



Effect of Aerobic and Arm Exercises on HbA1c and Immunological Properties of Breast Milk in Diabetic Lactating Women

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Abstract

Objective: To assess the therapeutic efficacy of aerobic and arm exercises on glycosylated hemoglobin (HbA1c) and immunological properties of breast milk in diabetic lactating women. **Material and Methods:** This study was carried out on thirty breast feeding diabetic lactating women. They were randomly divided into two groups. Group (A) received aerobic and arm exercises, diet program and medications for 8 weeks (n=15), while group (B) received diet program and medications for 8 weeks (n=15). HbA1c and immunological properties of breast milk (IgA, lactoferrin and lysozyme) were evaluated before and after treatment for both groups. **Results:** Comparing both groups post-treatment showed that there were a statistically significant reduction in HbA1c (p<0.05) and statistically significant increases in all immunological properties of breast milk (p<0.05) in favor of group (A). **Conclusion:** Aerobic and arm exercises have a significant positive effect on HbA1c and immunological properties of breast milk in diabetic lactating women.

Keywords: Diabetic lactating women, Aerobic and arm exercises, HbA1c, Breast milk, Immunological properties

1 Introduction

Lactation gives immunological support for the infant against infections during the first months of life and over the long-term. Accordingly, the American Academy of Pediatrics reaffirms its recommendation of exclusive breast feeding for six months followed by continued breast feeding with introducing complementary foods for at least one year [1]. Immunoglobulin A (IgA), lactoferrin and lysozyme represent three proteins that are found in relatively high levels in breast milk and provide beneficial immunological impact. IgA prevents bacterial adherence to mucosal surfaces and neutralizes toxins from microorganisms. Lactoferrin works at the mucosal sites and has antimicrobial and anti-inflammatory activities. It competes with bacteria for ferric iron and prevents the growth of microorganisms. Lysozyme is a protein that provides bacterial lysis and works synergistically with IgA and lactoferrin in antibacterial functions [2]. Diabetic lactating women have decreased concentrations of immunological factors in their breast milk. The total IgA concentration in diabetic breast milk was 63.6% lower than in those without gestational diabetes [3]. The reduced immunoglobulins in breast milk of diabetic women could be a result of reduced function of B-cell lymphocyte associated with hyperglycemia in diabetes [4-6]. Another mechanism explaining the reduction in milk immunoglobulins in diabetic women could stem from the reduced circulating levels of prolactin associated with obesity and diabetes as demonstrated in insulin-dependent diabetes mellitus [7]. Prolactin regulates humoral immunity by binding to prolactin receptors on B lymphocytes and stimulating ornithine decarboxylase, the rate-limiting enzyme in polyamine biosynthesis required for

synthesis and secretion of immunoglobulins [3]. Hence, physical therapy programs for improving glycemic control and breast milk immunological properties in diabetic lactating women are desirable.

Regular exercise is a cornerstone of treatment for diabetes. In the 2018 Diabetes Standards of Care publication, the American Diabetes Association recommended most patients with diabetes should engage in 150 minutes or more of moderate intensity physical activity per week [8]. Aerobic exercise increases work capacity, improves cardio respiratory fitness, improves insulin sensitivity, improves glycemic control as reflected in HbA1c, enhances the immune function and brings favourable changes in body mass, body composition and lipid profile, even without dietary restriction [9-11]. Previous studies investigated the effect of maternal exercise on immunological properties of breast milk in healthy lactating women [2, 12]. Additionally, other studies examined the effect of exercise training on glycemic control in diabetic patients [13, 14]. However, none of them had examined the effect of maternal exercise on glycemic control and immunological properties of breast milk in diabetic lactating women. Therefore, this study was the first one which aimed to investigate the effect of aerobic and arm exercises on HbA1c and immunological properties of breast milk in diabetic lactating women.

2 Materials and methods

2.1 Study Design

The study was designed as a prospective, pre- and post-test, randomized, controlled trial. Ethical approval was obtained from the institutional review board at Faculty of Physical Therapy, Cairo University. The study followed the Guidelines of Declaration of Helsinki on the conduct of human research. It was conducted between May 2019 and February 2020.

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2.2 Participants

Thirty sedentary, nonsmoking, diabetic lactating women were selected, from the Outpatient Clinic of Gynecology and Obstetrics, Imbaba General Hospital and Kasr Al- Ainy Hospital, to engage in this study. They had delivered a single, full-term, healthy infant without any complications. Their HbA1c was greater than or equal to 6.5%, their ages ranged from 25 to 35 years old and their body mass index (BMI) ranged from 25 to 30 Kg/m². Lactating women were excluded if they had poor lactation, nipple problems (retracted, cracked, inflamed or inverted nipples), breast cancer, previous surgeries in breast or chest, any cardiorespiratory disease, anemia, immune dysfunction, infectious diseases or psychiatric disorders. Additionally, lactating women that had received contraceptive pills or corticosteroid medications were excluded from this study.

2.3 Randomization

Informed consent was obtained from all participants following the detailed explanation of the study. The privacy of all received data and the right to refuse or leave at any moment were also provided to all participants. The diabetic lactating women were randomly assigned into two groups (A and B) using a computer-generated randomization cards saved in sealed envelopes. After randomization, there was no dropping out of subjects.

2.4 Interventions

Group (A) included 15 diabetic lactating women who received aerobic and arm exercises plus diet program for 8 weeks, while group (B) included 15 diabetic lactating women who received medications plus diet program for 8 weeks.

2.4.1 Aerobic and arm exercises

Each diabetic lactating woman in group (A) received aerobic exercise for 30 minutes using treadmill and received arm exercise for 15 minutes using multi gym machine for 8 weeks. For aerobic exercise performance, participants were asked to walk on treadmill for 30 minutes (five minutes of warm up, 20 minutes of moderate aerobic exercise at 60 to 70% of maximal heart rate (HRmax) and 5 minutes of cooling down). HRmax was calculated by subtracting the age from 220 [15]. Then, participants were asked to perform arm exercise for 15 minutes using multi gym machine to train upper limb muscles including chest and arms muscles. The duration of the treatment session was 45 minutes, 3 times per week, for 8 weeks.

2.4.2 Diet program

All diabetic lactating women in both groups (A and B) received diet program to follow it during treatment course. They were instructed to eat every day 2-3 servings of protein foods (e.g. meat, poultry, fish, eggs, beans, nuts and seeds), 4-5 servings of dairy products (e.g. milk and yoghurt), 2-4 servings of vegetables per day (including dark green and yellow vegetables), 2-3 servings of fruit per day, and 4-5 servings of whole grains (e.g. whole wheat breads, pasta, cereal and oatmeal), as well as drink plenty of water (6-8 glasses) and fluids daily [16].

2.4.3 Medications

All diabetic lactating women in both groups (A and B) were instructed to follow medications prescribed by physician for diabetes during treatment course.

2.5 Outcome Measures

2.5.1 Plasma blood HbA1c

Blood samples were collected from all diabetic lactating women in both groups to measure plasma levels of HbA1c, a weighted average of blood glucose levels during the preceding 120 days [17], pre- and post-treatment. Samples were collected into serum separating tubes and allowed to clot at room temperature for 30 minutes. Then, centrifugation of blood clot was done at 3000 g for 15 minutes. Aliquots of the serum samples were stored at -20 °C for further use. HbA1c was measured by using high performance Elisa kit (Bionic Company, China) [18].

2.5.2 Analyses of immunological properties of breast milk

A sample of 10 mL of breast milk was collected from each diabetic lactating woman in both groups to check the concentrations of IgA, lactoferrin and lysozyme pre- and post-treatment. Samples were collected into sterile sample bottles and transported on ice to the laboratory for analysis through an enzyme-linked immunosorbent assay procedure. IgA was analyzed by Human IgA ELISA core kit (KOMA BIOTECH), while both lactoferrin and lysozyme were analyzed by AssayMax Human ELISA kit (ASSAYPRO, USA) [19].

2.6 Statistical analysis

Statistical Package for Social Science (SPSS) computer program (version 23 windows) was used for data analysis. Results were expressed as mean and standard deviation (SD). The Kolmogorov-Smirnov distribution test was used for examining normal distribution of data. In comparing quantitative data, the unpaired samples t-test was used in intergroup comparison of parameters, while the Paired samples t-test was used for intragroup comparisons. The level of significance was set at P value of less than or equal to 0.05.

3 Results

Both groups were similar at baseline ($P > 0.05$) regarding age, weight, height, BMI and all outcome measures (tables 1-2). The HbA1c showed a statistically significant reduction within both groups (A and B) ($P < 0.05$). Also, the post-treatment comparison of both groups revealed a statistically significant reduction in HbA1c ($P < 0.05$) in favour of group (A) (Table 2). The immunological properties of breast milk (IgA, lactoferrin and lysozyme) showed statistically significant increases within both groups (A and B) ($P < 0.05$). Also, the post-treatment comparison of both groups revealed a statistically significant increases in all immunological properties of breast milk ($P < 0.05$) in favour of group (A) (Table 2).

4 Discussion

Diabetic lactating women have higher levels of HbA1c in their blood and lower levels of immunological factors in their breast milk [3, 20]. Therefore, the present study aimed to investigate the effect of aerobic and arm exercises on HbA1c and immunological properties of breast milk in diabetic lactating women. The results of the present study revealed that there were a statistically significant reduction in HbA1c and statistically significant increases in all immunological properties of breast milk (IgA, lactoferrin and lysozyme) post-treatment in favor of group (A). These results indicated the effectiveness of aerobic and arm exercises in improving glycemic control and immunological properties of breast milk in diabetic lactating women.

Table 1: Demographic features of women in both groups

Characteristics	Group (A) (n = 15)	Group (B) (n = 15)	P value
Age (years)	29.93 ± 2.46	29.47 ± 3.07	0.649 ^{NS}
Weight (Kg)	71.27 ± 3.39	73.27 ± 3.31	0.113 ^{NS}
Height (cm)	159.33 ± 3.90	160.40 ± 3.91	0.461 ^{NS}
BMI (Kg/m ²)	28.06 ± 0.76	28.47 ± 0.67	0.131 ^{NS}

^{NS} P > 0.05 = non-significant, P = Probability.

Table 2: HbA1c and immunological properties of breast milk for both groups

		Group (A) (n = 15)	Group (B) (n = 15)	P value*
HbA1c (%)	Pre-treatment	7.33 ± 0.67	7.37 ± 0.55	0.883 ^{NS}
	Post-treatment	6.43 ± 0.50	6.90 ± 0.51	0.017 ^S
	P value**	0.001 ^S	0.001 ^S	
IgA (µg/ml)	Pre-treatment	174.43 ± 13.70	180.61 ± 7.40	0.139 ^{NS}
	Post-treatment	240.06 ± 18.02	220.69 ± 22.82	0.015 ^S
	P value**	0.001 ^S	0.001 ^S	
Lactoferrin (µg/ml)	Pre-treatment	837.93 ± 66.65	813.98 ± 59.12	0.307 ^{NS}
	Post-treatment	912.62 ± 71.77	850.05 ± 64.56	0.018 ^S
	P value**	0.001 ^S	0.001 ^S	
Lysozyme (µg/ml)	Pre-treatment	272.90 ± 49.00	268.55 ± 32.36	0.777 ^{NS}
	Post-treatment	354.07 ± 41.65	317.95 ± 37.90	0.019 ^S
	P value**	0.001 ^S	0.001 ^S	

* 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.

Regarding HbA1c in group (A), our result was in line with previous studies that reported the positive effect of aerobic exercise on reducing HbA1c levels in diabetic subjects [21-24]. On the other hand, Aggarwala et al. [25] found non-significant changes in HbA1c following aerobic training. The contrast between studies could be related to the differences in different exercise parameters. The significant improvement in HbA1c reported in group (A) in the present study could be explained by the improving effect of physical training on insulin action primarily in skeletal muscle. The mechanism behind this effect involves a number of adaptations like increased capillary density and GLUT 4 content, a shift towards more insulin sensitive fiber types, alterations in the sarcolemma phospholipids composition, increased activity of glycolytic and oxidative enzymes and increased activity of glycogen synthase. Exercise causes glucose uptake increase in skeletal muscle in addition to 5'AMP- activated protein kinase activity increase, resulting in enhancement of glucose transport through increased cell surface GLUT 4 content in insulin resistant skeletal muscle and mediation of the effects of GLUT4 expression [21]. Moreover, regional adiposity, especially visceral and intramuscular fat stores, has a direct relationship to insulin insensitivity via fat-specific cytokine-mediated pathways. There is also a direct impact of intramyocellular fat storage on insulin receptor function within muscle tissue. Therefore, reduced fat mass through exercising diminishes the adverse effect of these factors [26].

Regarding HbA1c in group (B), the reported significant improvement was consistent with Sami et al. [17] who revealed that dietary management is a superior option for keeping HbA1c levels in an acceptable range and achieving glycemic control in diabetic patients. Also, Mottalib et al. [27]

concluded that structured nutrition therapy alone improves HbA1c in overweight and obese diabetics. Regarding immunological properties of breast milk in group (A), the results of this study came in line with Cieslak et al. [28] who reported that moderate exercise has a positive effect on the immune system through enhancing cell-mediated immunity and increasing IgA. Each session represents a boost in immune surveillance [29]. The mechanisms by which the moderate aerobic exercise caused significant increases in all immunological properties of breast milk (IgA, lactoferrin and lysozyme) are still unknown. However, the results of this study could be supported with Osman et al. [1] who found that moderate aerobic exercise produced a significant increase in breast milk lymphocytes. Since decreased B-cell lymphocyte function associated with hyperglycemia in diabetics causes decreased immunoglobulins in their breast milk [4-6], the improvement in lymphocytes associated with moderate aerobic exercise could result in increased immunoglobulins levels in diabetic breast milk. Additionally, prolactin plays a role in regulating humoral immunity [3]. Therefore, the significant increase in immunological properties of breast milk might be a result of the significant increase of plasma prolactin concentrations in exercising mothers that previous studies had demonstrated [30,31]. This increase of plasma prolactin might be in turn resulted in increase of breast milk prolactin which correlates significantly with total protein in milk [32]. In contrast, the results of the present study disagreed with Lovelady et al. [2] who reported that lactating mothers who exercised aerobically at least 30 minutes/day for 3 days/week had no significant differences in breast milk concentrations of IgA, lactoferrin and lysozyme. Also, Groër and Shelton [12] found that IgA concentrations in breast milk

were not affected by maternal exercise in 4-6 weeks postpartum women. However, significant limitations of those two previous studies are the cross-sectional design and use of self-reported exercise. The significant improvement in immunological properties of breast milk in group (B) could be related to the effect of maternal nutritional status. Chang [33] (1990) found that IgA and lysozyme concentration in breast milk of well-nourished women were twice their concentrations in malnourished women during the first 7 days of lactation and at most stages up to 8 weeks thereafter. These results provide new data about the therapeutic efficacy of aerobic and arm exercises on HbA1c and immunological properties of breast milk in diabetic lactating women. Further studies are needed in order to clarify the mechanisms underlying these responses to aerobic and arm exercises.

5 Conclusion

Aerobic and arm exercises for 8 weeks are effective in improving glycemic control and increasing immunological properties of breast milk in diabetic lactating women.

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Ethical issue

Authors are aware of, and comply with, best practice in publication ethics specifically with regard to authorship (avoidance of guest authorship), dual submission, manipulation of figures, competing interests and compliance with policies on research ethics. Authors adhere to publication requirements that submitted work is original and has not been published elsewhere in any language.

Competing interests

The authors declare that there is no conflict of interest that would prejudice the impartiality of this scientific work.

Authors' contribution

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