Journal Homepage: - www.journalijar.com
INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)
ISSN NO. 2320-5407
Article DOI: 10.21474/IJAR01/1461
DOI URL: http://dx.doi.org/10.21474/IJAR01/1461

RESEARCH ARTICLE

IMPACT OF AQUATIC EXERCISE PROGRAM ON PAIN SEVERITY AND GAIT PARAMETERS IN CHILDREN WITH JUVENILE RHEUMATOID ARTHRITIS.

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Manuscript Info

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Manuscript History

Received: 15 July 2016
Final Accepted: 19 August 2016
Published: September 2016

Key words:-
Aquatic exercise, juvenile rheumatoid arthritis, polyarticular, Gait

Abstract

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Background:- Juvenile rheumatoid arthritis is a significant public health problem that frequently restricts patients' activity with a major impact on gait.
Objective:- To investigate the effect of aquatic exercise program on selected gait parameters in children with juvenile idiopathic arthritis.
Methods:- Thirty poly-articular Juvenile idiopathic arthritis of both sexes aged from 8-12 were assigned randomly into two groups A&B (control and study) of equal numbers. All patients were evaluated for the following parameters, Pain, knee circumference and gait parameters [Foot off %, Step length (m), Cadence (steps / min), Speed (m /s), Stance phase %, Swing phase%] by 3-D motion analysis Lab before and after treatment program. Subjects in control group received selected physical therapy program (infrared radiation, muscle stretching, strengthening exercises, proprioceptive training, and gait training), whereas subjects in study group received the same selected physical therapy program in addition to aquatic exercise program. The program was applied 3 times/week for 3 successive months.
Results:- There was significant improvement in all measured variables in both groups but in favoring to study group (p value <0.05).
Conclusion:- Combination of exercise program and aquatic exercise program had significant effect on improving gait parameters and reducing pain in children with juvenile idiopathic arthritis.

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Introduction:-

Juvenile rheumatoid arthritis (JRA) is a disease that occurs in children beginning before sixteen years of age, persist for more than 6 weeks (Nevitt, 2004). Although JRA is a chronic disease of childhood, the actual cause of the disease is unknown (Hashkes and Laxer, 2005). Some common signs and symptoms of JRA are morning stiffness, joint guardian, fatigue, sleep disturbances and irritability (Tecklin, 2008). Juvenile Idiopathic Arthritis (JIA) is the commonest infrequently rheumatic disease in childhood with a variable worldwide prevalence ranging from 0.07 to 4.01 per 1000 children (April etal, 2006).

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Symptoms of JIA are often non-specific initially, and include lethargy, reduced physical activity, and poor appetite. The first manifestation, particularly in young children, may be limping. The cardinal clinical features are persistent swelling of the affected joint(s), which commonly include the knee, ankle, wrist and small joints of the hands and feet. Pain is an important symptom. Morning stiffness that improves later in the day is a common feature. Late effects of arthritis include joint contracture (stiff, bent joint) and joint damage. Children with JIA vary in the degree to which they are affected by particular symptoms (Judith, 2010).

In Behrens et al, (2008)'s study, equal distribution between polyarticular and oligoarticular patterns was noted at presentation (41% polyarticular, 40% oligoarticular and 7% monoarticular presentation) The wrists, knees and ankles are primarily the most commonly involved on initial presentation (Schneider and Laxer, 1998). Polyarticular JIA affects 5 or more joints in the first 6 months of disease. Usually the smaller joints are affected in polyarticular JIA, such as the fingers and hands (De Benedetti, 2003).

The most common complication of JIA is growth disturbances as the involved joint has an increase in blood flow due to the inflammatory nature of the local arthritis. This increase in blood flow encourages the area of bone growth (growth plate) to maximum activity and thus the involved leg is longer than the non-involved limb. However, as the disease progresses, the chronic nature of arthritis can damage the growth plate region causing premature fusion and thus the involved leg will be retarded relative to the uninvolved limb (Hartmann etal, 2010).

While juvenile arthritis is markedly different from adult rheumatoid arthritis, goals of management are similar, including reduction of joint inflammation, pain relief, prevention of disability and maintenance of function, the provision of education and attention to psychosocial, growth and development needs. A multi-disciplinary approach is required to deliver a comprehensive and effective program (Rosch and Markov, 2004).

Physical activities are increasingly considered as an important part of treatment for JIA patients. Moreover inactivity is expected as a major factor of substantial negative effects for the musculoskeletal system, the whole body-composition, and the physical ability of JIA patients (Hartmann etal, 2010).

Hartmann and his colleagues (2010) found that, there was wide range of disturbances in the mobility of the lower extremities in patients suffering from JIA. Nearly one third of JIA patients reaching adulthood suffer from limitations in their ability to move, therefore it is mandatory to enhance the treatment of children with rheumatic diseases especially concerning physiotherapy and sport therapy.

Aquatic therapy, is the use of water and water-induced resistance to improve physical function (Ondrak and Thorpe, 2007). As a result, aquatic physical activity protects the joint integrity than land-based activity (Fragala-Pinkham etal, 2009). Previous studies have reported that applying motor skills in water can potentially increase confidence and lead to less resistance with difficult tasks when compared to land training (Retarekar etal,2009). Moreover, activities in the water is a pleasure for children, enhancing motivation and interest (Thorpe etal, 2005).

The purpose of this study was to investigate the effect of an aquatic exercise program on pain and gait parameters in children with polyarticular juvenile idiopathic arthritis.

Methodology:-

Subjects and Methods:-

Thirty children had polyarticular JRA participated in the study ranged in age from 8 to 12 years. They were recruited for the study from the Abu- El-Rish Hospital, Cairo University and the National Institute of Neuromotor disorders , according to the following criteria:

Inclusion criteria: All patients should have fulfilled the American College of Rheumatology (ACR) criteria for polyarticular JRA: (Presence of arthritis in five or more joints during first 6 months of disease. Symmetry of arthritis, however, the degree of involvement was varied. Cardinal hallmark signs and symptoms of joint involvement in JRA that generally were marked by pain, swelling and morning stiffness).

Exclusion Criteria: Patients with systemic or oligoarthritis onset, patients with advanced radiographic changes, including (bone destruction, bony ankylosis, knee joint subluxation, epiphyseal fractures, growth abnormalities related to marked skeletal changes of JRA) , patients who had congenital or acquired skeletal deformities, patients who had any cardiopulmonary dysfunctions, Children with infectious dermatological conditions all were excluded.

All subjects gave written informed consent. All patients were initially aware about and fully understand the purpose and procedures of the study and so an informed consent was obtained from each patient; giving agreement to participation and publication the results of the study. All patients received the same medical treatment and the standard physical therapy program. Patients were randomly assigned into two groups through two stages by a person who did not share any other part of the study. First; eligible patients who fulfilled the inclusion criteria were initially recorded. Secondly; all reported patients were randomly assigned to either the study or the control group through a random number generation using an online random permutation generator from http://www.randomization.com.

Instrumentation :-

For Evaluation:-

1. Visual analogue scale
2. Three dimensional gait analysis

For Treatment:-

1. Bicycle ergometer
2. Infrared radiation
3. Swimming pool to apply under water exercises
4. Floating aids
5. Tumble forms (mat, wedges ,tilting board rollers and medical balls) from Preston for the application of the exercise program.

Procedures:-

For Evaluation:

-The primary outcome measure was pain:-

It was measured by a 10-cm visual analog scale (VAS), with 0 indicating no pain and 10 for maximal pain. The child was asked to bisect the line at point representing his or her position on scale. The score then obtained by measuring from 0 to the mark bisecting the scale (Burckhardt and Jones, 2003) before the treatment (pre-treatment) and by the end of three successive months of treatment (post treatment).

-The secondary outcome measured was gait parameters ((Foot off %, Step length (m), Cadence (steps/ min), Speed (m / s), Stance phase %, Swing phase %) evaluated by 3D motion analysis system:

Before data collection, the motion capture system was calibrated to assure accuracy of the obtained values. This calibration required these tools: A wand to provide the camera system with the measurement points to be used for the calibration. A reference structure for defining the calibration coordinate system. The reference structure was placed horizontally along the floor in the measurement area which is covered by the cameras. All cameras viewed the markers.These markers are retro reflective markers (diameter, 14 mm) were attached to specific anatomic landmarks including the anterior superior iliac spine, the superior border of the patella, a lateral point to the knee joint line, the tibial tuberosity, the lateral malleolus, the posterior aspect of the heel on the calcaneus bone, and between the second and third metatarsal heads of the foot. The six cameras which were used in capturing the patient motion were arranged as three on each side of the eight meters long walkway at a height of one and half to two meters. The participants stood comfortably with their feet placed shoulder-width apart on the floor, equidistant from the midline. The parents confirmed that the performance was representative of their children’s common gait pattern. Movements were recorded simultaneously with each camera and stored on a computer disk for analysis. Motion and calculations were recorded using the Q-trace C version 2.51, Q-trace V version 2.60, and Q-Gait 2.0 software (Qualisys; Qualisys Inc, Gothenburg, Sweden) for each time frame, along with joint angles and temporal parameters. For each child, three walking trials were recorded, and I have selected the best trial.

For Treatment:-
The participants were allocated to either the control group (A) or the study group (B). Both treatment groups received selected physical therapy program, which included infrared radiation, muscle stretching, strengthening exercises, and gait training for three successive months (one and half hr./day, three days/wk.).

Stretching exercises:-
Stretching exercises were conducted to maintain length and elastic recoil of all soft tissue liable to be tight especially the Achilles tendon, hamstring, hip flexors and adductors of lower limbs.

Active, active-assistive and passive ROM exercises, isometric exercises and contract relax techniques.

Strengthening exercises using Bicycle ergometer training:-
First, the patient performed pedaling on a bicycle ergometer starting with unloaded cycling for five minutes as warming up, then with intensity 50 ramps/minute for seven minutes with few seconds rest in between, increasing gradually to 10 minutes at the end of treatment period.

Gait training: in the form of open environment to minimize or eliminate observed deviations. This may be done through postural training; weight-bearing activities; and attention to symmetry, form cadence in front of mirror (Rhodes, 1991).

Group B (study) received the same exercise therapy program given to group A, in addition to the aquatic exercises therapy program for 45 minutes 3/week for a total of three successive months.

All participants used floating vests to ensure safety throughout the study. The aquatic program consists of the following activities in a 27-32°C pool:
- 10 minute warm up exercises focusing on the upper and lower extremities as well as cervical motions.
- 15 minute relay race in the deep end of the pool.
- 5 minute “relaxation period” – floating in a supine position, making no active motion.
- 15 minutes aquatic play activity – at the shallow end of the pool; consists of a modified synchronized swim, a balloon game, volleyball, and standing using a floating board (Ballaz et al,2011).

Data Analysis:-
Descriptive statistics of mean and standard deviation presented the children’s ages, weight, pain and gait parameters include: Foot off %, Step length (m), Cadence (steps / min), Speed (m/s), Stance phase %, Swing phase %. Data were analyzed using the non parametric Wilcoxon’s test and Mann Whitney u test.

Results:-
Thirty children (10 boys and 20 girls) with polyarticular juvenile idiopathic arthritis were included in this study. Participants were randomized to the control and study groups. The ages of participated were10±1.4 yrs and 10.2±1.5 yrs for the control and study groups respectively. The demographic and clinical characteristics of the participants in both groups are listed in Table 1. These data indicated that the groups had homogenous characteristics:

Table 1:- Demographic Data of children in control(A)&study(B) groups.

Variables	Group A (n=15) mean ±SD	Group B (n=15) mean ±SD	P-Value	Sig.
Age (years)	10±1.4	10.2±1.5	0.712	NS
Weight (kg)	32.46±6.2	30.66±5.8	0.981	NS
Height (cm)	137.6±4.5	141.2±6.1	0.12	NS

Before treatment, there were no statistically significant differences (P = 0.106) in the mean± SD values of pain scores between the control and study groups as presented in table (2) In contrast, there was a statistically significant difference (P = 0.006) between the mean values of pain scores obtained during the baseline and post treatment assessments. The post treatment mean ± SD values pain scores’ were 4.73 ±0.80 and 3.8 ± 0.77 for both the control and study groups, respectively. These results indicated that the children in the study group showed remarkable decrease in pain when compared with the children in the control group.

Table 2:- Pre and post treatment pain intensity score within each group and between groups.

Pain intensity	Pre mean ±SD	Post mean ±SD	P value	Sig
Group (A)	5.8±0.86	4.73±0.80	0.006	S
Group(B)	6.47±1.13	3.8±0.77	0.001	S
P-value	0.106	0.006		
Sig. (P<0.05)	NS	S		

Before treatment, there were no statistically significant differences in the mean ± SD of measured gait parameters (foot off was 60.29±0.72 and 61.15±1.77, step length was 0.53± 0.02 and 0.55± 0.23, cadence was 102.3±1.67 and 101.3±1.72, speed was 1.06±0.026 and 1.07± 0.0033, stance phase was 47.2±1.86 and 46.07±1.39, and swing phase was 53.87± 2.17 and 54.8± 1.93) for control and study groups respectively as presented in Table (3). In contrast, there were statistically significant differences between the mean values of gait parameters obtained during the baseline and post treatment assessments ($P < 0.05$). These results indicated that the children in group(B) showed remarkable improvement when compared with the children in group (A) for all measured parameters (foot off was 59.62±1.13 and 57. 5±2.09, step length was 0.55± 0.023 and 0.60± 0.22, cadence was 104.47±3.02 and 106.73±1.33, speed was 1.1±0.029 and 1.3± 0.146, stance phase was 48.87±2.10 and 57.8±1.42, and swing phase was 51. 7± 2.52 and 44.47± 2.75) for control and study groups respectively as presented in Table (6).

Table3:- Comparison of the mean ± SD values of measured gait parameters before treatment for both groups.

Gait parameters	Group (A) mean ± SD	Group (B) mean± SD	MD	P-Value	Sig.
Foot off %	60.29±0.72	61. 15±1.77	-0.86	0.51	NS
Step length(m)	0.53±0.02	0.55±0.23	-0.02	0.55	NS
Cadence(step /min)	102.3±1.67	101.3±1.72	1	0.139	NS
Speed(m /sec)	1.06±0.026	1.07±0.33	-0.01	0.266	NS
Stance phase %	47.2±1.86	46.07±1.39	1.13	0.113	NS
Swing phase %	53.87±2.17	54.80±1.93	-0.93	0.138	NS

Table 4:- Comparison of the mean values of gait parameters pre and post treatment for control group .

Gait parameters for group (A)	Pre mean ± SD	Post mean ± SD	MD	P-Value	Sig.
Foot off %	60.29±0.72	60.29±0.72	0.67	0.017	S
Step length(m)	0.53±0.02	0.55±0.023	-0.02	0.021	S
Cadence(step /min)	102.3±1.67	104.5±3.02	-2.2	0.013	S
Speed(m /sec)	1.06±0.026	1.1±0.029	-0.04	0.001	S
Stance phase %	47.20±1.86	48.87±2.19	-1.67	0.005	S
Swing phase %	53.87±2.17	51.7±2.52	2.17	0.002	S

Table 5:- Comparison of the mean values of gait parameters pre and post treatment for study group.

Gait parameters For group (B)	Pre mean ± SD	Post mean ± SD	MD	P-Value	Sig.
Foot off %	61.15± 1.77	57.5±2.1	3.65	0.017	S
Step length(m)	0.54±0.018	0.60±0.022	-0.06	0.021	S
Cadence(step /min)	101.33±1.72	106.73±1.33	-5.4	0.013	S
Speed(m /sec)	1.07±0.033	1.29±0.15	-0.22	0.001	S
Stance phase %	46.07±1.39	57.8±1.42	-11.7	0.005	S
Swing phase %	54.8±1.93	44.47±2.75	10.3	0.002	S

Table 6:- Comparison of the mean values of gait parameters post treatment for both the control (A) and study (B) group.

Gait parameters	Group (A) mean ± SD	Group (B) mean ± SD	MD	P-Value	Sig.	%of changes
Foot off %	59.62±1.13	57. 5±2.09	2.12	0.002	S	3.6
Step length(m)	0.55±0.023	0.60±0.22	-0.05	0.001	S	9.1
Cadence(step /min)	104.47±3.02	106.73±1.33	-2.26	0.01	S	2.16
Speed(m /sec)	1.1±0.029	1.3±0.146	-0.02	0.001	S	1.8
Stance phase %	48.87±2.10	57.8±1.42	-8.93	0.000	S	18.3
Swing phase %	51.7±2.52	44.47±2.75	7.23	0.001	S	13.98

Discussion:-

Statistical analysis of the post treatment results of the present study revealed great improvement in pain and gait parameters in both control (A) and study (B) groups when comparing their pre and post treatment mean values. Improvement was noticed in favor of group B receiving aquatic therapy program, in addition to the selected physical therapy program, when comparing its post treatment mean values with that of group A.

The gait pattern of children with JIA is complicated by compensatory gait alternations, resulting from joint pain, stiffness, and in some cases joint deformity. It has been shown that the kinematics of the hip, knee and ankle joints is clearly related to walking velocity (Broström etal,2002) , and that both the profile and magnitude of the external ground reaction forces are velocity dependent (Bauby and Kuo2000& Broström,2007). Individuals with physical weakness or dis-coordination may not be able to adjust step width with similar biomechanical mechanism to maintain walking balance (Burckhardt and Jones 2003).

The improvement reported in gait parameters in both control and study group can be attributed to the increase in lean muscle mass in both groups that received exercise therapy in the form of passive stretching, strengthening exercises, in form of bicycle ergometer and this comes in accordance with studies that revealed that exercise therapy can increase joint range of motion, endurance, muscles strength and coordination and can improve joint stability (Brighton etal,1993).

Muscle activation during exercise therapy will cause blood circulation improvement, reducing hypertension and more efficient oxygen flowing toward muscles and joints that eventually leads to reducing pain (Buzzard, 2000), in addition water actually represents a medium in which everyone can take part in recreational and therapeutic activities, irrespective of their age (Daly and Lambeck, 2007), a person in pain has difficulty with weight bearing exercise. Aquatic exercise allows aerobic exercise to be accomplished with less load on the joints (Wang etal,2007).

Mechanism of more improvement in pain intensity by aquatic exercise therapy not familiarized yet (Vaile etal, 2008). However, we can contribute these beneficial influences to physical properties of water. Effects of hydrostatic pressure on the body during the immersion cause centralization of peripheral fluid. This results in various physiological responses such as increasing cardiac output and decreasing peripheral resistance (Wilcock etal,2006). Reducing edema, inflammation and improvement in contractile tissues activity are the results of this process.

Another reason for more reduction in pain level in patients following aquatic exercise therapy can be associated with water temperature. The main physiological responses due to immersion in cold water include local hypovascularity and decreasing blood flow that can reduce the edema (Marossy etal, 2009). However, applying cryotherapy will induce antalgic effect, so can decrease pain in patients (Cheung etal, 2003).The Arthritis Foundation Guidelines suggest a superior limit range of water temperature of 31°C (Foundation, 2002).

Despite the explained reasons, the placebo effects of aquatic exercise therapy should not be neglected. Hróbjartsson and Gøtzsche (2001) studied the placebo effects of aquatic exercise therapy and concluded that this approach has the main beneficial effects on subjective symptoms while no significant difference was indicated in objective symptoms. The subjective symptoms of (i.e., pain intensity) was significantly improved in subjects who finished the aquatic treatment intervention, but there was no significant difference in objective measurements (i.e., knee joint ROM) after performing therapeutic interventions in both experimental groups (Hróbjartsson and Gøtzsche,2001).

Despite what is assumed, the most important aspect of treating patients through aquatic exercise therapy is related to buoyancy, rather than water temperature. This unique property of aquatic exercise therapy will cause decreasing pressure exerted on the lower extremity due to weight bearing, thus encourages patients to continue their therapeutic program in a more effective way (Hinman, 2007). We believe that this principle is the reason for reducing pain and improving gait parameters.

An additional benefit of aquatic exercise is the reduced levels of joint loading and impact, providing a gentler environment for children with unstable joints who experience persistent and abnormal loading (Dodd etal, 2002).

Conclusion :-

Adding underwater exercises to the exercise program are effective for improve gait parameters and reduce pain in children with juvenile idiopathic arthritis

Conflict of interest:- The authors declared no conflict of interest.
Funding:- The authors received no fund from any individual or organization.

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