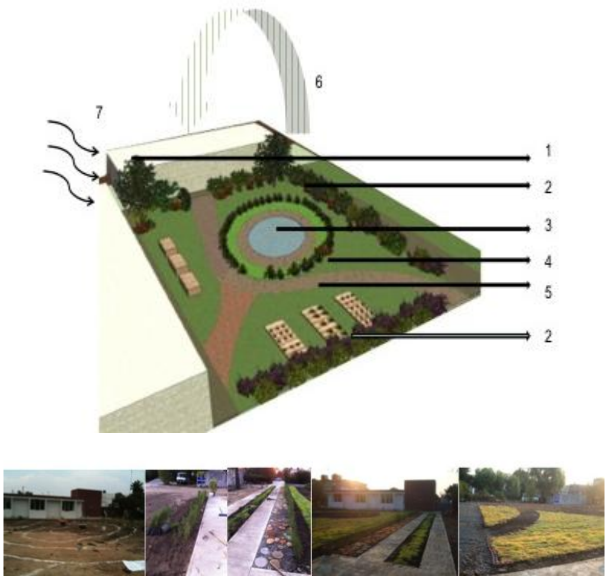


Figure 3: Design Proposal and execution of the Therapeutic Garden.

Analysis of the study group:

1. Preferences of the natural environment: the results of the surveys indicated that in the therapeutic garden, psychomotor activities can be developed in addition to coincide with activities that the students prefer to perform in these areas such as playing, walking and observation. In addition, physical contact with a natural environment helps to improve the development of their skills better than visual or acoustical contact. However, relatives claimed that the frequency that their children have direct contact with vegetation was once per week during the weekends at evenings and it was usually in a park.

In relation to the characteristics of the vegetation and environmental factors, therapists and students agree that they prefer sweet smells more than fresh or citrus ones. It was revealed that students have preference for the sounds of nature in contrast to the opinion of their relatives and therapist who claimed that they prefer classical music. As for the results of the characteristics of the vegetation, students chose medium size trees and they were more attracted by fruit trees. All of them agree that water, vegetation, and sun are the natural elements that they prefer over rocks and shade.

The colour that the students choose mostly was purple, the relatives blue and the therapists green. While the parents and therapists agree that the texture of their preference was smooth, the students did not have special preference for rough, rugged or smooth.

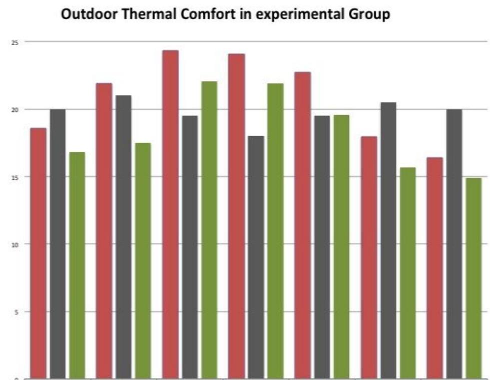
Comfort factors evaluated indicated that students prefer and tolerate the sensation of heat. The environmental conditions that students prefer were light, sunny days and much wind. In contrast to the opinion of their relatives and therapists, who believe that students prefer shade and no wind. The survey include a section exclusively for parents they were asked about their preferences concerning the factors of comfort and environmental conditions, the above because it is common in cases like people with DS, they do not know how to express their preference of thermal comfort with the same ease as a child in common conditions. The relatives consider that they have the same perception to the environment. This assumption was confirmed during the sessions in the garden, where the experimental group had to be instructed to develop the ability to express when they felt heat or cold.

2. Bioclimatic analysis: Sessions were held during the seven sessions from August to October between 8:40 a.m. to 9:40 a.m. The bioclimatic analysis indicates that the experimental group express comfort in activities carried out mainly in shadow and in days with up to 80% cloudiness, with an activity of 2.2 and 2.6 MET (value assigned to low impact activities by moving the limbs) and a clothing insulation of 1 CLO (shirt long sleeve, cotton, pants, jacket or long sleeves pullover socks and shoes). In the sessions in which the experimental groups manifest thermal comfort the data collected indicates average maximum temperature 22.7 °C, minimum 17.9 °C, maximum air temperature 20.5 °C and a minimum 19.5 °C, maximum heat Index 19.6 °C and minimum 19.4 °C. Relative humidity average of 61.5%.

The experimental group expressed thermal discomfort specifically to feel warmth, in activities carried out mainly in Sun and days cleared with 20% of cloud cover, with an activity of 2.2 and 2.6 MET and 1 CLO clothing insulation. Sessions in which the collected data of conditions were felt in comfort climate indicate that during those days average maximum temperature 24.3 °C, minimum 16.4 °C, maximum air temperature 21 °C and minimum 18 °C, the maximum heat Index 22.0 °C and minimum 18.8 °C. Relative humidity average of 66.7 %. Wind speed was very low, being that higher 0.8 m/s and the airflow of 0.1 m/s.

Considering the above climate and environmental conditions, clothing insulation and metabolic activity, it is interesting to note that the maximum temperature for thermal comfort of the experimental group was 22 ° C, below of the thermal comfort parameters for common people which is 25.4 ° C. The relative humidity and wind speed values were within comfort but no maximum or minimum comfort values could be determined (Fig. 4).

In most of the sessions in which the experimental group express comfort were when the days were cloudy, as well, when they were under the shade.



	shade 24/08/11	sun 31/08/11	sun 07/09/11	sun 11/09/11	sun 28/09/11	shade 11/09/11	shade 12/10/11
Temperature ºC	18.6	21.89	24.35	24.09	22.73	17.94	16.38
Air temperature ºC	20	21	19.5	18	19.5	20.5	20
Heat Index ºC	16.8	17.49	22.04	21.93	19.59	15.68	14.92

Figure 4: Thermal comfort analysis Chart

According to bioclimatic analysis from August to October between 7 a.m. to 11 a.m. the climate conditions are below the thermal comfort of common people, then people with DS could present greater heat intolerance than those persons under normal conditions.

It is important to indicate that the experimental group did not express verbally their discomfort, but it was through physical actions, or the request that their jackets be removed, for example. In the first's session they acted by imitation, but at the end of the evaluation period, individuals express themselves independently; they developed as well the ability to express the sensation of heat or cold. Inside the classroom the collected data the average of maximum temperature was 20.5 °C and minimum was 18.5 °C, relative humidity average was 68.5% However the control group did not develop the ability to express comfort or thermal discomfort, so it was not possible to know if they felt thermal comfort or not.

3. Skills analysis: the activities planned for the sessions in the therapeutic garden were designed focusing on different aspects such as: psychomotor development, knowledge of the environment, discrimination and selection of shapes, sizes and colors, time-space relationship which to are aspects consider to improve the cognitive area.

The 60% of the studied group require extended support, which refers to support without limit of time, and the rest of the group require intermittent support which refers at some specific periods of time or actions in their lives.

The evaluation prior to the experimental component indicated that the control group from 43 assessed abilities, 43.8 % of them were acquired (A), 37.6 % were in process of acquisition (PA), and 18.6 % were not acquired (NA). The skills evaluations of the experimental group prior to the experimental component were 37.2% (A), 38.9 % (PA), and 23.8 % (NA).

Results in acquired skills after the experimental component indicated: in control group, 43.8% (A), 38.5% (PA) and 17.8% (NA). In the experimental group, 61.5 % (A), 26.6 % (PA) and 11.4 % (NA).

The control group had a minimum increase in skills acquisition; in contrast, the experimental group had an increase of 24% in the acquired skills. Being the most favored areas, psychomotor development, and knowledge of the environment, discrimination and selection of shapes, sizes and colors.

In addition to these findings it was observed that students were excited during the sessions in the therapeutic garden, also it was relevant that the students showed a breakthrough in verbal and physical expression to discriminate and select objects, colors, shapes and sensations of heat and cold. During the first few sessions the students showed intolerance to the texture of the grass, at the end they tolerated completely the feeling of the grass. Being the gravel their favorite texture. After the first session, they behaved independently in the garden. It was observed that they found difficulties to walk on the grass; however this was beneficial for their psychomotor skills development. They have no problem to follow instructions regarding defined paths within the garden, either linear or circular. Finally during some of the sessions, sounds from nature were used as support, such as water, birds singing in which they were more relaxed in contrast to when this setting was not used. In contrast to results of surveys regarding the preferences of natural elements, the shadow and the stones were attractive. Considering that the assessment prior the experimental components were held with visual supports.

CONCLUSION

The evaluations realized in the Foundation CEDAC (Centre of education and training for people with Down syndrome), in the State of Mexico, suggested that the experimental group accepted the guidelines of design for Healing gardens. Specifically for people with DS, shaded spaces, acoustic and wind barriers, open spaces with a clear view, circulations paths with defined shape and with different textures should be considered, as well as the use of elements like vegetation with medium size fruit trees, and flowers with red, yellow and orange colors. Natural elements such as water and stones, the sounds of nature are of significant influence for the individual's mood.

The maximum limit of thermal comfort of persons with DS is about 22ºC, which is lower than the common persons (25.4 °C). To obtain more specific values it is suggested to obtain Climate analysis and assessments of skills in longer periods of time and with individuals of different ages.

The methodology determined in this research work will be useful for future studies, whereas climate analysis of the site, parameters of thermal comfort, conditions and characteristics of DS individuals are involved.

Although it is true that the activities of people in green areas are for relaxation or fun, programs and activities can be developed in specialized centers for people with DS to improve their cognitive skills, the seven session described in this work have demonstrated a 24% increase in the acquired skills in particular on the cognitive area of the experimental group.

The activities that can be performed in a therapeutic garden can be varied according to the needs of the users. Also it is important that sessions at the therapeutic garden be developed with a specific plan of activities and with supervision of the therapist, considering that is a space full of stimuli in which individuals may lose attention easily.

The conditions of comfort and the outdoor design guidelines for a therapeutic garden for people with Down syndrome have been determined and their impact on the development skills in particular in the cognitive area has been demonstrated.

Today the CEDAC Foundation carries out activities in the therapeutic garden as part of their training and education programs at all levels of people with DS that they attend.

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