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Effect of pilates exercise on quality of life in patients with sickle cell disease

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ABSTRACT

Objectives: This study aimed to investigate the randomized controlled response of quality of life (QoL) to 12-week Pilates exercise in patients with sickle cell disease (SCD).

Materials and methods: Patients were recruited from a tertiary hospital affiliated with the General Authority for Health Insurance. Forty patients were randomly assigned to the 30-min Pilates group (PG) (20 patients trained 5 times per week) or the control not-trained group. The outcome measures were six-minute walking distance (a measure for physical capacity), quadriceps force, hand grip force, the total score of Pittsburgh sleep quality index, Beck depression inventory, and the mental and mental summaries of short form 36.

Results: In the PG only, the results of the tested outcomes measures reported significant improvements ($p < 0.05$).

Conclusions: In conclusion, to improve QoL, sleep quality, muscle strength, depression, and physical capacity in patients with SCD, Pilates training is a good and safe choice.

Keywords: quality of life, Pilates, sickle cell disease

INTRODUCTION

Increased liability of red blood cells (RBCs) to sickling on deoxygenation leaving vaso-occlusive crisis (VOC) (one of the most causes of irritating acute pain) is the definition of a genetically heterogeneous group of disorders, sickle cell disease (SCD) [1]. Despite the significant increased number of published articles, many aspects of SCD pathophysiology and complications remain not fully explained [2]. Polymerization of within-RBCs deoxygenated sickle hemoglobin (Hb), red RBCs rigidity, blood flow obstruction, tissue hypoxia, acute pain, chronic damage of organs, hemolytic anemia, and premature mortality are the assumed pathophysiological sequences of VOC crises, the main clinical manifestation of SCD [3].

To suppress the synthesis of abnormal Hb from the bone marrow, regular blood transfusion is the main SCD management. Iron deposition in different vital organs, which negatively affects their functions, is the main complication of blood transfusion [4]. Limited functions of different vital organs and repeated painful VOC crises may affect the quality of life (QoL) of SCD patients who usually complain of depression (ranges from 18 to 44% in those patients) [5], unpleasant sleepiness SCD [6], and low physical capacity [7].

The suggested mechanisms of low physical fitness/capacity in SCD patients are various. Compromised blood flow to skeletal muscles (especially those of lower limbs), declined oxygen (O_2) affinity and carrying capacity, pulmonary parenchymal damage and vascular disease, cardiac limitation, and low rheology of sickle blood [8].

Physical exercise based on a short-term training program [9], was thought to have the potential to exacerbate tissue hypoxia and provoke VOC crises by initiating metabolic changes, raising the body's O_2 demand and serum lactate, and favoring dehydration [10]. The cumulative SCD research recommended the use of long-term training programs is better than the short-term or acute ones. Long-term programs reported more safety, low reported complications, low side effects, high improvements in physical capacities and muscle metabolism, and 17% raise in skeletal muscle capillary density [11].

Physical exercise utilizing the Pilates approach has been increasingly popular in recent years. This method entails a physically and mentally approached training that includes specialized exercises such as resistance and dynamic stretching, all of which are synced with breathing and adhere to the following fundamentals: mastery, precision, centralization, fluency of motion, and attentiveness. The approach has several advantages, including increased strength, QoL [12], and walking efficiency [13].

The authors' aim of this exercise trial in SCD patients was to test the following hypothesis: randomized controlled Pilates training would have no effect on physical capacity, quadriceps and hand grip strength, sleeping, depression, and QoL in SCD patients. This hypothesis was not investigated before, so our goal is to test this hypothesis in this article.

MATERIALS AND METHODS

Settings of SCD Study

Patients were recruited from the Hematology Outpatient Clinic, one of Al-Firdaws Comprehensive Outpatient Clinics of the General Authority for Health Insurance from the 22 June to 30 December 2022. The intervention, Pilates, was conducted five times weekly. All ethics including Helsinki recommendations and local institutional approval were applied.

Inclusion Criteria For the 40 SCD Patients

Hb electrophoresis was used to confirm SCA diagnosis, and genetic analyses were used to confirm the diagnosis if the Hb electrophoresis outcomes were unsatisfying. Sedentary participants were recruited in a medically stable state in the last three months (i.e., without any VOC crises, hospitalized complications, blood transfusion, or analgesic administration for bony, articular, or multiple-site pains).

Exclusion Criteria

A physician excluded stroke history, infection (HIV and hepatitis), serious electrocardiographic changes (cardiac arrhythmias, ischemia, or infarction), echocardiography-diagnosed heart (ventricular dysfunctions, pericardial disease, or cardiomyopathies) and valvular diseases. Rheumatology-disease patients, pregnant or lactating SCD women, systemic disease patients, SCD smokers/alcoholics, or patients with malignancies or neurogenic/orthopedic complaints were excluded.

SCD-Patient Randomization

With the assistance of a two-block computerized wait list, SCD patients were randomized. Statistical technicians randomly assign patients (who are aged > 18 years and up) to Pilates group (PG) (this group contained 20 SCD participants who received Pilates training) or CG (this group contained 20 SCD participants who were requested not to change their usual daily or weekly activity for 12 weeks) (**Figure 1**).

Intervention (12-Week Pilates)

Every SCD started the intervention with a warm-up (one-minute breathing exercise and one-minute stretching for every muscle of the following: hamstring, wrist extensors, pectoralis

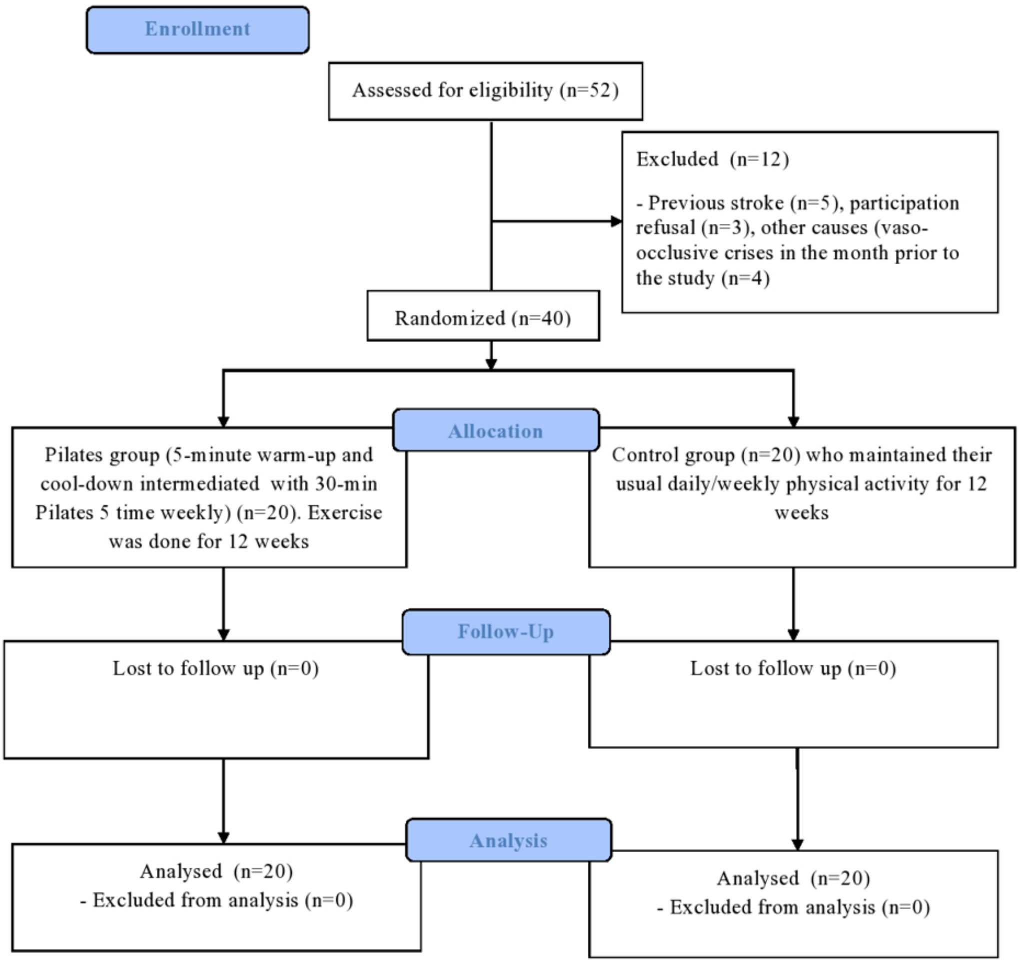

Figure 1. Flow chart of SCD participants (Source: Authors' own elaboration)

major, and scalene). The 30-minute Pilates was executed sequentially, according to [14]:

1. 3-minute floating exercise,
2. 30-second level-1 single-leg stretching (for every leg),
3. 1-minute level-2 single-leg stretching (for every leg), 30-second level-1 hip twisting (for every hip),
4. 1-minute level-2 hip twisting (for each hip),
5. 3-minute roll-up,
6. 1.5-minute side kicking (for each leg),
7. 3-minute saw exercise,
8. 3-minute spine stretch,
9. 3-minute one leg circle,
10. 3-minute shoulder bridge, and
11. 3-minute double-arm stretch.

After the end of Pilates, there was a cool-down conducted with the same details as the warm-up.

Outcomes

The total score of Pittsburgh sleep quality index

The 21-item total score of Pittsburgh sleep quality index (TS-PSQI) was the primary outcome. TS-PSQI is a self-reported questionnaire that assesses sleep quality/interruptions. Each item of TS-PSQI was scored from 0-3 [6].

Physical and mental QoL summary measures

To assess QoL, the widely known short-form 36-item questionnaire (SF-36q) was used. SF-36q is disunited into two broad summaries: the 21-item physical summary of SF-36q ($SF\text{-}36q_{ps}$) and the 14-item mental summary of SF-36q ($SF\text{-}36q_{ms}$). The findings were generated on a scale of 0-100 points, with higher scores reflecting better QoL. [15].

Beck depression inventory

To examine SCD-related depression, the Beck depression inventory (BDI-II) was employed. There are 21 items in the questionnaire used. Each item was scored from 0-3 [16].

Physical capacity

SCD-related physical capacity was assessed by 6-minute walking distance (6MWD). requesting the SCD patients to walk for 6 minutes as quickly as they could along a 30-meter track at their normal gait pace, 6MWD.

Muscle force

Hand-held muscle tester, made in USA was used to assess muscle force.

Hand-grip force (HG_f): The mean of 3-repetition dominant HG_f trials was value taken. In the sitting position, HG_f strength was measured while SCD patients held the muscle tester with 90-degree elbow flexion and neutral-position forearm.

Quadriceps force (QF): The mean of 3-repetition dominant QF trials was the value taken. In the sitting position, QF was measured while SCD patients started the range of motion from 90-degree knee flexion.

Blinding

The blinding procedures were applied in this SCD trial by avoiding supplying data to outcome assessors.

Sample Size of SCD Study

Using the G*Power program, assuming TS-PSQI was the primary outcome, the need for 36 patients (each group containing 18 patients) was extracted from the pilot test at 80% power, effect size = 0.98, and 16 SCD pilot-test patients. To prohibit the effect of dropout, the number of SCD participants was increased to 40 patients (the increase reached 10%).

Statistical Analysis

The clinical and demographic data of SCD participants were tested using the unpaired test (to assess their between-group significance before Pilates application. The ANOVA test (repeated measure) was used to the within- and between-group significance of examined SCD outcomes. It is worth noting that the statistical tests used were chosen after documenting the normal distribution of data by the Smirnov test of the SPSS (version 18).

RESULTS

Before Pilates application, comparing between-group demographic and clinical data of SCD participants showed non-significant differences (**Table 1**).

Table 1. Clinical (baseline) data of sickle cell disease groups

Data		PG	CG	p-value*
Sex frequency (males: females)		9: 11	11: 9	-
M ± SD of age (year)		38.05 ± 4.90	40.20 ± 3.25	0.110
M ± SD of body mass index (kg/m²)		23.18 ± 3.06	22.73 ± 2.73	0.626
M ± SD of forced vital capacity (%)		78.35 ± 14.62	77.50 ± 16.70	0.864
M ± SD of forced expiratory volume in the first second (%)		74.60 ± 17.99	74.55 ± 15.66	0.992
M ± SD of FEV1/FVC (%)		84.65 ± 7.43	83.05 ± 7.59	0.504
M ± SD of hemoglobin		9.97 ± 1.73	9.72 ± 2.24	0.695
M ± SD of tricuspid regurgitant velocity (m/s)		2.66 ± 0.62	2.47 ± 0.61	0.334
M ± SD of urea (mg/dL)		20.26 ± 2.28	19.31 ± 2.79	0.245
M ± SD of creatinine (mg/dL)		0.42 ± 0.14	0.44 ± 0.11	0.618
Hydroxyurea therapy	Yes	12	11	
	No	8	9	
Frequency of vaso-occlusive crises per year	≤ 1	12	10	
	≥ 2	8	10	
Frequency of blood transfusion per year	≤ 1	15	14	
	≥ 2	5	6	

Note. M: Mean; SD: Standard deviation; *The represented p-value of **Table 1** is > 0.05 so it is non-significant; & FEV1/FVC: Forced expiratory volume in the first second/ forced vital capacity

Table 2. Pre- and post-values of SCD patients' data (M ± SD)

Patients' data			PG	CG	p-value
6MWD (M)		Baseline	499.25 ± 72.68	487.10 ± 70.02	0.593
		12-week	532.50 ±78.15	484.90 ± 68.28	0.047*
		p-value	< 0.001*	0.465	
Dominant HG_f (kg)		Baseline	30.82 ± 5.48	31.02± 3.82	0.892
		12-week	34.33 ± 4.63	30.06 ± 4.13	0.004*
		p-value	< 0.001*	0.175	
Dominant QF (kg)		Baseline	24.92 ± 3.72	24.08 ± 3.56	0.469
		12-week	35.69 ± 3.63	23.81±3.88	< 0.001*
		p-value	< 0.001*	0.774	
SF-36q	Baseline 12-week	Baseline	40.60 ± 7.86	41.50 ± 4.09	0.652
		12-week	49.10 ± 6.10	40.70 ± 4.20	< 0.001*
		p-value	< 0.001*	0.374	
	Baseline 12-week	Baseline	43.90 ± 3.30	42.80 ± 3.79	0.334
		12-week	53.20 ± 3.92	41.50 ± 5.40	< 0.001*
		p-value	< 0.001*	0.215	
S-PSQI		Baseline	8.15 ± 1.30	7.90 ± 1.51	0.580
		12-week	6.05 ± 1.14	8.00 ± 1.48	< 0.001*
		p-value	< 0.001*	0.714	
BDI-II		Baseline	8.00 ± 1.41	8.30 ± 1.45	0.512
		12-week	5.90 ± 1.37	8.50 ± 1.70	< 0.001*
		p-value	< 0.001*	0.583	

Note. M: Mean; SD: Standard deviation; & *Because the magnitude of the presented p-value in **Table 1** is less than 0.05, this mark denotes its significance

Also, before Pilates application, comparing between-group pre-outcome data (SF-36q_{ps}, BDI-II, SF-36q_{ms}, HG_f, QF, 6MWD, and TS-PSQI) of SCD participants showed non-significant differences. After Pilates application, comparing within-PG outcome data (SF-36q_{ps}, BDI-II, SF-36q_{ms}, HG_f, QF, 6MWD, and TS-PSQI) of SCD participants showed significant differences. After 12-week, within-CG comparison of outcome data (SF-36q_{ps}, BDI-II, SF-36q_{ms}, HG_f, QF, 6MWD, and TS-PSQI) showed non-significant differences (**Table 2**).

DISCUSSION

Despite warnings not to admit SCD patients in any exercise form because it may increase VOC occurrence due to sickling/viscosity of blood (due to increased polymerization of Hb, blood acidosis, and venous deoxygenation especially with high-intensity acute physical activity), regular moderate-intensity exercise in SCD patients proved that it is a safe therapeutic modality which can be applied without fear from increasing blood-viscosity hematological parameters [17]. Moreover, it reduces the number of VOC crises due to the reduction of oxidative stress and improvement of antioxidant/nitric oxide responses [18].

Experimental studies on SCD mice reported that exercise decreases sequestration of sickle erythrocytes due to reduction of spleen congestion and spleen/body mass ratio, attenuating the high levels of plasma cytokines and white blood cells, decreased acidosis and enhanced venous blood oxygenation (both decrease Hb polymerization and RBC sickling especially with chronic regular exercise) [19], and molecular reduction of hematological components involved in vascular adhesion as plasma soluble vascular adhesion molecule [20] and pulmonary p-selectin [21].

Impaired vascular reserve, low density of skeletal muscle capillaries, impaired blood rheology, and chronic anemia are documented co-factors that limit exercise capacity in SCD patients [22]. The gained positive increase of skeletal muscle microvasculature after regular exercise in SCD in the study conducted in [23] may correct the above-mentioned limitations to support the reported increase of 6MWD, QF, SF-36q_{ps}, and HG_f in the present study.

Consequently, in SCD adults, long-term improvements in fitness and physical activity/functioning are linked to improved cardiovascular outcomes, overall mortality, health-related QoL, and other sufferer-centered outcomes [24].

Regarding the improved BDI-II and SF-36q_{ms}, besides decreased distraction, during-exercise-induced social interactions increase competence, self-efficacy, social support, and confidence perceptions may positively affect mental health [25]. Also, exercise-induced psycho-physiological arousal [26] may explain the reduced depression symptoms in the present study.

Regarding the improved TS-PSQI, exercise could be a good candidate for better sleeping quality. Insomnia is linked to a lack of thermoregulation, which appears to be improved by frequent exercise. Exercise raises skin warmth, which helps deep sleep. Exercise also affects the amounts of pro-inflammatory cytokines, growth hormones, and brain-derived neurotrophic factors in the bloodstream, all of which are implicated in sleep regulation [26].

The selection of Pilates exercise, as a moderate-intensity exercise in this study, was consequent with the recommendations of a new systematic review [27] and the results of a 12-week exercise trial [28]. The two studies mentioned that physical exercise (conducted with moderate intensity) not only supports safety, as it does not evokes VOC crisis and consequent morbid complications, but also induces gains by improving systemic inflammation, fatigue, and exercise tolerability [27, 28].

Improved 6MWD in the present study was supported by another Brazilian study. This study assumed that improved cardiovascular functions (ejection fraction and diastolic function) were the cause of the significant increase in the walked distance on the treadmill (as a cardiovascular functional test) after the 8-week adherence of SCD patients to home-based aerobic exercise (5 times/weekly) [29].

The application of an exercise program (walking, resisted training, balance training, and flexibility exercise) for 12 weeks (60 min, 3 times weekly) safely improves the 6MWD, physical and mental summaries of SF-36q, QF, and HG_f in SCD patients [30]. Again, supporting the exercise-induced muscle strength gains in this study, conducting physical therapy exercises in water (aquatic exercises) for 12 weeks significantly improve the strength of the trunk and hip muscles in SCD patients who complained of lumbar and hip pains [31].

In thalassemia, inherited hemolytic anemia, designing an eight-week walking program for sufferers aged ≥ 18 years reported a significant improvement in SF-36q [32]. Again, and in thalassemia, involving the sufferers in an eight-week aquatic aerobic training can positively impact SF36q mean score [7].

In agreement with the reported SCD patients' findings after using 12-week Pilates, training sedentary adults (aged 22 ± 2 years) by the same exercise type and duration significantly improved their SF-36q and sleepiness level [33].

As a support to the choice of Pilates in this study, women who were trained via regular Pilates training reported significant BDI-II [34-38], QoL [34,37,39], TS-PSQI [38], 6MWD [34, 39], HG_f [40], and QF improvements [35,36].

In other studies, contradicting the results of this study, assessment of QoL using SF-36q after a 12-week Pilates exercise did not show significant improvement may be due to the limited inclusion of geriatric participants [41]. Opposite to our results, exercise performance was not affected after 6-week training in twelve SCD patients, despite the increase in daily activity level, which may be due to the number and short duration of the sessions (15-30 min, 2 sessions weekly) [42]. Again, despite the improved fatigue perception, BDI-II did not significantly improve after regular physical activity (which may be due to the small sample size of undergoing-chemotherapy breast malignancy women and the short duration of the indoor exercise program) [43]. Also, QF was not changed after Pilates training in overweight/obese adults (the short duration, 8 weeks, maybe the cause of the non-changes) [44]. Also, despite the improvements in depression (assessed by BDI-II), aerobic capacity (assessed by 6MWD), and QoL, training with Pilates alone did not produce a significant change in TS-PSOI may be due to the associated comorbidities of rheumatoid arthritis present in the participants [45].

Regular follow-up to the presented SCD findings is the missed point in this Pilates interventional research. This point must be addressed in future SCD studies.

CONCLUSIONS

To improve $SF\text{-}36q_{ps}$, BDI-II, $SF\text{-}36q_{ms}$, HG_f, QF, 6MWD, and TS-PSQI in SCD patients, Pilates training is a good and safe choice.

Author contributions: AMAI & FBY: conception and design of this SCD study; **HAE, MNMK & AMAEA**: acquisition of data analysis; **KAKAM**: interpretation of data; **SKME**: drafting the manuscript; **AMAI, FBY, HAE, MNMK, AMAEA & SKME**: revising and reviewing the SCD manuscript critically for important intellectual contents. All authors have agreed with the results and conclusions.

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Declaration of interest: No conflict of interest is declared by the authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

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