Postural Control: Static and Dynamic Balance in Juvenile Rheumatoid Arthritis Patients

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ABSTRACT

The aim of the present study was to assess and identify the effect of a specific balance program on the improvement of postural control for children with rheumatoid arthritis (RA). Children with balance problems often have difficulty controlling posture in static and dynamic situations. Children with rheumatoid arthritis have reported fear of falling and thus reducing their physical activity level. The present study was conducted on 30 Juvenile rheumatoid arthritis (JRA) children of both sex, their ages ranged between 7 to 12 years ($\overline{X}$9.5±2.5). They were divided randomly into 2 groups of equal number (A) and (B). The static and dynamic balance were tested at the start of the study and after 10 weeks. Both groups received the traditional treatment program for JRA 5 times/week. In addition, group (B) underwent a specific intervention program for balance. At the end of the study the results revealed a significant improvement in the static and dynamic balance ($P<0.05$) for group (A) and a highly significant improvement for group (B) in the same parameters measured ($P<0.001$). It could be concluded that static and dynamic balance would be involved in physical therapy for JRA patients.

INTRODUCTION

Juvenile rheumatoid arthritis (JRA) is the most common rheumatic disease of childhood. In a child under age of 16 years, persistent arthritis that lasts for more than 6 weeks can be diagnosed as JRA if other causes of joint pathology have been excluded. The peak onset is between 1 and 3 years[8,9].

Rheumatoid arthritis (RA) is a chronic rheumatic disease characterized by inflammatory flares mainly localized to the synovia of the joints and tendon sheaths. Inflammation may cause pain, as well as episodic or permanent changes in muscles and joints. Temporary or long-term physical inactivity and physical dysfunction may result[8].

Ehdahl (1992)[4] found that RA patients have a greater postural sway in a standing position than healthy controls, and this was postulated to the disturbed postural control.

The feeling of reduced postural control can be reflected in the way that patients perform physical activities. Small step length and abducted upper arms during walking as well as joints that "give away" during motion can be signs of reduced control.

Balance and stability problems may also be evident when there are rapid changes of external stimuli or when a patient is simultaneously concentrating on mental task. Both imbalance and instability may be more apparent during one-foot standing than when standing on both feet[15].

About 50% of patients with rheumatoid arthritis have reported fear of falling, and 38% had reduced their physical activity level because of this fear[6].

So, the present study aimed at assessing and identifying the effect of specific balance training program on the improvement of postural control for children with juvenile rheumatoid arthritis.

SUBJECTS AND PROCEDURES

I. Subjects

Thirty children with Juvenile Rheumatoid Arthritis of both sexes (13 males, 17 females) participated in this study. Their ages ranged from 7 to 12 years ($\overline{X}$=9.5±2.5) and collected from Abou El Reach Paediatric Hospital. They were divided randomly into 2 groups of equal number (group A and B).

- All subjects had the following criteria:
- A known history of JRA for at least 3 to 4 years after the onset.
- Ability to walk without assisstance or assistive device.
- Symmetrical involvement of joints in both lower limbs.
- All patients were under medical control for pain.
- Clinically all children revealed muscle weakness, limited range of motion due to tightness of muscles of lower limbs.
- None of the subjects had fixed orthopaedic deformities or neurological problems (vestibular or cerebellar dysfunction).
- Willingness to participate in this study.

II. Evaluation procedures

- Children of both groups (A) and (B) were administered in static and dynamic standing balance assessment, at the beginning of the study and after 10 weeks.
- They were assessed in a quite room.
- All children were assessed barefeeted with open and closed eyes and demonestrated a practice trial before being tested individually either on static or dynamic balance tests.
- The procedures for both static and dynamic balance tests were scored three times for each test individually and the average value in each condition was recorded.
- A digital stopwatch was used to record the timed measurements of all the static balance conditions.
- The assessment of both static and dynamic standing balance was carried out according to Shumway-Cook and Horak's (1986)[21].

Static balance test: "Single leg stance test":

- Each child was positioned 2 feet from the wall with hands on hips.
- A visual target was placed on the wall at eye level.
- Each subject was instructed to lift one foot and look at the target.
- For the condition of standing balance with eyes open, timing was started using a digital stop watch, as soon as the child lifted his or her foot, while it was stopped under one of the following conditions:
  - The child touched the free foot to the floor.
  - He/her removed hands from hips.
  - Moved the supporting foot from the original position.
  - Dropped the free leg below 45° of knee flexion.
  - Looked away from the visual target.

- For the condition of eyes-closed one-leg standing balance test; the child was instructed to lift one foot, and then asked to close his/her eyes. Timing was started as soon as the child closed eyes, and stopped in addition to the previous criteria when the child opened his/or her eyes.

Dynamic balance test: "Tilt board tip balance test":

- Each child was positioned with feet together, medial malleoli opposed, on foot prints marked in the center of a nonskid surface tilt board which had angle markers extending 4 inches from the board to the wall, where a chart with degree lines (from 0° with increments of 5° up to 60°) was located on the wall.
- Each child was instructed to stand with hands on hips and maintain his/her balance as long as possible, timing was started when the therapist alternately tipped the tilt board slowly to the right or left.
- Three trials were administered to each side, alternating right and left sides for both open and closed eyes conditions.
- Timing was stopped for the open eyes test when one of the following criteria occurred:
  - Hands were off hips.
  - Raising a foot or stepping.
  - Beginning to fall.
  - Requiring support from the therapist.
- In the eyes-closed condition, the test was terminated if the child opened his or her eyes in addition to the previous criteria.
- The line to which the angle marker was closest at the point where the subject made a postural adjustment was determined, up to the maximum of 60° to measure the angle in degrees.

III. Treatment procedures

- Children of both groups (A) and (B) received the traditional program for treating juvenile rheumatoid arthritis (JRA) including strengthening exercises, passive and active range of motion (ROM), gentle stretching, and general relaxation exercises.
- In addition, children of group (B) underwent an intervention exercise regimen designed for balance, it was adapted and modified from the protocol used by Richardson et al, (2001)[20].
- These exercises were performed, on a firm surface, including:
  - Warm up (open chain active ankle ROM exercises 3 min.).
  - Bipedal toe raises and heel raises as quickly as possible (lifting the forefoot as one does to balance on heels), using support as necessary, subjects started with 1 set of 10 and increased by 1 set every 5 exercise sessions.
  - Unipedal toe raises and heel raises, subjects attempted to perform this as quickly as possible. They started with 5 repetitions of each exercise and increased to 10 repetitions after 5 exercises and then to sets of 10 after 10 exercise sessions.
  - Unipedal inversion and eversion, subjects inverted and everted the foot while standing on it, to challenge balance and to create a closed chain exercise of ankle invertors and evertors. They used their hands for balance when needed. They started with 1 set of 5 repetitions in each direction and increased to 10 repetitions after 5 exercise sessions.
  - Wall slides, subjects started with bipedal slides with knee flexion maximum of 45°. They performed 3 sets

of 10, after 5 exercise sessions the first set was performed on each foot.
- Unipedal balance was performed according to the child's ability.

- The treatment program was conducted 5 times/week for 10 weeks for both groups.

RESULTS

At the start of the study, the 2 groups showed grossly similar baseline mean age values, ($\overline{X}$ 9.4±2.3 and 9.6± 2.7 years) for group (A) and (B) respectively. Also they were matching for sex, where group (A) included 7 males and 6 females and group (B) comprised 8 males and 9 females.

Static balance results

Statistical analysis of $\overline{X}$±SD values of group (A), after the conduction of the traditional program, revealed significant improvement in duration (in seconds) of single leg stance balance, right and left; with open and closed eyes tests, (P<0.05), as shown in table (1), while the post treatment results of group (B), who received a specific training program for balance, indicated a highly significant improvement when compared to the pre treatment results, (P<0.001) as shown in table (2).

Dynamic balance results

Comparing the pre and post treatment results for the group (A), the results, revealed significant improvement, where the degrees of tilt (right and left combined) increased with open and closed eyes tests (P<0.05), as clarified in table (3); where angle measured to indicate how far the tilt board can be tipped before the child loses his/her balance or step off. While for group (B) the results showed highly significant improvement in the same parameters for dynamic balance with (P<0.001) as shown in table (4).

Comparing the post treatment results of both groups (A) and (B), the mean ±SD values of duration (in seconds) for static balance test, revealed significant improvement, with open and closed eyes, for group (B) with (P<0.05) as shown in table (5) and (Fig. 1). On the other hand, the post training results of dynamic balance revealed highly significant improvement in degrees of tilting angle (right and left combined) with both eyes open and eyes closed tests, (P<0.001) in the favour of group (B) as shown in table (6) illustrated with (Fig. 2).

Table (1): Pre and post treatment mean values for duration (in seconds) of single leg stance static balance test, for group (A).

Static balance	Pre	Post	Md	t	P*
	$\overline{X}$ ± SD	$\overline{X}$ ± SD			
* Eyes open					
- SBR	14.9±4.1	20.7±4.7	5.8	3.481	<0.05
- SBL	12.7±3.7	17.7±4.1	5	3.378	<0.05
* Eyes closed					
- SBR	7.2±2.2	9.4±2.3	2.2	2.588	<0.05
- SBL	5.5±1.6	7.7±1.9	2.2	3.313	<0.05

SBR = Static balance right
SBL = Static balance left
*P = <0.05 (Significant)

Table (2): Pre and post training mean values for duration (in seconds) of single leg stance, static balance test, for group (B).

Static balance	Pre	Post	Md	t	P**
	$\bar{X} \pm SD$	$\bar{X} \pm SD$			
* Eyes open					
- SBR	15.1±4.2	25.5±4.8	10.4	6.081	<0.001
- SBL	12.2±3.2	22.7±4.5	10.5	7.089	<0.001
* Eyes closed					
- SBR	7.4±1.9	11.8±3.2	4.4	4.427	<0.001
- SBL	5.2±1.5	10.4±2.1	5.2	7.547	<0.001

**P = <0.001 (Highly significant)

Table (3): Pre and post treatment mean values for tilting angle (in degrees) of tilt board tip dynamic balance test, for group (A).

Dynamic balance	Pre	Post	Md	t	P
	$\bar{X} \pm SD$	$\bar{X} \pm SD$			
* Eyes open	55.5±12.7	72.2±15.8	16.7	3.083	<0.05
* Eyes closed	36.7±7.3	49.1±10.2	12.4	3.5	<0.05

Table (4): Pre and post treatment mean values for tilting angle (in degrees) of tilt board tip, dynamic balance test, for group (B).

Dynamic balance	Pre	Post	Md	t	P
	$\bar{X} \pm SD$	$\bar{X} \pm SD$			
* Eyes open	53.5±11.2	89.3±16.3	35.8	6.776	<0.001
* Eyes closed	37.4±8.6	60±12.5	22.6	5.512	<0.001

Table (5): Post treatment mean values for duration (in seconds) of single leg stance static balance test, between groups (A) and (B).

Static balance	Pre	Post	Md	t	P
	$\bar{X} \pm SD$	$\bar{X} \pm SD$			
* Eyes open					
- SBR	20.7±4.7	25.5±4.8	4.8	3.612	<0.05
- SBL	17.7±4.1	22.7±4.5	5	3.067	<0.05
* Eyes closed					
- SBR	9.4±2.3	11.8±3.2	2.4	2.264	<0.05
- SBL	7.7±1.9	10.4±2.1	2.7	3.367	<0.05

Table (6): Post treatment mean values for tilting angle (in degrees) of tilt board tip dynamic balance test, between both groups (A) and (B).

Dynamic balance	Pre	Post	Md	t	P
	$\bar{X} \pm SD$	$\bar{X} \pm SD$			
* Eyes open	72.2±15.8	89.3±16.3	17.1	2.82	<0.05
* Eyes closed	49.1±10.2	60±12.5	10.9	2.529	<0.05

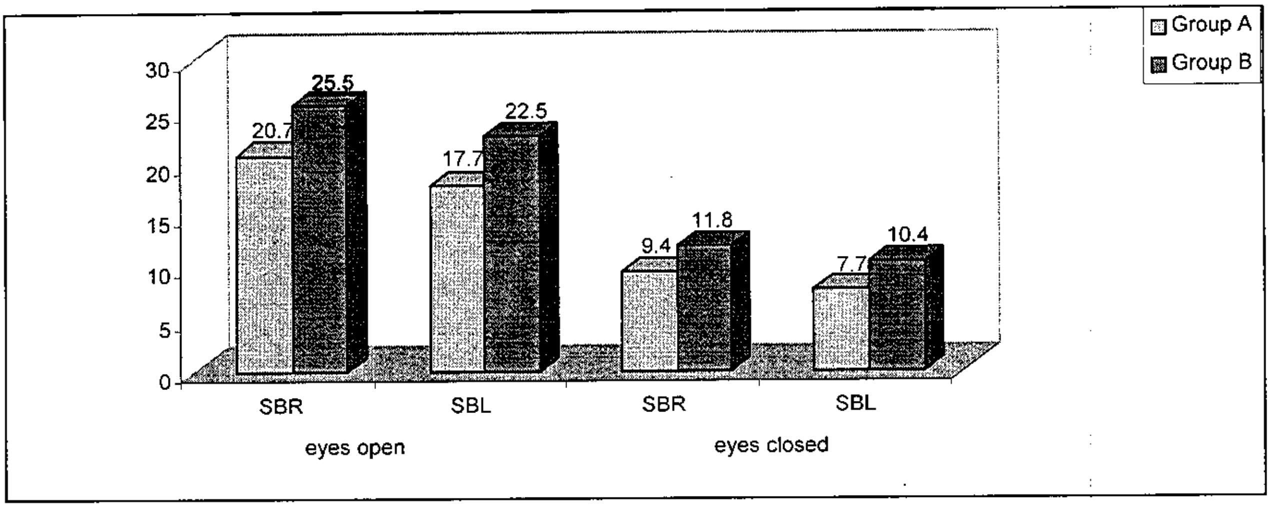

Fig (1): Static balance, comparison of mean values of duration (in seconds) between group (A) and group (B) post training.

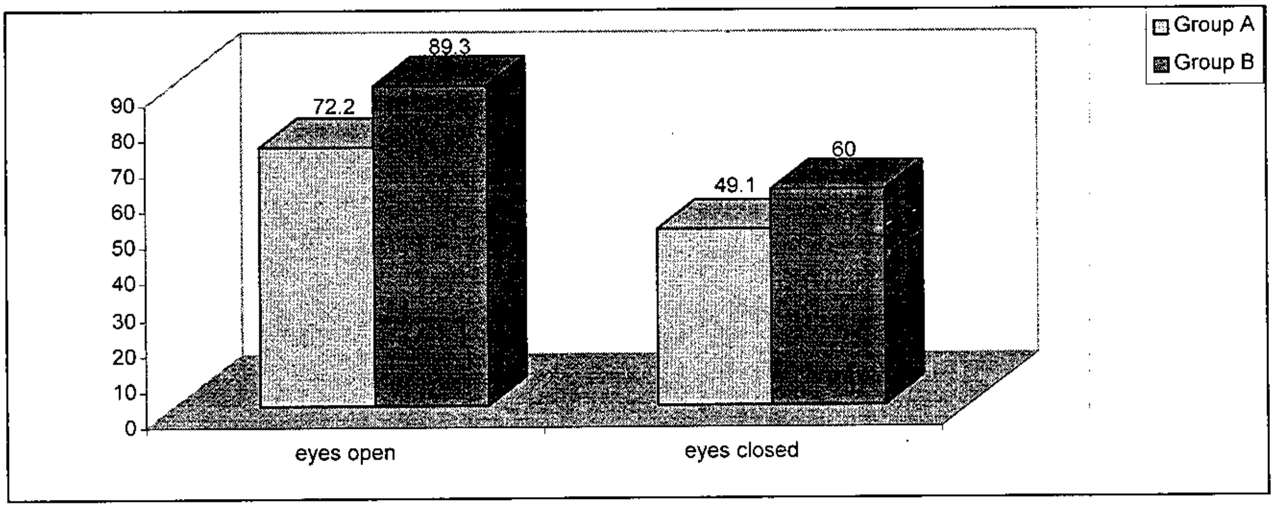

Fig (2): Dynamic balance, comparison of mean values of tilting angle (in degrees) (combined right and left) between groups (A) and group (B) post treatment.

DISCUSSION

Children with many types of disabilities, ranging from mild to severe motor problems have shown to have dysfunction of postural control, these children may exhibit frequent falls during regular daily motor activities[23].

Both static and dynamic postural control are thought to be important, necessary and appears to be an integral part of all motor abilities. Therefore, improvements in postural control may lead to improvement in all daily activities[22].

Balance and stability are highly dependent, in addition to the musculoskeletal system, on information from the somatosensory nervous system, as well as the vestibular and visual systems[15].

Balance is affected when part of the control system is not working correctly[1].

Hence, children who have rheumatoid arthrities (RA), exhibit alternation of information from joints, muscles, and skin (somatosensory nervous system), which may be related to inflammation and mechanical changes in the joint structures and/or tendinitis[10].

These changes would result in reduced physical capacity which was experienced as lowered muscle endurance[5,17], muscle strength[13] and range of motion[16] and they also have reported a history of repeated fall[6].

At the start of the study, the collected data for children of both groups (A) and (B) showed that they were matching in age and sex. Also the predetermined criteria of these patients indicated defect in postural control mechanism manifested by lack of both static and dynamic balance and frequent falling. When the pre and post treatment mean values of both static and dynamic balance parameters measured, for group (A), who underwent the traditional treatment program for treating JRA, the post treatment results revealed significant improvement ($P<0.05$).

Hence, the common symptoms reported by patients with rheumatoid arthritis (RA) as pain, stiffness, and fatigue were regarded activity and were claimed to influence the ability to maintain balance of the body. Changes in joint congruency, axes of motion, range of motion were also claimed to play an important role in the development of stability problems in RA patients. Ligaments and joint capsules can be shortened or elongated to cause either hypo-or hypermobility. Such changes together with degeneration of the joint surfaces may also change the axes of motion. Thus, movements around non-physiological axes may occur. Muscles were also considered to be highly involved when maintaining a posture and during motion. If the muscles are strong, they may partly compensate for joint dysfunction, conversely, weak muscles may increase the risk of developing joint instability[15].

So, the post treatment improvement which was reported for group (A) could be attributed to complex organization of many senses that are related, by the central nervous system, to many muscles that act on a multi linked musculoskeletal system and due to postural orientation (Sensory organization components) as well as to motor co-ordination[11], Also it may be due to improvement in muscle strength[15].

In order to keep positions of joints or body during standing as well as during motion, the muscles must be able to develop force and one muscle group has to co-operate with other muscle groups. Furthermore, muscles have to react to sudden or sustained stimuli as well as to develop force continuously or repetitively and should counteract maximum resistance given by the therapist[15].

On the other hand, the highly significant improvement ($P<0.001$) in both static and dynamic balance parameters, which was recorded for group (B), could be attributed to feedback postural control obtained from the specific balance exercise regimen, due to postural adjustments which help to achieve smooth execution of any desired movement as well as maintenance of postural stability triggered by sensory input, needed for developing or improving balance[25].

Postural stability is maintained through complex interactions among sensory motor control, which provide the main inputs to the automatic postural reflexes and contribute to voluntary postural control, therefore, this was of considerable value in the contributions of different sensory cues to postural stability[2].

Postural stability is essential and of great concern in the everyday activities and it is modulated by postural control, which is exhibited in the form of postural adjustment[18,19].

Postural adjustments occur in order to maintain equilibrium. Those postural adjustments which maintain balance are known as equilibrium reactions[14].

The equilibrium reactions are carried out by a complex process involving afferents from the sensory system, integration of the afferents by the central nervous system (CNS) and the efferents by the sent from CNS to an intact musculoskeletal system[3].

The subjects ability to maintain balance by standing on one foot with their eyes open and subsequently with their eyes closed, thus reducing their base of support[7].

Stoffregen and Riccio (1990)[24] have urged that an important goal of postural control is to provide stability to both sensory and motor systems, which optimizes the influx of sensory information while moving.

The primary systems involved for the process of balancing are (1) the sensory system: visual, cutaneous and proprioceptive (Called "Somatosensory"), and vestibular senses, which either cues the child that a response needs to be made to maintain control or gives feedback to alter the balance action during a voluntary motor task, (2) the motor system, which creates the movement to maintain posture, and (3) the biomechanical system, which includes the bony and joint frame on which movements are made and the muscles that create the movement torques[12,22,23].

The results of the present study at the end of treatment revealed a significant improvement ($P<0.05$), when the post treatment mean values of both groups (A) and (B) were compared, in the favour of group (B), as shown in tables (5,6) and illustrated in Fig. (1,2).

The data from this study showed that a designed balance exercise program improved both static and dynamic balance (Single leg stance and tilt board balance) among JRA patients.

The study further showed that these improvement developed in a relatively short period of time (10 weeks) and that the designed exercise regimen was well tolerated by all children.

The results of the present study come in agreement with Walfson et al., 1995[26], who emphasized the strong association between falls/loss of balance and decreased ankle strength. They claimed that an improvement in ankle muscle strength, and therefore, muscle tension, may improve ankle proprioceptive thresholds.

And also it was supported by those done by Rechardson et al, 2001[20] who studied the effect of a specific exercise regimen on improvement of unipedal stance, functional reach and tandem stance time for elderly patients with diabetic peripheral neuropathy.

Conclusion

It could be concluded that the designed balance exercise regimen was reasonable intervention to be added for treating children having rheumatoid arthritis, because it was tolerable and effective. So, it could be pointed out that balance and stability problems should be considered with the physical therapy program of JRA.

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الملخص العربي

العلاج الطبيعي بواسطة ضبط القوام لعلاج الاتزان في الثبات والحركة لمرضى التهاب المفاصل الروماتويدى عند الأطفال

الهـدف مـن هـذا البحث هو تقييم وتحديد تأثير برنامج اتزان خاص بالتحكم في القوام للأطفال الذين يعانون من مرض التهاب المفاصـل الـروماتويدي ، وهـؤلاء الأطفال عادة يعانون من صعوبة في التحكم في الاتزان عند الثبات أو الحركة ، كما يظهر بصورة واضحة في تكرار وقوعهم أثناء السير مما يؤثر على مستوى المجهود البدني الذي يبذلونه.

وقـد أجـرى هـذا البحـث على (٣٠) طفلا من الجنسين تتراوح أعمارهم بين سبع سنوات أثنى عشر سنة . وقد قسموا إلى مجموعتين متسـاويتين ، إحداهما ضابطة والأخرى تجريبية أجرى لها البرنامج المقترح ، وقد تم اختبار الاتزان عند الثبات والحركة لهؤلاء الأطفال قبل البدء في الدراسة ثم بعد عشر أسابيع من تطبيق برنامج العلاج الطبيعي التقليدي في المجموعتين علاوة على البرنامج الخاص بالاتزان بالنسبة للمجموعة التجريبية لعلاج هؤلاء المرضى وقد تم تطبيق البرنامج لمدة خمس أيام أسبوعيا لكل طفل .

وفـي نهايـة البحث وجدت فروق ذات دلالة إحصائية بين المجموعتين الضابطة والتجريبية ويمكن التحسن في الاتزان بالنسبة للمجموعة التجريبية كان أكثر في الدلالة الإحصائية من حيث التحكم في القوام والاتزان .

وبـنـاء علـى هذه النتائج الإيجابية نستطيع أن نضيف برنامجا مقترحا خاص بالاتزان في التحكم في القوام لدى الأطفال المصابين بمرض روماتويد المفاصل علاوة على الطرق التقليدية المستخدمة لعلاجهم .