

Efficacy of aquatic exercises on balance in children with sickle cell anemia: A randomized controlled trial

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ABSTRACT

The aim of this study was to investigate the efficacy of aquatic exercises on balance in children with sickle cell anemia. A randomized controlled trial was conducted. Sixty children with mild sickle cell anemia and poor balance from both sexes (35 boys and 25 girls) participated in this study. Their ages ranged from 5-10 years with a mean value of 7.30 ± 1.66 years in the study group (A) and 7.26 ± 1.70 in the control group (B). They were divided into two equal groups: the study group (A) and the control group (B). The study group (A) consisted of 30 children (17 boys and 13 girls), who received medical treatment (prescribed by physician), balance exercises, and aquatic exercises sessions. The control group (B) consisted of 30 children (18 boys and 12 girls) who received medical treatment (prescribed by physician) and balance exercises only. The program continued for eight weeks with two sessions per week with a total of sixteen sessions. Each session lasted forty minutes for aquatic exercises sessions and thirty minutes for the balance exercises sessions. Balance was measured before and after treatment using the Pediatric Balance Scale (PBS). A complete blood analysis was performed before and after treatment. The balance functions showed a statistically significant improvement in the study group (A) ($p < 0.05$) with an improvement of 28.09% after treatment, while in the control group (B) the improvement was not statistically significant ($p > 0.05$) with a percentage of 10.93% after treatment. The mean Hb value also improved by 29.2% in the study group (A) with a statistically significant increase ($p < 0.05$), while in the control group (B) there was no statistically significant improvement ($p > 0.05$) with a percentage of 8.44% after treatment. The aquatic exercise program has a positive effect on improving balance functions in children with sickle cell anemia.

KEYWORDS

Sickle Cell Anemic Children; Aquatic Exercises; Balance Measurements; Complete Blood Analysis

1. INTRODUCTION

Sickle cell anemia (SCA) is the world's most common genetic defect. All over the world, more than 300,000 neonates are born with SCA. Each year more than 75% of children with sickle cell anemia are born in sub-Saharan Africa. There is no sex prediction as sickle cell anemia is not an X-linked disease. Without treatment, about 50% to 90% of affected children in sub-Saharan African countries die before reaching 5 years (Esoh et al., 2021). The highest percentage is found in Africa, where about 20% of African people are carriers of the sickle gene, a percentage of about 8% in the African-American people with a lower prevalence in the Middle East (Al Naama et al., 2015). In Saudi Arabia, about 5.2% of the population carries the sickle cell trait, in Oman about 3.8%, in Bahrain about 2%, and in Egypt 9% to 22% (Hagag et al., 2016). The disease results from the inheritance of HB S gene either in a homozygous state or a double heterozygous state with additional abnormal hemoglobin gene. Sickle cell anemia is characterized by abnormally shaped (sickle) red blood cells and less hemoglobin in blood, leading to many complications as tissue ischemia, vascular occlusion, stroke, acute chest syndrome, leg ulcers, pulmonary hypertension, ear problems, muscle dysfunctions, body imbalance, heart failure, pulmonary embolism, infections and multi-organ failure (Inusa et al., 2019).

Sickle cell anemia causes poor nutritional status, growth retardation, muscle weakness, dysfunction and decreased daily life physical activities that affect body balance in children (Merlet et al., 2019).

Water resistance, viscosity and buoyancy are physical properties of water which have considerable effects on the biomechanical aspects of rehabilitation leading to increase in muscle strength, sensory feedback and improve balance and gait (Anna et al., 2016). Water's natural buoyancy gently helps joints to encourage free movement as it works against resistance in all directions and not just gravity alone, this means more aerobic endurance, flexibility and muscle tone (Methajarunon et al., 2016). Aquatic exercises can also increase total HB S and red cell mass in sickle cell anemia via enhancement of oxygen-carrying capacity. These mechanisms are proposed to come mainly from bone marrow, including stimulated erythropoiesis with hyperplasia of the hematopoietic bone marrow, improvement of the hematopoietic micro-environment is enhanced by aquatic exercises and cytokine-accelerated erythropoiesis (Yusniel et al., 2017).

Aquatic exercise programs are safe, effective, inexpensive, popular with all children, and a beneficial alternative method that has been proposed primarily as part of exercise programs for children with disabilities (Ilona et al., 2015).

No study has been conducted in Egypt on the efficacy of aquatic exercises in improving balance in sickle cell anemic children. So, the aim of this study is to determine the effect of aquatic exercises on balance in children with sickle cell anemia, while the ultimate goal of this study is to improve balance, hemoglobin levels, and quality of life in children with sickle cell anemia through the use of aquatic exercise.

2. METHODS

2.1 Study Design

A randomized controlled trial was conducted to investigate the effect of aquatic exercises on balance in children with sickle cell anemia. The study was conducted in the Internal Medicine Outpatient Department of Shebin Elkom Teaching Hospital in Egypt from the first day of April 2019 to December 31, 2019. Pre- and post-treatment data were collected by the research ethics committee before the start of the study [No. P.T.REC/012/003127].

2.2 Participants

Sixty children of both sexes (aged 5-10 years) with mild sickle cell anemia and poor balance were recruited from the Internal Medicine Outpatient Clinic of Shebin Elkom Teaching Hospital in Minofia, Egypt.

Inclusion criteria: 1) children with mild sickle cell anemia with Hb level ranging from 8-11 g/dl; 2) they participated in the study if they could stand and walk with help and could sit, roll and crawl without help; 3) all children that were able to understand and follow verbal commands and instructions included in both test and training procedures.

Exclusion criteria included: 1) children with high fever ($>38^{\circ}\text{C}$), chest infections or unstable cardiac status; 2) children who had previous history of surgical interference (orthopedic or neurosurgeries), uncontrolled seizure disorders, allergy and fear of water, open wounds, hepatitis A; 3) children with visual or auditory problems, bowel or bladder incontinence, skin diseases and severe circulatory problems as deep venous thrombosis or gangrenes.

All parents signed an informed consent form to allow their children to participate in the study. They had the right to terminate the program at any time.

2.3. Randomization

The recruited patients were randomly assigned after signing consent form by parents into two equal groups; Group (A) (experimental or study group, n = 30) and Group (B) (control group, n = 30). An even number was assigned to group (A) (experimental group) and a blind randomization was carried out by assigning the odd numbers to group (B) (control group). Following randomization, there was no dropout out of subjects from the study (Figure 1).

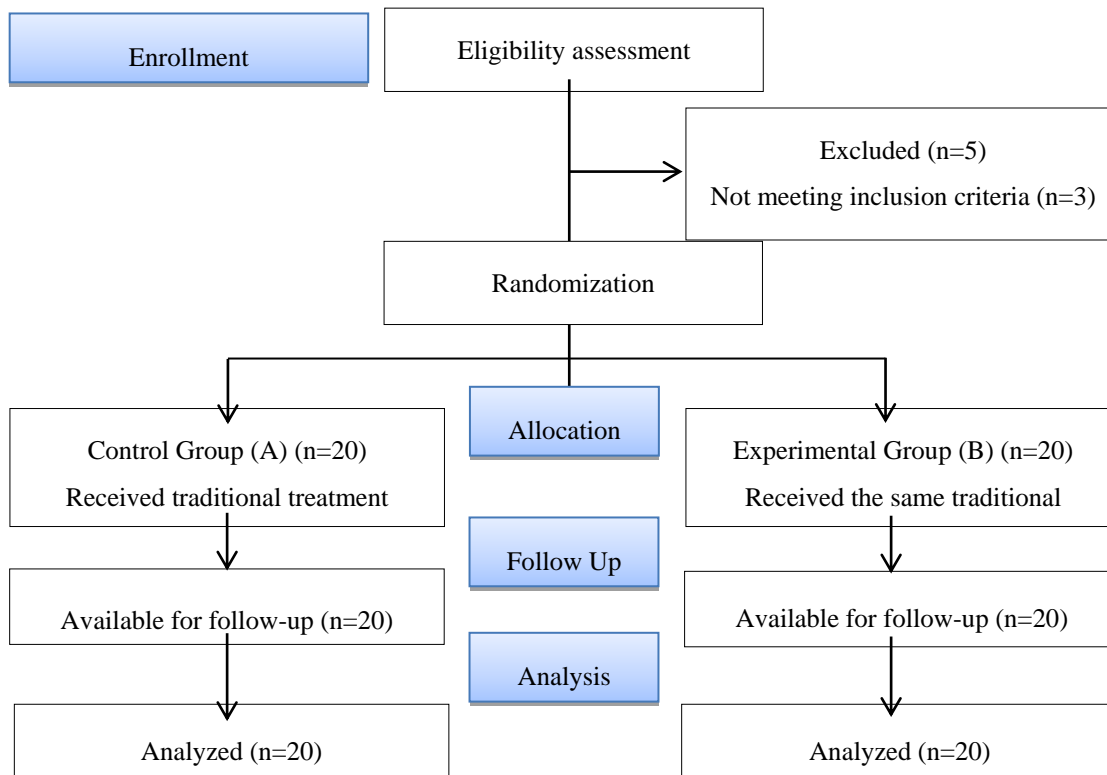


Figure 1. Flow chart of the study

2.4. Interventions

Group (A) (experimental group) included 30 participants who received medical treatment (prescribed by physician), balance exercises and aquatic exercises for 8 weeks, whereas Group (B) (control group) included 30 participants who received medical treatment (prescribed by physician) and balance exercises for 8 weeks. All sessions were given to all children individually not in group sessions. Both groups received the same medical treatment prescribed by a physician of internal medicine.

The program for Group A (experimental group) and Group B (control group):

- Equipment's and assessment materials: blood analysis apparatus, a stop watch, two chairs of 20 to 30 cm in height and a tape measurement.
- Treatment materials: walker, parallel bars, canes, balance board, stepper, up and down stairs, a private rectangular-shaped swimming pool in Shebin El Koom Centre measuring 7.5 meters' width and 11 meters' length with a depth of 90 cm and with a mean temperature of 30°C and swimming aids (jacket, collar and small balls).
- Frequency of exercises: Sixteen sessions (eight weeks with 2 sessions per week).
- Intensity of exercises: Moderate intensity exercise 12 to 14 point on Borg Scale of Perceived Exertion (PRE); a subjective measure of physical activity intensity levels during exercises (including increased heart rate, increased respiration or breathing rate, increased sweating and muscle fatigue). The most common types of scales are 15-point scale (6-20) and the 11- point scale (0-10). The Borg PRE numbers range from 6 to 20 with a rating of “6” indicates the least amount of effort and “20” denotes the most effort (Williams, 2017).
- Balance exercises: All participants in both groups performed balance exercises for 30 minutes which consisted of standing on balance board for 5 minutes then walking with walker, canes, within step separator, walking between parallel bars for 5 minutes for each device, up and down stairs performed for 5 minutes (Wanees & Mohamed, 2016) (Figure 2).

Group (A) (experimental group):

Aquatic sessions were performed after balance exercise sessions with 30 minutes' rest in-between for each child and if there was any tiredness or fatigue or any cardiac or respiratory problems the program would be stopped (Williams, 2017).

Aquatic session exercises: Aquatic exercises were done by a qualified physical therapist. Each child had his/ her own swimming jacket to assist the child to be supported in the pool. Before starting the program, the following factors were settled: water temperature, room temperature and air temperature of pool area were 25°- 30°C. Throughout the sessions the children were immersed in water to chest level, thus bearing 25% of their body mass (Wanees & Mohamed. 2016).

Each child in group (A) received aquatic session exercises for a duration of 40 minutes, consisting of warming up exercises performed for 5 minutes in a water pool with mild upper and lower limbs range of movement exercises and trunk exercises.

Aquatic exercises were performed for 30 minutes and consisted of standing exercises with help, squatting to standing, standing on right leg then left leg, standing with raising right arm then left arm then raising both arms, walking exercises with assistance by therapist, walker, then walking

using the pool surfaces, walking with one cane on the right side then on the left side, walking with mild pushing to right, to left side, forward and backward then walking faster (Hasanpour et al., 2020) (Figure 3).

Cool Down exercises were performed for 5 minutes in a water pool and consisted of mild upper and lower limbs range of movement exercises (Wanees & Mohamed. 2016).

After finishing the underwater exercises, the child left the pool, took a shower (25°C), stayed in the changing room (22°C) for at least 15 minutes and took a juice before leaving (Hasanpour et al., 2020).



Figure 2: Balance walking exercises.



Figure 3: Aquatic standing exercises.

2.5 Outcome Measures

2.5.1. Blood Analysis

Blood analysis was performed before and after the study by using blood analysis devices for complete blood analysis. Blood samples were obtained from each child. Venous blood samples were drawn by a qualified laboratory specialist from the antecubital vein that were analyzed (Hyeon et al., 2018) in a medical laboratory in Shebin Elkom city to determine the level of HB in the blood before and after the program.

2.5.2. Balance Measurements

The Pediatric Balance Scale (PBS) was used as a performance-based clinical measure of balance. The focus of the measure was on the assessment of the performance of many activities, performed before and after the study to objectively determine a child's ability (or inability) to safely

balance during a series of a predetermined tasks. It was a 14 item list, with each item consisted of a five-point ordinal scale ranging from 0 to 4, with 0 indicating the lowest level of function and 4 indicating the highest level of function with a total score of 56. It took approximately 20 to 30 minutes to be completed (Sibley et al., 2017).

2.6. Statistical Analysis

The statistical analysis was done by using statistical SPSS Package program version 25 for Windows (SPSS, Inc, Chicago, IL). Data were screened, for normality assumption test and homogeneity of variance. Normality test of the data was performed using the Shapiro-Wilk test to check the normal distribution of the study variables. All the findings were allowed to conduct parametric and non-parametric analysis. Quantitative descriptive statistics included the mean and standard deviation for demographic data, balance functions variable and HB level. Quantitative descriptive statistics included the number and percentage for gender. Chi-square test (χ^2 -test) was used to compare the results between group (A) and group (B). Paired T-test was used to compare the results of balance functions and HB level variables between pre and post-treatment within each group. Unpaired T-test was used to compare the results between group (A) and group (B) regarding age, weight and height variables. All statistical analyses were significant at level of probability less than 0.05 ($p \leq 0.05$).

3. RESULTS

There are no statistically significant differences between group A and B in terms of demographic characteristics (age, weight, height, and gender) ($p > 0.05$) (Table 1).

Table 1. Differences between group A and B in terms of demographic characteristics

	Group (A) (n = 30)	Group (B) (n = 30)	p value
Age (years)	7.30±1.66	7.26±1.70	0.343 ^{NS}
Weight (kg)	20.60±3.83	18.56±2.86	0.262 ^{NS}
Height (cm)	109.33±5.6	114.26±8.8	0.174 ^{NS}
Gender [n (%)]			
Male	17(28.33%)	18 (30%)	0.212 ^{NS}
Female	13(21.67%)	12 (20%)	0.452 ^{NS}

Note: $p > 0.05$ = non-significant, p = probability

The balance functions showed a statistically significant improvement in the study group (A) ($p < 0.05$) with an improvement of 28.09% after treatment, while in the control group (B) the

improvement was not statistically significant ($p > 0.05$) with a percentage of 10.93% after treatment. The mean Hb value also improved by 29.2% in the study group (A) with a statistically significant increase ($p < 0.05$), while in the control group (B) there was no statistically significant improvement ($p > 0.05$) with a percentage of 8.44% after treatment (Table 2).

Table 2. Descriptive and inferential statistics of the dependent variables in the experimental and control groups before and after the eight-week study period

		Group (A) (experimental group) (n = 30)	Group (B) (control group) (n = 30)	p value**
Balance functions	Pre treatment	31.82±3.22	31.55±2.43	0.78 ^{NS}
	Post treatment	46.76±0.97	35.00±1.87	0.00 ^S
	% of change	28.09 ↑↑	10.93↑	
	P value**	0.00 ^S	0.09 ^{NS}	
Hb level scores	Pre treatment	10.00±1.13	9.83±0.88	0.82 ^{NS}
	Post treatment	12.92±1.60	10.66±0.73	0.00 ^S
	% of change	29.2 ↑↑	8.44↑	
	P value**	0.00 ^S	0.34 ^{NS}	

Note: * (Inter-group comparison); ** (intra-group comparison of the results pre and post treatment);
^{NS} $p > 0.05$ (non-significant); ^S $p < 0.05$ (significant); p (Probability)

4. DISCUSSION

The aim of this study was to investigate the efficacy of aquatic exercises on balance in children with sickle cell anemia. Aquatic exercises application in mild sickle cell anemic children resulted in significant improvements of balance in the study group ($p < 0.05$). The results of this study support the importance of aquatic exercises on balance in sickle cell anemic children. Aquatic exercises support weak muscles and aid to decrease the fear of falling. It provides confidence as the body is challenged to stabilize against the continuously moving water and then improve balance. The supportive properties of the water give patients with poor balance time to react when falling by slowing the movement (Methajarunon et al., 2016).

The results of this study can be explained by the statement of Hyeon et al. (2018) that, children with disabilities are less physically fit than children without disabilities. They have problems in motor skills, physical activity and decrease balance. Aquatic exercises have more effects on their motor skills, physical fitness and emotional behaviors. Ilona et al. (2015) concluded that dynamic and static balance abilities are important components of daily life activities for all children. The aquatic environment makes activities in the water more attractive and motivating than exercising on land, encourages social connection and a persistent level of acceptance, thus improving balance in children with intellectual and developmental disabilities.

Additionally, Kim et al. (2016) found that aquatic exercises help patients to exercise more steadily, positively affect their emotional state and improve balance. Water resistance and buoyancy increase muscle strength and sensory feedback, leading to improved gait ability.

Pozzi et al. (2013) reported that the reduced joint and muscle stress during immersion allows the patient to easily perform exercises and activities. Immersion to the pubic symphysis unloads approximately 40% of the body weight, immersion to the umbilicus unloads 50% and immersion to the xiphoid process unloads 60%. Decreased loading of joints and early rehabilitation could be beneficial for patients with balance problems. Asimonia et al. (2013) discovered that the aquatic environment is considered a safer environment than land, as it provides increased stability and reduces the risk of injury. Consequently, performing some exercises in the aquatic environment offers clear advantages over the land-based equivalent for populations with a high risk of falls.

The results of this study came in agreement with Hasanpour et al. (2020) who stated that, aerobic exercises improve mental health, self-confidence, well-being, happiness, reducing depression, anxiety and increased the quality of life of SCA patients. Aquatic exercises caused an increase in hemoglobin and hematocrit in the experimental group. Abd El-Kader et al. (2017) showed that aerobic exercise training improves prolonged coagulation indices and altered markers of platelets and endothelial activation among patients with SCA in asymptomatic steady state.

Moreover, Waked (2017) evaluated the efficacy of physical therapy on quality of life of SCA patients. The results showed significant improvements in quality of life. Cones et al. (2011) underlined the basic principles that are used for exercise practice and could be used for exercise prescription and rehabilitation in patients with sickle cell anemia. SCA patient should be advised to exercise slowly and progressively, to maintain adequate hydration during and after exercise.

Many previous studies as Zanoni et al. (2015) showed that aquatic exercises are effective in treating musculoskeletal dysfunction in SCA patients. For example, Tinti et al. (2010) reported that two sessions per week of aquatic rehabilitation improve muscle strength and quality of life in a SCA patient. Moreover, Gellen et al. (2018) showed that individualized program with three calibrated 45 min exercise sessions per week, for 8 weeks, was safe for patients with SCA and was able to increase functional capacity.

Furthermore, Daneshjoo & Yusof (2016) investigated the effects of water and land sensorimotor programs on static balance. They concluded that a 6- week training program in water was associated with a significant improvement in static balance compared to training on the ground, that explained by the fact that water exercises require more strength to propel the body forward. A

water-based program which included; forward and backward jogging with arms pushing and pulling could improve muscle strength and balance (Bento et al., 2012)

Pugh et al. (2015) indicated that water exercises improve cerebrovascular function and health. The increase in blood flow and shear stresses that arise are strong stimuli for improvement in endothelial function and arterial remodeling in peripheral arteries. Lee et al. (2014) revealed that balance exercises were effective in encouraging gait, while Oviedo et al. (2014) determined that balance exercises can improve cardiovascular fitness, strength, balance and functional trials in patients with intellectual disabilities.

On the other hand, the results of current study concerning improvements in hemoglobin level in blood is contradicted with a study performed by Grau et al. (2019) which showed that aerobic exercises could improve the physiological and biological markers in SCA patients with no effect on hematological profile. The possible reason could be the short duration of the program.

5. LIMITATIONS

The study was limited by external factors that may have affected the results of this study, such as the short duration of the program (eight weeks). The children were afraid of exercising in water and afraid of falling.

6. CONCLUSION

In conclusion, the aquatic exercise program has a positive effect on improving balance functions in children with sickle cell anemia.

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CONFLICTS OF INTEREST

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