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Effect of Aerobic Exercise Versus Calcium Supplementation on Serum Calcium Level in Hypocalcemic Children

SALWA FOUAD, M.Sc.*; ELHAM E. SALEM, Ph.D.*; SHOROUK E. BAYOMY, Ph.D.* and SAHAR A. MOHAMED, M.D.**

The Department of Physical Therapy for Paediatrics, Faculty of Physical Therapy and Paediatrics Department, Faculty of Medicine**, Cairo University*

Abstract

Background: Hypocalcemic child is the presence of low serum calcium levels in the blood. Normal blood calcium level is between 8.5 to 10.5mg/dLin children. Calcium is the most important abundant mineral in the body which is important for growth bons, teeth and their skeleton.

Purpose: To investigate the effect of aerobic exercise versus calcium supplementation on serum calcium level in hypocalcemic children.

Subjects and Methods: This study was carried out on 36 hypocalcemic children of both sexes, subdivided into two groups, eighteen in each group. Their ages ranged from 24-42 months old.

Results: Serum free total calcium, gross motor function measure 88score of standing and walking domain measured for all children before and after 12 weeks of intervention. Group (A): Were participated in aerobic exercise program in the form of bicycle ergometer training program 3 time/week for 12 weeks in addition to balanced daily diet calcium supplement. Group (B): Children were be treated by calcium supplementation in form of calcium carbonate (lactose) which was given once daily.

Non significant difference in gross motor function measure 88 scoreing of standing and serum calcium level but there was significant increase in gross motor function measure 88 scoreing of walking in Group (A) compared with Group (B).

Conclusion: This study concluded that aerobic exercise has benifical effect on walking ability and serum calcium level in children with hypocalcemia.

Key Words: *Calcium – Aerobic exercise – Calcium supplementation – Hypocalcemia.*

Introduction

CALCIUM is the most abundant mineral in the body, is found in some foods, added to others, available as a dietary supplement, and present in some medicines. Calcium is required for vascular contraction and vasodilation, muscle function, nerve transmission, intracellular signaling and hormonal secretion, though less than 1% of total body calcium is needed to support these critical metabolic functions. The remaining 99% of the body's calcium supply is stored in the bones and teeth where it supports their structure and function. Calcium is a vital mineral that our body uses to stabilize blood pressure and build strong bones and teeth. Everyone should consume the recommended amount of calcium per day through the food they eat or, by taking calcium supplements. Insuffient amount of calcium may increase the risk of developing diseases such as osteoporosis and calcium deficiency disease, also known as hypocalcemia [1].

Calcium consumption is essential for bone development and must maintain normal level throughout life, so the fetus in utero and the neonate through breast-feeding are dependent on maternal sources for the total calcium load, adequate maternal calcium intake also can affect fetal bone health positively. Proper calcium consumption can be attained through the diet by the consumption of dairy products or leafy greens (such as kale), the consumption of fortified foods, or by supplementation with widely available calcium-containing supplement products [2].

Calcium deficiency is a condition in which the body has an inadequate amount of calcium. Dietary calcium deficiency is a condition in which there is an inadequate calcium intake, which can lead to depleted calcium stores in the bones, thinning and weakening of the bones, and osteoporosis [3].

Correspondence to: Dr. Salwa Fouad, The Department of Physical Therapy for Paediatrics, Faculty of Physical Therapy, Cairo University

Hypocalcemia is the presence of low serum calcium levels in the blood. Physiologically, blood calcium is tightly regulated within a narrow range for proper cellular processes. Normal blood calcium level is between 8.5 to 10.5mg/dL. Symptoms of hypocalcemia include neuromuscular irritability including tetany, electrocardiographic changes, and seizures. The neuromuscular symptoms of hypocalcemia are caused by a positive bathmotropic effect due to the decreased interaction of calcium with sodium channels. Since calcium blocks sodium channels and inhibits depolarization of nerve and muscle fibers, convulsions,arrhythmias, tetany and numbness,parasthesias in hands, feet, around mouth and lips may found [4].

Calcium balance is maintained by concerted functions of three major organs, i.e., the gastrointestinal tract, bone, and kidneys. The kidney must excrete the same amount of calcium that the small intestine absorbs. Bone not only serves a structural function but also provides the calcium exchange system for minute-to-minute and adjustment of calcium level in plasma [5].

Aerobic exercise induces elongation and increase in the diameter of the striated muscle fibre. It improves their capillary vasculature, and increased calcium in the cell of sarcoplasma in the skeletal muscles, which is prevalent during the muscle contractions and positively affects their blood pressure measurements, their brain function and the lipid profile [6].

The purpose of this study was to investigate the effect of aerobic exercise versus calcium supplementation on serum calcium level in hypocalcemic children.

Subjects and Methods

This study was conducted in out-clinic of Helwan General Hospital during 2016. This study was carried out on thirty-six hypocalcemic children from both sexes, their ages ranged from 24-42 months old, children were included. Their serum calcium level was be below 6.5mg/dl according to blood calcium analysis [4], they had a delayed walking milstone according to caregiver complain and level I GMFCS. Incidence of falling was recurrent according to caregiver complain. Children were excluded if they had one or more of the following criteria:

• Neuropediatric disorders.

• Musculoskeletal deformities in their bodies.

• Mental disabilities.

• Artificial pacemaker or cardiac arrhythmia.

• Sensory disturbances.

• A Systemic disease of musculoskeletal system.

Material and Methods:

A- *For Evaluation:*

1- Gross motor function measure 88:

All children were assessed before and after 12 weeks of intervention by GMFM88. GMFM88 is standardized observation instrumentation designed and validated to measure change in gross motor function over time. It include 5 domain lying and rolling-sitting-crawling and kneeling-standing-walking, running and jumping. Each domain contain some of items which can score by 0=does not initiate, 1 = Initiates, 2 = Partially completes, 3 = Completes. We were used the domain of standing and walking.

2- Laboratory analysis:

Serum free total calcium measured for all children before and after 12 weeks of intervention.

B- *Treatment Instramentation:*

I- Bicycle ergometer 3600RC StairMaster Spinnaker systems (USA) was used to train children of study group (A) and was adjusted to fulfill the preselected parameters.

It was equipped with electronic meter showing pedal revolutions or ramps per minute, the power, total pedal revolution and time function.

The height of bicycle seat was set so the knee angle was 10 to 15 degreesof flexion when the child's foot was at apex via an extra strap to provide complete fixation of child's foot on ergometer pedal and thus reducing the shear stress on the knees and protecting the anterior cruciate ligaments. Each child in study Group (A) received aerobic exercise in form of bicycle ergomter training program. At first the child performed pedaling on bicycle ergometer starting with unloaded cycling for 5 minute as warming up exercise then training begin with intensity of 50 ramps for 5 minute with few seconds rest in between. Intensity and time were increased gradually to 15 minutes training at end of treatment period. The training was 3 days/week for 12 weeks.

II- Calcium supplementation:

Each child in Group (B) was treated with calcium carbonate (lactose) supplements were given one teaspoonful daily, [7]. Group (B) follow-up each 3 weeks in out clinic.

Statistical analysis:

Numerical data were described as mean and standard deviation and range. Categorical data were described as numbers and percentages. Data were explored for normality using Kolmogrov-Smirnov test and Shapiro-Wilk test. Comparisons between two groups for normally distributed numeric variables were done using the Student's *t*-test. Comparisons between categorical variables were performed using the chi square test. Paired *t*-test was done to assess changes overtime in each group separately. Two way repeated measure analysis of variance was done to assess change over time in between groups. A *p*-value less than or equal to 0.05 were considered statistically significant.

Results

Patient demographic data was presented the collected data through measuring children age, height, weight. There were no statistical difference between the mean values of both groups.

Patient's characteristics:

There was non significant difference in sex distribution between both groups (*p*-value=0.317).

Baseline assessment:

Pre-treatment mean values, standard deviation and independent *t*-test for comparing between 2 study groups initially for GMFM standing, walking and serum calcium level. There was no significant difference between both groups pre-treatment.

Statistically, there was significant increase of GMFM standing and GMFM walking between both groups after treatment (*p*-value <0.001).

There was non significant difference in GMFM 88 of standing between both groups [Group (A) and Group (B)] after treatment *p*-value=0.251, there was significant differencein GMFM 88 of walking between both groups after treatment *p*-value=0.054 while there was non significant differencein calcium level between both groups after treatment *p*-value=0.075.

Table (1): General characteristics of two studied Groups (A & B).

	Group A		Group B		Mean difference	*t*-value	*p*-value
	Mean	SD	Mean	SD			
• Age (months)	31.94	2.84	30.83	3.33	1.11	1.077	0.289
• Weight (kg)	10.92	0.65	10.83	0.54	0.08	0.419	0.678
• Height (cm)	87.28	2.82	86.5	2.36	0.78	0.897	0.376

$p \leq 0.05$ is considered statistically significant.

Table (2): Sex distribution in both groups.

	Group A		Group B		χ_2 value	*p*-value
	No	%	No	%		
Sex:						
Boy	10	55.6	7	38.9	1.003	0.317
Girl	8	44.4	11	61.1		

$p \leq 0.05$ is considered statistically significant.
χ^2 : Chi square.

Table (3): Mean, standard deviation and independent *t*-test for comparing between 2 study groups initially.

	Group A		Group B		Mean Difference	*t*-value	*p*-value
	Mean	SD	Mean	SD			
• GMFM standing	30.0	2.03	29.33	2.11	0.67	0.965	0.341
• GMFM walking	53.06	2.96	53.17	2.46	–0.11	–0.123	0.903
• Calcium level	6.16	0.22	6.13	0.25	0.03	0.419	0.678

$p \leq 0.05$ is considered statistically significant.

Table (4): Mean and standard deviation, independent *t*-test for comparing variables among 2 groups after treatment.

	Group A		Group B		Mean Difference	*t*-value	*p*-value
	Mean	SD	Mean	SD			
• GMFM standing	13.45	6.41	11.73	4.08	1.72	0.96	0.344
• GMFM walking	10.81	4.71	8.47	2.03	2.34	1.935	0.061
• Calcium	15.49	5.46	19.85	8.49	–4.36	–1.833	0.076

$p \leq 0.05$ is considered statistically significant.

Table (5): Mean, standard deviation and 2 ways ANOVA with repeated measure test.

	Group A				Group B				Time *p*-value	Group *p*-value	Interaction *p*-value
	Per		Post		Per		Post				
	Mean	SD	Mean	SD	Mean	SD	Mean	SD			
GMFM standing	30	2.0	33.9	1.6	29.3	2.1	32.7	1.9	<0.001	0.119	0.251
GMFM walking	53.1	2.9	58.7	2.8	53.2	2.5	57.7	2.9	<0.001	0.597	0.054
Calcium level	6.2	0.2	7.2	0.3	6.1	0.3	7.3	0.3	<0.001	0.190	0.075

$p \leq 0.05$ is considered statistically significant.

Table (6): Mean and standard deviation, paired t-test for comparing variables before and after treatment in Group A.

Group A	Pre		Post		Mean difference	95% CI		p-value
	Mean	SD	Mean	SD		Lower	Upper	
GMFM standing	30	2.03	33.94	1.59	3.9	3.1	4.8	<0.001
GMFM walking	53.06	2.96	58.72	2.89	5.7	4.6	6.8	<0.001
Calcium	6.16	0.22	7.27	0.34	1.0	0.8	1.1	<0.001

$p \leq 0.05$ is considered statistically significant.

Table (7): Mean and standard deviation, paired t-test for comparing variables before and after treatment in Group B.

Group B	Pre		Post		Mean difference	95% CI		p-value
	Mean	SD	Mean	SD		Lower	Upper	
GMFM standing	29.33	2.11	32.72	1.87	3.9	3.4	2.9	<0.001
GMFM walking	53.17	2.46	57.67	2.85	5.0	4.5	4.0	<0.001
Calcium	6.13	0.25	7.33	0.32	1.4	1.2	1.0	<0.001

$p \leq 0.05$ is considered statistically significant.

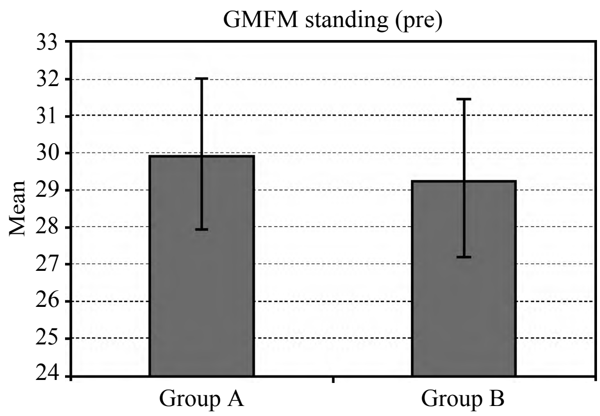

Fig. (1): Bar chart representing mean GMFM standing and standard deviation among studied groups pre treatment.

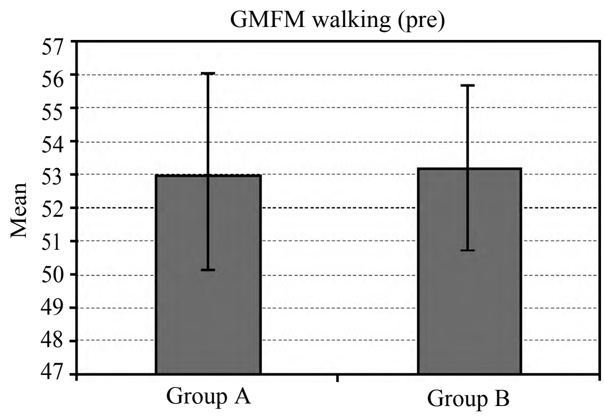

Fig. (2): Bar chart representing mean GMFM walking and standard deviation among studied groups pre treatment.

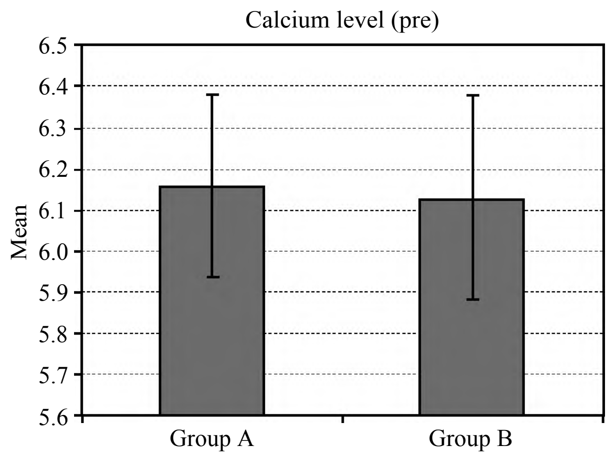

Fig. (3): Bar chart representing mean calcium level and standard deviation among studied groups pre treatment.

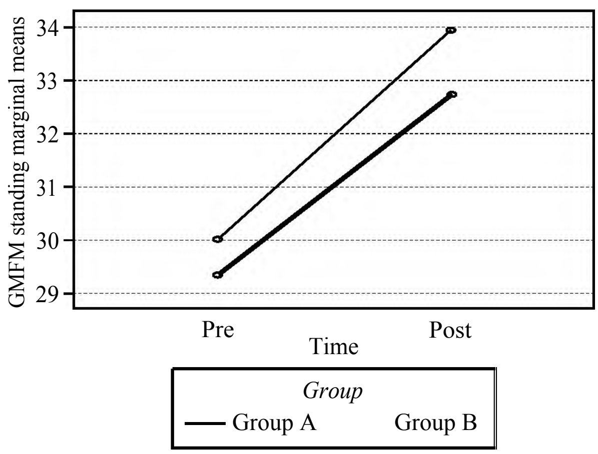

Fig. (4): Line diagram representing mean GMFM standing in both groups pre and post-treatment.

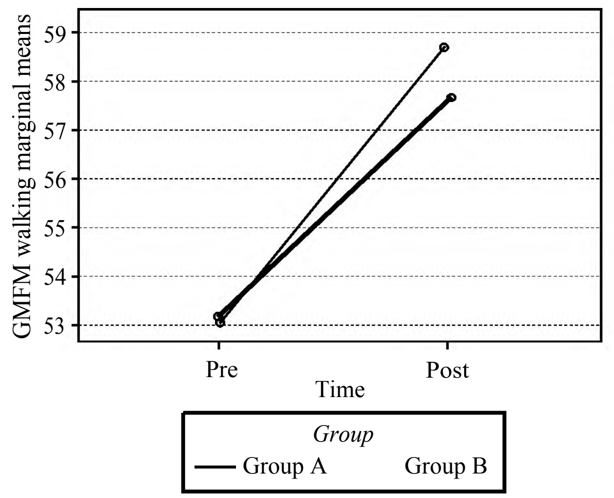

Fig. (5): Line diagram representing mean GMFM walking in both groups pre and post treatment.

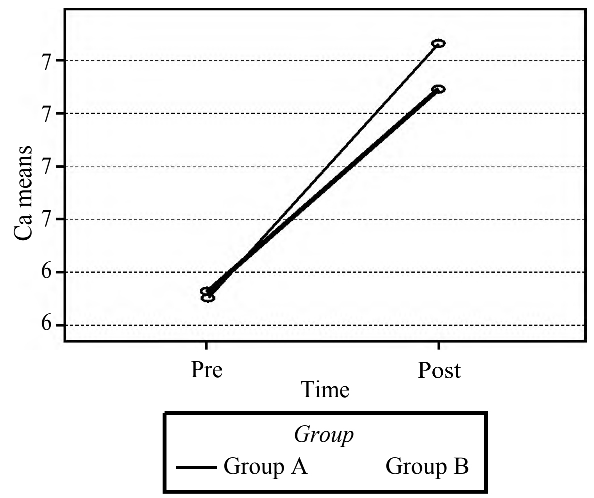

Fig. (6): Line diagram representing mean calcium in both groups pre and post-treatment.

Discussion

The results of this study have revealed that statistically there was non significant difference between both groups regarding base line characteristics, age, (p-value=0.289), height (p-value =0.376) or weight (p-value=0.678). And there was non significant difference in sex distribution between both groups (p-value=0.317).

These result conducted that aerobic exercises are effective in treatment of hypocalcemia also the aerobic exercise responsible for increasing serum calcium level comparing with calcium supplementation. These findings were agree with investigations using aerobic exercise in im provement of serum calcium level which showed that aerobic exercise is related to an enhanced bone mineral density in peripubertal boys and also in young children. Aerobic exercise can already acutely influence various Ca metabolic parameters in children [8].

Aerobic exercise intensity results in regional increase in bone mass and serum calcium level [9].

Dairy products of calcium are the best sources of calcium because of their high calcium content and bioavailability. USDA's Food Guide Pyramid (FGP) recommends that individuals 2 years and over consume 2-3 servings of dairy calcium per day depending on age. So there is positive relationship between dietary calcium and serum calcium [10].

Growth is highly dependent on the absorption of nutrients. Inadequate calcium and vitamin D intake may compromise bone mineralization and growth. There is a great deal of concern regarding calcium and vitamin D intake, as well as biochemical changes in children and adolescents, which led us to investigate calcium and vitamin D levels during growth [11].

Calcium has a major role in the development and maintenance of peak bone mass during childhood and adolescence, as well as in the subsequent prevention of osteoporosis. Calcium absorption and bone accretion are affected by dietary calcium and vitamin D status. so this finding suggests that vitamin D levels are maintained for a period of time after sun exposure [12].

Adequate calcium intake may have a crucial role with regards to prevention of many chronic diseases, including hypertension, hypercholesterolemia, different types of cancer, obesity and osteoporosis. In children, sufficient calcium intake is especially important to support the accelerated growth spurt during the preteen and teenage years and to increase bone mineral mass and serum calcium level to lay the foundation for older age [13].

Both aerobic exercises and high calcium intake were associated with a higher bone mineral density, higher serum calcium level. Diet habits and exercise must be considered the main strategies during childhood to prevent adult osteoporosis. These results support that adequate calcium intake may be required for optimal action of aerobic exercise on bone development and that improving levels of calcium in childhood [14].

Calcium homeostasis is maintained mainly by controlling the gastrointestinal absorption of calcium. Typically, calcium absorption at recommended intakes is an active process, dependent on an adequate vitamin D status and intact renal and parathyroid function. Fractional calcium absorption is inversely proportional to calcium intake, [15].

The effective adaptation of calcium homeostasis to low calcium intakes is achieved on diets frequently high in phytates and oxalates which are thought to impair intestinal calcium absorption in humans [16].

Calcium deposition in bones is an ongoing process that occurs throughout childhood and persists into adolescence, reaching maximal levels during the pubertal growth spurt [17].

Bone Mineral Density (BMD) and calcium acquisition during childhood and adolescence is very important for adult bone mass accrual and skeletal formation [18].

Childhood and adolescence are considered to be crucial periods for maximising genetically predetermined peak bone mass and calcium through the modification of lifestyle and environmental factors. Peak bone mass and calcium subsequent bone losses are important determinants of osteoporosis later in life [19].

Maximising peak bone mass and calcium is advocated as a way to prevent osteoporosis. As a prerequisite to the elaboration of any preventive programme aimed at maximising peak bone mass and calcium, it is important to determine how the rate of skeletal growth at clinically relevant sites, such as lumbar spine and femoral neck, proceeds in relation to age and pubertal stages in both sexes [20].

Environmental factors such as nutrition and physical activity play important roles in the achievement of maximum bone mass and elevat calcium level [21].

Conclusion:

The results of this study supported the effect of aerobic exercise and showed a significant increase serum calcium level in hypocalcemic children.

Children living in the majority of developing countries have habitual dietary calcium intakes between one third and a half of the recommended intakes for children in the developed world. For the majority of these children, there is little evidence to suggest that their mineral balance or bone mass is adversely affected by these low intakes, provided their vitamin D status in not compromised as well. There is, however, evidence that children on very low calcium intakes may develop rickets and osteomalacia, which responds to treatment with calcium supplements alone. Further research is required to elucidate the various factors predisposing these children to rickets. Calcium supplementation in children from developing countries does not appear to improve growth and may in fact have adverse effects on final height. Bone mass increases during calcium supplementation, but most studies have found that the benefit is lost following cessation of the supplement.

Poor vitamin D status remains a major public health problem among infants, young children, and adolescents in many developing countries despite adequate sunshine and UV radiation. Overcrowding, atmospheric pollution, the lack of vitamin D-fortified food, and social customs which reduce sunlight exposure are major factors responsible for the high prevalence. Vitamin D deficiency and low dietary calcium intakes act synergistically in increasing the prevalence of rickets, hypocalcemia in communities where both problems are present.

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تأثير التمرينات الهوائية مقابل العلاج الكالسيوم على مستوى الكالسيوم فى الدم عند الأطفال المصابين بنقص الكالسيوم

الخلفية العلمية: الكالسيوم هو أهم المعادن وفيرة فى الجسم لذلك الأطفال المصابين بنقص الكالسيوم يحتاجون إلى طرق سهلة لزيادة مستوى والكالسيوم فى الدم الذى هو مهم لنمو الأسنان وهيكلها العظمى.

الهدف من الدراسة: متابعة تأثير التمرينات الهوائية مقابل العالج بالكالسيوم على مستوى الكالسيوم فى الدم عند الأطفال المصابين بنقص الكالسيوم.

الأشخاص والطرق العلاجية: أجريت هذه الدراسة فى عيادة خارجية من مستشفى حلوان العام نفذت على ستة وثلاثين من الأطفال الذين يعانون من نقص كالسيوم الدم من كلا الجنسين، وتنقسم إلى مجموعتين، ثمانية عشر فى كل مجموعة. وتراوحت أعمارهم بين ٢٤-٤٢ شهراً من العمر.

المواد والطريقة: مصل خالية من الكالسيوم الكلى وGMFM88score قياس لجميع الأطفال قبل وبعد ١٢ أسبوعاً من التدخل. مجموعة الدراسة (أ): كانوا يشاركون فى برنامج التمارين الهوائية فى شكل برنامج تدريب مقياس قوة دراجة ٣ مرات فى الأسبوع لمدة ١٢ أسبوعاً بالإضافة إلى التوزان الغذائى اليومى للمكملات الغذائية الكالسيوم. المجموعة (ب): تم علاج الأطفال عن طريق مكملات الكالسيوم فى شكل كربونات الكالسيوم (اللاكتوز) أعطيت مرة واحدة يومياً. تم متابعة GMFM88scoring ومستوى الكالسيوم عن طريق تحليل الدم قبل وبعد ١٢ أسبوع من الدراسة.

النتيجة: لم يكن هناك فرق معنوى فى مستوى الكالسيوم فى مصل الدم قبل المعالجة بين المجموعتين فى حين أن النتيجة بعدها كانت هناك زيادة معنوية فى GMFM88scoring والكالسيوم فى الدم فى المجموعة (أ) مقارنة مع المجموعة (ب).

الخلاصة: لخصت هذه الدراسة إلى أن التمارين الهوائية لها تأثير إيجابى على مستوى الكالسيوم فى الدم والقدرة على المشى فى الأطفال الذين يعانون من نقص كالسيوم الدم.