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The effects of therapeutic exercises and education to parents on weight bearing, range of motion, joint stability, and disease complications in 4-10-year-old children with congenital hip dysplasia

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Abstract

Background: Late diagnosis and treatment of congenital hip dysplasia (CHD) can cause many problems in a person's daily life.

Aim: Therefore, the present study aimed to investigate and compare the effect of therapeutic exercises and education on parents' weight bearing, range of motion, joint stability, and disease complications in 4-10-year-old children with congenital hip dysplasia.

Materials and Methods: This semi-experimental study was conducted with a pre-test and post-test design on 40 children with CHD in two groups of 20 people: therapeutic exercises and education. The training program of the therapeutic exercises group was done on a middle day for 8 weeks from 60 to 90 min in each session. Also in the training group, parents were taught about the correct methods of sitting, standing, and lying down. Before and after the intervention, the subjects were evaluated by the researcher in terms of performance indicators. These indicators were evaluated with specialized tests (weight bearing with standing flexion test, range of motion with stork test, and joint stability with sitting test). The analysis of variance was used to compare the differences between groups in terms of the effect on the indicators.

Results: Based on the findings, the difference between the two groups of therapeutic exercises and education to parents was significant in weight-bearing and range of motion (P=0.000 and P=0.000), but in hip joint stability and disease complications, no significant difference was observed (P=0.269 and P=0.163).

Conclusion: Considering the greater effectiveness of the therapeutic exercises, it is suggested to design a codified program in the physical education program of U10 children to correct skeletal abnormalities, especially hip dysplasia.

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1. Introduction

Developmental Dysplasia of the Hip (DDH) is a condition where the hip joint does not properly form in babies and young children. This can lead to a dislocated or unstable hip joint, causing discomfort and mobility issues. Sometimes, the ligaments that help hold the joint in place are stretched. The degree of laxity or instability of the hip joint in children with hip dysplasia is different. In the most severe condition, the femoral head is displaced from the socket [1].

Congenital hip dysplasia (CHD), if not treated properly in childhood, can cause many problems for the patient in adulthood. The most important of these problems are pain in the hip joint, lameness, and shortness of the lower limbs [2]. Among these problems, pain is the most important and troublesome. Pain can keep a person away from living a comfortable life. The cause of pain in these patients is the rubbing of the head of the femur into the remaining deformed cavity of the acetabulum. In case of severe pain, the patient has no choice but to undergo hip replacement surgery [2]. However, researchers have not yet been able to provide a definitive treatment method to fix the hip in these children [3].

Treatment for hip dysplasia in infants requires special measures because if the head of the femur remains in an abnormal position, the hip joint will not develop normally. The earlier the initial treatment is started, the more likely the treatment will be successful and the lower the long-term complications [4]. The common interventions in this direction are [5]:

a) therapeutic modalities including ultrasound waves, electrical stimulation, cold therapy, laser, and other methods to reduce the pain and inflammation of tendons and bursae damaged in the joint;
b) Neuromuscular retraining (restoring nerve and muscle coordination) including techniques to restore stability in the hip joint and leg muscle retraining;
c) manual therapy techniques that include soft tissue massage, muscle stretching, and contraction by the physiotherapist, which is done to improve the position of the joint and its range of motion;
d) Corrective movements, including stretching exercises and strengthening exercises to restore the range of motion of the joint;
e) Strengthening, stretching, and stabilizing exercises provided to the patient, as well as providing instructions for performing daily activities and improving the patient's performance level.

Among these interventions, corrective movements and therapeutic exercise have been investigated less in research [2], so it is necessary to conduct more studies on finding effective corrective movements for the treatment of CHD in children.

There is evidence that parents influence motor behavior of their children through role modeling (being active themselves), material support (financial, logistic, co-participation), and encouragement [5]. During the first COVID-19 virus lockdown, parental encouragement and support was positively associated with healthy active behaviors in children and adolescents [5].

Most of the previous studies have focused on cross-sectional designs describing the association between children's disease complications and environmental factors and a possible association between parental role modelling and children's abnormal position. On the other hand, both evidence on parental

education on lifestyle and information regarding the exercise therapy in primary school children is scarce.

Zviriaka et al. (2021) stated that the use of rehabilitation measures helps to eliminate the consequences of hip dysplasia, significantly improve the function of the musculoskeletal system, correct the imbalance of soft tissue components, and prevent further complications [6]. Also, Reimer et al. (2019) suggested that progressive resistance training can be an alternative to osteotomy. In many previous cases, surgery has been used to treat CHD, which has always been criticized due to the patient's fear, high costs, and specific risks of surgery [7]. It should be noted that most cases of CHD patients refer to treatment clinics at the age of 5 to 11 years, but no research found that the performance indicators of children have improved at this age [8].

Concerning therapeutic exercises and teaching correct movements to children and their effect on the recovery process of DDH, a research gap is observed in the literature. Therapeutic exercises are a special rehabilitation exercise program based on the individual's condition and using techniques that aim to improve the patient's ability to bear his own weight on the legs and hip joint, balance, and muscle strength [9].

Therefore, in this research, for the first time, we designed and compared two methods of therapeutic exercises and movement education with the aim of improving functional indicators (weight bearing, improving range of motion, hip joint stability) and disease complications in children with CHD.

2. Materials and Methods

2. 1. Participation

This semi-experimental study with a pre-test and post-test design was conducted on 4-10-year-old children with CHD in Tehran and Alborz provinces. The sample size was estimated to be 40 individuals based on the previous studies and Cochran's formula. After sending an invitation to participate in the research to the parents of people interested in participating in the research, 40 people were randomly selected. After performing medical and physical tests, the subjects were randomly assigned to two groups: therapeutic exercises (20 people) and parental education (20 people).

The inclusion criteria were age between 4 to 10 yrs., at least one positive item in neurological assessments, at least one positive item in screening assessments, the normal IQ level, and education of parents.

The exclusion criteria were absence at more than two sessions of training/education, worsening the disease symptoms during the study, and not being willing to do the sessions.

Informed consent was obtained from parents and all potential risks and issues related to the study were explained to them.

2. 2. Instrument

The specialized evaluations used in this research were: a) screening evaluations (examination of disease complications) and b) objective evaluations (examination of variables of weight bearing, range of motion, and joint stability).

2. 2. 1. Screening evaluations (examination of disease complications)

a) Nerve stretching test

The patient lies on the non-involved side and the tester gives the patient's back and a full flexion to the neck and spine. The lower leg is in full flexion. The tester then places

the upper leg in full extension and some abduction (the patient's knee should be flexed). If this nerve is involved, neurological symptoms appear during the test, and pain is felt in the front of the thigh [10].

b) Stretch test of the lateral cutaneous nerve of the thigh

It starts in a situation similar to the previous test. Along with the bending of the neck and spine, the lower knee bends. The tester stabilizes the pelvis while holding the leg in slight hip adduction and knee extension with the other hand. The leg is brought into maximum hip extension, which puts pressure on the lateral femoral cutaneous nerve. Then the patient is asked to put his neck in the extension position. When pain occurs, along with hip extension and pain decreases with neck extension, the test is positive [11].

c) Leverage test

The patient sits on the bed with one leg bent and hanging under the other leg. The tester places a forearm under the midpoint of the thigh slowly brings it down and presses on the distal femur. The forearm can move from top to bottom and apply pressure. If there is a fracture in the bone, the symptoms of the patient will appear [10].

d) Hamstring length test

The patient lies supine and the leg is extended and the tester is placed next to the patient to perform the test. The patient's opposite ASIS is palpated and the ankle is tested. The patient's leg is raised and the knee is extended until the ASIS moves against it. The therapist measures the hip flexion angle and the test is repeated on the other side. This test can be used to stretch the nerve with dorsiflexion of the ankle before raising the leg and as long as the knee is extended [12].

e) Directly active leg-raising test

This test measures the ability to transfer load effectively between the lumbar-sacral vertebrae and the legs. If the movements are in the pelvis, attributed to the trunk or legs, then there can be instability of the pelvis or weak muscle activation in that area and the general system [13].

2. 2. 2. Objective evaluations (examination of weight-bearing variables, range of motion, joint stability)

a) Standing flexion test (forward trunk bending)- range of motion

In this test, the iliosacral movements are completed by locating the PSISs. The patient is asked to lean forward from the midline to touch the fingers. The head and neck should be in flexion and the hands should hang loosely from the shoulders. The patient should bend forward and the therapist should note the upward movements of the PSIS and related movements of the pelvic girdle in the femoral head. The normal response is the relative movements of PSISs. This test may be repeated several times [14].

b) Stork test (test of stability)- evaluation of weight-bearing

It checks the osteo-kinematic movements of the inamina and sacrum and the lower back vertebrae. The PSISs are located from the back and the patient is asked to stand on one leg and raise the knee to 45 degrees of hip flexion. PSIS moves down more on the non-weight-bearing side. The weight-bearing side moves less. An alternative assessment method is to use the second lumbar spine as a reference point. Anterior rotation of the non-weight bearing inamina test was positive [14].

c) Sitting test- joint stability

The sitting position fixes the inamina on a chair or bed and eliminates the influence of the hamstrings on the pelvis, and the sacroiliac movement within the inamina is tested. In addition, active rotation of the trunk is better tested in this position because hip and pelvis movements are stabilized. The therapist should pay attention to the patient's posture in this position because the patient with sacroiliac dysfunction often takes help from a healthy battuk to sit. The same sitting position also facilitates neurological assessment, which includes testing muscle strength, sensation, and stretch reflex of muscles like lying down [14].

2. 3. Procedure

The exercise program of the therapeutic exercises group started as one day in the middle (three days a week) with one hour per session and gradually increased to one and a half hours per session during 8 weeks. Each training session consisted of a 10 min warm-up, a body workout, and a 10 min cool-down. The principle of overload was applied in the form of increasing repetitions (from 4 to 10), using aids and changing the type of movement [15]. The exercises used in this research fall into two general categories: stretching and strengthening exercises. The framework, goals and categories of exercises have been prescribed and evaluated as effective in previous research, including Schwend, Shaw, and Segal (2014). The researcher made changes in the exercises to match the characteristics and needs of the samples of the present research [9].

Therapeutic exercises were performed by the researcher and help was taken from a research colleague to control the subjects' movements. The exercises included the following two categories:

a) Stretching exercises for the muscles around the hip joint with the aim of reducing stiffness and improving joint mobility (knee lift, external hip rotation, double rotation of hip, hip, and lower back stretch). For example, in knee lift exercise you should first lie on your back and place your legs and thighs flat on the floor. Then keep the left leg straight raise the right knee and pull it towards the chest. Place both hands on that knee and pull your knee towards your chest with your hands.

b) Exercises to strengthen the hip muscles with the aim of supporting the hip joint and pain relief (hip flexion, hip extension, hip abduction, raising the heel to the hip, minor squat, quadriceps arc short, quadriceps toe up, bridging, standing up from chair, abdominal exercises). For example, in a minor squat, you should first stand straight and spread your legs shoulder-width apart. Then, if necessary, hold a chair, table, or wall and lean on them. Then, 3-keep your back straight. Bending your knees, slowly lower your body until your knees are above your toes. Stay in this position for a few seconds. Then straighten your legs to return to the starting position.

On the other hand, in the education group for parents, weekly meetings were held in the presence of the parents of the children. In these meetings, education was given through video clips, brochures, and oral presentations by an expert in this field regarding the correct methods of sitting, standing, and lying down, and brochures were provided to the parents about the child's height status. Then, the subjects were evaluated by the researcher in terms of performance indicators.

2. 4. Statistic

SPSS version 26 software is used for data analysis and statistical operations. To provide descriptive statistics, mean, standard deviation, and frequency distribution charts and tables are used. In inferential statistics, the Shapiro-Wilk test is used to check the normality of data distribution. In order to compare the average and find the effect of the intervention in each group, before and after the intervention, the parametric t-test is used. Variance analysis is used to compare the difference between the research groups in the effect on the investigated indicators. The significance level for all statistical analyses is considered at $\alpha < 0.05$.

3. Results

Based on the findings, the average age of children with hip dysplasia was 7.14±1.55 in the therapeutic exercises group and 6.90±1.61 in the parent education group. Disease complications in these children were determined based on the number of positive cases in screening evaluations (femoral nerve stretching tests, lateral cutaneous nerve stretching tests, leverage, hamstring length, and leg active raising).

Performance indicators in the current research were evaluated with specialized tests (weight bearing with standing flexion test, range of motion with stork test, and joint stability with sitting test). Figures 2 to 4 show the mean and standard deviation of the subjects of the two research groups in the pre-test and post-test of performance indicators.

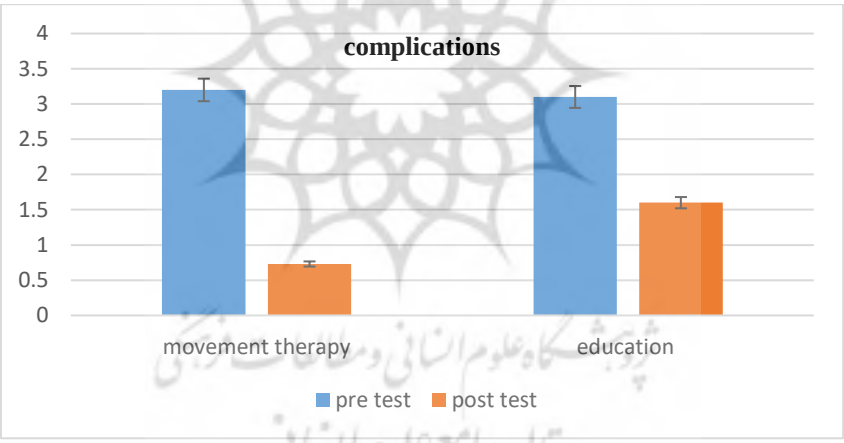

Figure 1. The disease complications in two groups of research

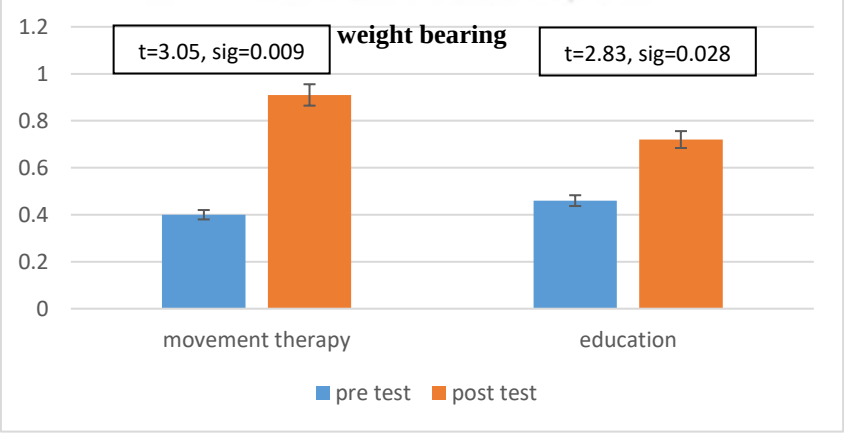

Figure 2. Weight bearing in two groups of research

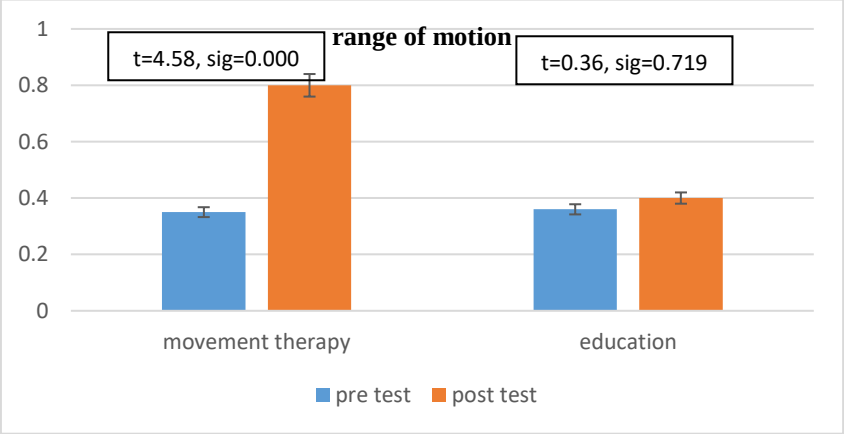

Figure 3. Range of motion in two groups of research

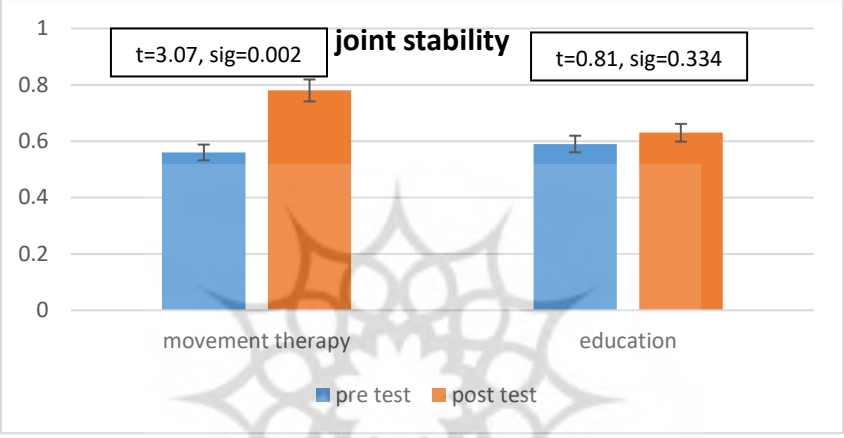

Figure 4. Joint stability in two groups of children with hip dysplasia

The results of the research in this section indicated that the therapeutic exercises group had improvements in disease complications (P=0.000; t=3.22), weight-bearing (P=0.009; t=2.05), range of motion (P=0.000; t=4.58) and joint stability (P= 0.000; t=3.07) at $P\leq0.05$ level of significance. Also, the parent education group experienced a significant improvement in disease complications (P= 0.000; t=3.06) and weight bearing (P= 0.028; t=2.83), but no significant change was made in their range of motion (P= 0.719; t=0.719) and joint stability (P= 0.334; t=0.334) at $P\leq0.05$ level of significance. To compare the research groups in the studied variables, the analysis of variance statistical test was used (Table 1).

The analysis of variance results showed that the difference between the two groups in weight-bearing (P=0.002; f=10.50) and range of motion (P=0.000; f=22.28) was significant (P=0.05). However, their differences were not significant in terms of disease complications (P=0.193; f=2.30) and joint stability (P=0.269; t=1.75) at P=0.05 level of significance.

Table 1. ANOVA test results to compare research variables between two groups

Variable	Sum of squares	d.f	Mean square	F	Sig
Complications	1.63	2	0.84	2.30	0.193
Weight bearing	3.60	2	1.80	10.50	0.002*
Range of motion	4.13	2	2.06	22.28	0.000*
Joint stability	1.58	2	0.79	1.75	0.269

4. Discussion

Congenital defects of the musculoskeletal system are of particular importance among birth deficiencies [16]. CHD develops gradually after birth and, if not diagnosed and treated early, leads to negative consequences that will appear in preschool and early elementary school age [17, 18].

Based on the findings of this research, a significant change in the complications of the disease was observed in both therapeutic exercises and parent education groups.

Moreover, the effect of therapeutic exercises on functional indicators (weight-bearing, improved range of motion, and hip joint stability) in children with dysplasia. The results showed that all three variables of weight bearing, range of motion, and hip joint stability had a significant change in the therapeutic exercises group from pre-test to post-test. However, in the second research group, the range of motion and the strength of the hip joint in the parent education group did not change significantly from the pre-test to the post-test. However, training to parents was able to create a significant improvement in weight tolerance.

Also, there was a significant difference between the two groups of exercise therapy and training for parents in weight-bearing and range of motion, but no significant difference was observed in hip joint stability and disease complications. These findings were consistent with the results of Mortensen (2018) [19], Sakellariou et al. (2014) [20], and Reimer et al. (2019) [7] and inconsistent with the results of Harris (2021) [21] and Numanoğlu et al. (2020) [22].

By understanding the nature of CHD and its potential long-term effects, parents can actively participate in their child's treatment plan and provide necessary support at home. Education on proper positioning and handling techniques is also essential in preventing further damage to the hip joint. Parents can also learn how to identify early signs of CHD and seek appropriate medical attention, leading to earlier diagnosis and treatment [23].

As Zviriaka et al. (2021) have pointed out, the use of rehabilitation measures helps to eliminate the consequences of hip dysplasia, significantly improve the function of the musculoskeletal system, correct the imbalance of soft tissue components, and prevent further complications [6]. Weight-bearing, joint stability, and range of motion seem to be closely correlated because they all had similar changes as a result of the therapeutic exercise program [24].

According to Harris, Lewis and Park (2021), the muscles surrounding the hip joint are responsible for supporting and stabilizing the joint, as well as facilitating movement. When these muscles are weak or tight, it can lead to imbalances and compensations, which can further aggravate the condition. By targeting these muscles with specific exercises, children can improve their muscle strength and flexibility, allowing for better joint function and reduced discomfort [21].

Structured treatment and prevention of problems in people with CHD is a priority. Although some physical education programs have randomly paid attention to corrective movement exercises for children with posture disorders, there is still no written action to deal with the problems [25, 26, 27].

Dysplasia has not been studied in preschool and elementary school children, and the exercises that have been used so far have not been effective enough [28].

Considering the above and due to the

lack of sufficient research on the effect of corrective movements in controlling the complications of CHD, we addressed this issue in the present study.

It is important that once the child is mobile, an appropriate walking program should be established for the child to prevent further trauma to the hip. Dropping weight immediately after hip and knee mobilization should be done with care and it is recommended that this is possible when there are at least 90 degrees of hip and knee flexion and the muscles are strong to prevent duck walking. Also, it is important to prevent any asymmetry in walking as soon as you start walking. For example, if the left side is not corrected, this may become habitual for the child and cause later acquired deformities. In the current research, there was a special emphasis on this issue in training, which can be the main reason for the improvement of performance indicators in the parent education group.

Defects in the development of anatomical structures and the weakness of joint ligaments that continue until the child starts walking cause that even if treated on time, 5-20% of cases do not achieve stability of the head of the femur in the acetabulum, and in 60% of cases this instability is associated with joint damage and ischemic disorders [29, 30, 31]. One of the important signs observed in patients with this condition is a violation of the correct pattern of walking and standing [32]. This indicates the importance of correcting walking patterns and maintaining correct posture in these people.

5. Conclusion

Considering the effectiveness of the corrective movement exercises used in this research, it is suggested to design a codified program in the school physical education program to correct skeletal abnormalities, especially hip dysplasia. In addition, since teaching parents were able to produce results similar to corrective movements in the weight-bearing factor, this emphasizes the need to increase the knowledge of all parents through the media and other methods such as parents' associations and schools, because you can achieve impressive results with minimum time. Finally, it is suggested that more research be done on the effectiveness of different types of corrective movement exercises that affect the pelvic region (such as core stability exercises) to control complications and disease risk.

According to this research, the therapeutic exercise method was more effective in improving performance indicators than teaching parents. The therapist's practice, by designing a special therapeutic exercises program based on the condition of these people, used techniques to gradually increase the patient's ability to bear his weight on his legs and hip joint, his balance, and muscle strength.

Based on the present findings as well as the results of previous researchers [17, 19, 21], it can be stated that the mechanisms through which therapeutic exercises have caused changes in the functional capacity are putting adjusted pressure on the pelvis, improving the stability of the pelvis due to the strengthening of ligaments and tendons, and also reducing the complications caused by the disease due to the improvement of blood supply to It was the pelvis.

Overall, therapeutic exercises are recommended for helping children with CHD as the positive outcomes shown such as strengthening muscles surrounding the hip, improving joint mobility, correcting poor posture, decreasing tendon inflammation, enhancing gait, and better body awareness.

Conflict of interest

The authors declared no conflicts of interest.

Authors' contributions

All authors contributed to the original idea, study design.

Ethical considerations

The authors have completely considered ethical issues, including informed consent, plagiarism, data fabrication, misconduct, and/or falsification, double publication and/or redundancy, submission, etc.

Data availability

The dataset generated and analyzed during the current study is available from the corresponding author on reasonable request.

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