

The Effect of Moderate Intensity Aerobic Exercise on Breast Milk IgA Concentrations

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Abstract

Background: The immune properties of mothers' milk are well known. But the effects of physical activity on humeral immune properties of mothers' milk is still undetermined. Therefore, reports on the impact of exercise on IgA concentrations of mothers' milk is controversial. The purpose of the present study was the investigation of the effects of selected aerobic exercises in maximum intensity of 60-70% of heart rate reserve on IgA concentrations in breast milk as well as body composition. **Method:** In this research, 28 sedentary women (29 ± 5.7 years; $VO_{2max} 36 \pm 4$ ml/Kg/min), divided into two exercise and control groups through random sampling, took part. The exercise group performed some particular exercises for 10 weeks whereas the control group did not do so. Milk samples were taken from both groups and measured by the ELISA method. Body composition was also measured in different stages of the study. **Results:** In the rest status, the two groups were identical in terms of IgA concentrations ($p= 0.549$) and body composition ($p=0.204$). IgA concentrations under exercise load of 60% ($p=0.060$) and 70% ($p= 0.001$) of the HRR respectively showed a significant increase as compared to the resting status mean values in the two groups. Body composition variables were only of significant values in terms of comparing the general effects, only in the factors of group ($p=0.003$) and reciprocal effect of the grouping - the duration of the exercises ($p=0.024$). **Conclusions:** The results of this research show that, under the effects of moderate intensity exercise, the mothers' secretory immune system experiences some changes. Therefore, IgA concentrations in the milk increase. In addition, with the reduction of fat weight, the decrease of fat mass percentage, and increase in the body density, the level of the mothers' aerobic fitness is increased, which is in no contradiction with their lactation performance. **Keywords:** Mucosal immunity, Breast milk, Aerobic exercise, W

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INTRODUCTION

The existence of a particular immune system in the secretory mucosal is rather a new theory, and the present information about mucosal immunity is based on the research done on the digestive system. However, it is likely that, immune responses in mucosal and lymphatic tissues (the mother's mammary glands) are basically similar (Soltani, 2018). The mother's mammary glands are one of the areas that produce milk. A mother's milk is a suspension of fat and protein, a solution of lactose and minerals, which is isotonic with plasma. Most of the milk proteins are unique and are not found elsewhere in the body. Secretory IgA is one of the three proteins in a mother's milk, and its concentration is high and plays an important immunological role for the infant (Johnston, Landers, Noble, Szucs, & Viehmann, 2012). Immunoglobulin A in a mother's milk has the shape of S-IgA and is therefore very resistant to the proteolytic activity of the stomach-intestine track of the infant's digestive system (Lovelady, Hunter, & Geigerman, 2003). On the other hand, different factors affect a mother's secretory immune system. For example, the IgA present in a mother's milk as index of mucosal and humeral immunity may change during sport activities as the most important antibody in the infant's body. The results of the studies carried out on the type of sport, intensity and time of the exercise and its impact on IgA concentration in the milk are diverse and contradicting. This adds to the mother's uncertainty about the amount of milk taken by the infant and possible change of immunity composition (Lee & Kelleher, 2016). Ogawa et al. (2004) emphasized the varied results on the influence of other various bioactive factors and physical activity on the concentration of secretory IgA antibodies in the mother's milk and colostrum (Ogawa et al., 2004). Mackinnon (1994) related the different general responses of the immune system to the intensity and kind of exercise. Lovelady et al. (2003) and Klentrou, Cieslak, Macneil, Vintimner, & Pyley (2002) reported an increase in the milk's IgA concentration followed by middle intensity of physical activities, while Schouten, Verschuur, and Kemper (1998) and Lovelady et al. (2003) reported a drastic decrease in the milk's IgA concentration followed by physical activities. However Su, Zhao, Binns, Scott, and Oddy (2007) reported that exercise did not affect breast-feeding compositions and volume (outcomes) at the usual levels of activity undertaken by mothers.

Despite the various studies carried out, the importance and role of physical activities during a mother's breast feeding period from viewpoints of immunology and physiology have not been paid attention, and few researches have been carried out on this subject. In addition, the research performed on the IgA concentration during different physical activities in Iran has not been reported, and there are limited studies worldwide. On the other hand, mothers who breast feed their infants and are involved in sports use higher energy, which is likely to lead to changes in their body composition. The increase in the energy consumption may change the milk's volume and components such as IgA. This issue also needs more essential study. Moreover, because the mechanism responsible for suppression and enforcement of secretory immune system have not been known yet, more research for understanding the relationship between sport (exercise intensity) and this system during breast feeding is required. Therefore, the aim of the present study is the investigation of the effects of selected aerobic exercises with the intensity of 60% HRR (during the first five weeks) and 70% HRR (during the second five weeks) on the IgA concentration in the first year of breast feeding and the variables of the body composition. Furthermore, in this study, the plan of exercises has followed a certain pattern.

METHOD

Participants

In this research, 28 non-athletic healthy volunteer mothers with the following properties: they were 6-8 weeks after delivery; they breast fed their babies for the first year and were divided into two exercise and control groups through random sampling; took part (Table 1).

Exercise protocol

Breast-feeding mothers took part in the research for three time periods including rest period, aerobic exercises during the first five weeks, and second five weeks of aerobic exercises. To determine the primary level of the intensity of exercises, an introductory pretest was conducted, and the highest range of reserve heart rate of the exercises was computed (135-144 beat/min⁻¹ in the first five weeks and 142-153 beat/min⁻¹ in the second five weeks).

Table 1: Characteristics of lactating mothers

Group \ Variable	Age (year)	Height (cm)	Weight (kg)	Maximal estimated heart rate (beat/min)	Maximal oxygen consumption (ml/kg/min)
Experimental (n=14)	28.8±5	161±3.8	74±12	191±5.8	36.6±4.2
Control (n=14)	29.4±6	160±2.6	71.9±7.3	190±6.4	35±3.9

Values are expressed as mean ± standard deviation.

A certain questionnaire based on the previous research was provided and distributed in order to know about the primary health of the mothers (Yoneyama, Ikeda, & Nagata, 1990) and survey their physical activity (Pate et al., 1995). Control variables were also measured. The similarities of the variables during the rest of the control and experimental groups were determined. The experimental group performed aerobic exercises with the intensity of 60% reserve heart rate for three sessions per week in the first five weeks. The group continued the same exercises with the intensity of 70% reserve heart rate for three sessions per week for the second five weeks (Bopp, Lovelady, Hunter, & Kinsella, 2005; Lovelady et al., 2003). The control group was not involved in the exercises.

Measurement of body composition and maximal oxygen consumption

To figure out the percentage of the body fat, bioelectrical impedance analysis (Omron HBF-306C) was used. Fat weight and lean body mass (kg) were calculated from the percentage of fat and weight and body mass index measured by WHO method (2018) (27). In this study, the maximal oxygen consumption was computed using the method in George et al.'s (2007) study.

Measurement of the concentration of Immunoglobulin A

5^{CC} milk samples, using Ogawa et al. methods (2004), were obtained through a sterilized breast pump. The milk was kept in -20^C in a freezer in order to be analyzed. Then, the ELISA method was used to measure the amount of IgA in the mother's milk (Thiha & Ibrahim, 2015).

Statistical analysis

To analyze the data statistically, statistics' tests MANOVA, One-way ANOVA, independent sample T test, paired sample T test, and one sample T test were used.

RESULTS

The effect of chosen aerobic exercises with their intensity of 60% and 70% HRR on IgA concentrations and body composition variables were studied and the following results were obtained.

Comparison between experimental and control groups to find the similarity of average immunoglobulin A concentration during rest

This index was studied during rest to ensure IgA sameness to be measured in both groups, at the beginning of study. As the data in Table 2 shows, there was not a considerable change ($p=0.549$) in the milk's IgA in both groups during rest.

Table 2: Comparison between experimental group and control group regarding the average sameness of IgA concentrations in the mother's milk during rest

Group	Statistics*	Mean (mg/dl)	Standard deviation	Mean standard deviation	P**
Experimental (n=14)		25.6	7	1.9	0.549
Control (n=14)		24	6.6	1.8	

*Independent Sample T, P**: Significance level, Values are expressed as mean \pm standard deviation.

Comparing the milk's IgA mean concentration in both groups during first five weeks (60% HRR) and second five weeks (70% HRR) of aerobic exercises

Table 3 data shows that IgA mean concentration with the activity intensity of 60% ($p=0.001$) compared to IgA mean concentration during rest in both groups had a significant change (figure 1).

Table 3: Comparison between IgA average of mother's milk in aerobic exercises with the intensity of 60% and 70% reserve heart rate and mean amounts of rest

Statistics Stage	Average amounts of test = 24.8 mg/dl					
	IgA (exp*)	IgA (con**)	Mean difference	90% confidence range of difference		Two sided significant level***
				Minimum	Maximum	
70% reserve heart rate	40.4±11.6	24±6.6	15.56	10.05	21.06	0.001
60% reserve heart rate	29.9±9.3	24±6.6	5.13	.071	9.54	0.060

*Experimental Group, **Control Group, ***One-Sample T Test

The regression line fitted to the figure 1 shows that there is a considerable difference between IgA concentration during rest (baseline) and IgA concentration in exercises with the intensity of 60% HRR. Moreover, due to the impact of intense exercises, the amounts of antibody in the experimental group increased. In addition, there was a significant difference between IgA concentration in the activity intensity of 70% HRR and the former amounts, and IgA concentration increased. Furthermore, there is a significant difference between the two kinds of intensities of the exercises in the first five weeks and second five weeks, and IgA concentration in the mother's milk increased. On the other hand, MANOVA test showed that mean IgA concentration difference throughout the phases was generally significant ($p=0.004$). Therefore, One-Way ANOVA test and Post-Hoc test were used to interpret the data. Thus, the difference between mean pairs of rest-exercises in the first five weeks ($p=0.079$), rest-exercises in the second five weeks ($p=0.001$), and exercises in the first five weeks-second five weeks ($p=0.008$) was different.

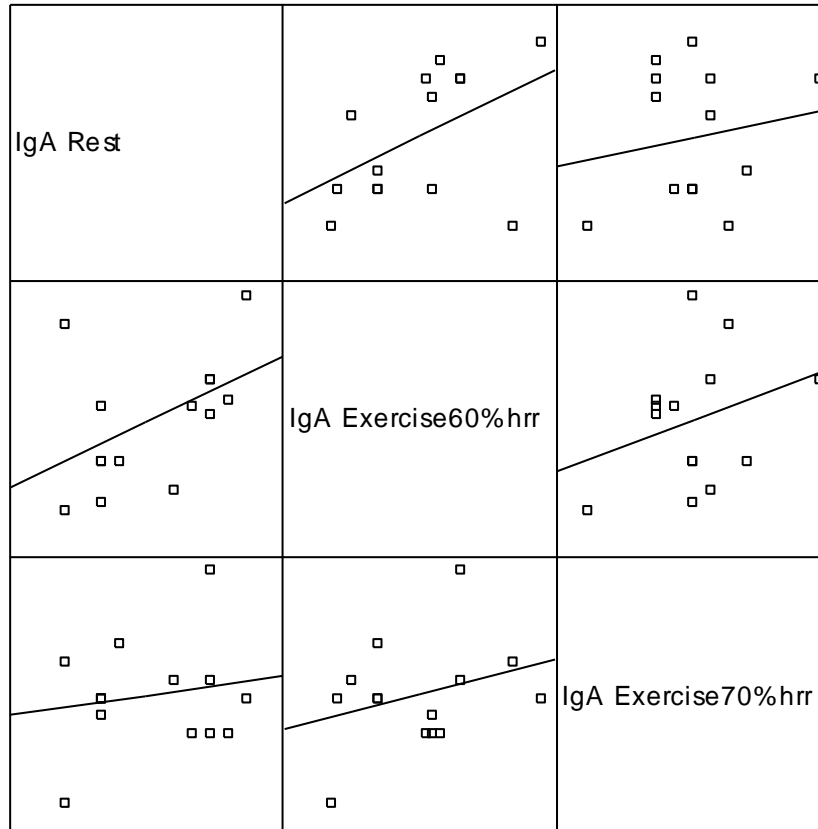


Figure 1: Comparison between mothers' milk IgA concentrations in rest, first five weeks, and second five weeks exercises

Comparison between experimental and control group to find the sameness between mean indexes of body composition in rest

To find out the general difference, through the MANOVA test, body composition indexes in rest were studied and no considerable difference ($p=0.204$) was noticed. Detailed analysis of body composition variables through One-way ANOVA test also showed the sameness between average body composition indexes between the two groups.

Comparison of mean indexes of breast-feeding mothers' body composition in experimental and control groups in rest, first five weeks and second five weeks of aerobic exercises

The general impact of body composition variables in rest, first five weeks, and second five weeks of aerobic exercises in both groups was studied (Table 4 and Table 5).

Table 4: Mean body composition indexes in control and experimental groups in rest, first five weeks, and second weeks of aerobic exercises

Stages Groups	Rest		First five Second five weeks of exercises weeks of exercises	
	Variables	IgA (M±SD)	IgA (M±SD)	IgA (M±SD)
Experimental (n=14)	Weight (kg)	74.4±12	72.9±11.6	70.6±10.9
	Fat weight (kg)	22±5.6	20.7±5	18±4.8
	Lean body weight (kg)	52±6.7	53±7.5	53.6±7.7
	%Fat	29±3	28±2.9	25±2.7
	Body density (gr/cm3)	1.03199±0.9125	1.0346±0.636	1.0411±0.575
	Body mass index (weight/height ²)	28.5±4	27.7±4	27.2±4.6
Control (n=14)	Weight (kg)	71.9±7	72.3±7.3	72.9±7
	Fat weight (kg)	20.6±4.7	21±4.6	21.9±4.2
	Lean body weight (kg)	51±3	51.3±3	51±3
	%Fat	28±3.6	29±3.4	31±3.2
	Body density (gr/cm3)	1.0345±0.6171	1.0334±0.755	1.0317±0.678
	Body mass index (weight/height ²)	28±2.6	27.9±2.4	28.3±2.4

Table 5: The comparison of the general impact of the group, time-period of exercises, and the impact of group-time period of exercises on breast-feeding mothers' body composition index in the two groups

Statistics test	Statistics*	Statistics F	P*
	Group (Wilk's Lambda)	3.682	0.003
	Trend (Wilk's Lambda)	1.346	0.199
	Group - trend (Wilk's Lambda)	2.044	0.024
	<i>*Multivariate Tests (MANOVA)</i>		

According to Table 5, group (experimental - control) factor had a considerable effect ($p=0.003$) on body weight, fat weight, lean body mass, percentage of fat mass body density, and body mass index. The reciprocal (group - time period of exercises) impact on the six mentioned indexes were significant ($p=0.024$). However, the time period exercises factor alone did not have a significant impact ($p=0.199$) on the indexes. The test was conducted through a One-way ANOVA test. Every variable was studied separately, and the body density variables regarding group factor ($p=0.080$), and group-time period ($p=0.006$), and also mass percentage fat regarding group factor ($p=0.013$), and group-time period ($p=0.001$) were significant.

DISCUSSION

Infanthood is a vulnerable period. In this period, the baby passes through different immunological and physiological adjustments to have life outside the womb. The mother's milk contains antibodies, some of which are absorbed by the intestine. Secretory IgA in the mother's milk is one of the most common immunoglobulins in a mother's milk in this connection. Thus, this study focused on the role of exercises with respect to the kind of activity, intensity, time-period activity, and time-period of the plan for the activity on the immunological responses of mother's milk, especially changes in IgA concentration and also body composition variables. In this research, the intensity of exercises at 60% and 70% reserve heart rate equaled 135-153 beat/min. The exercises lasted for 49-71 minutes per session, 3 sessions per week, for 10 weeks. New scientific observations were considered in this research, which have recently shown that body activity with the average intensity correspondent to

energy cost has psychological and mental advantages (Äijö, Kauppinen, Kujala, & Parkatti, 2016).

In the research done (such as ACSM), the intensity of the exercises, 60%-70% of the maximal heart rate (equals 50%-85% of the maximal aerobic power) and 20-60 minutes of time-period activity, was suggested (Pate et al., 1995). The present research has shown that during breast-feeding, exercises with the intensity of 60%-70% HRR, had significant impact on the IgA concentration of the mother's milk. In addition, IgA concentration was affected during aerobic exercises in such a way that during the first five weeks of exercises, the amount of baseline IgA increased significantly from 24.8 mg/dl to 29.9±9.3 mg/dl. The increase was more noticeable during the second five weeks, so that the amount extended to 40.4±11.6 mg/dl. Further, the antibody's concentration had significant changes between the two kinds of activity intensity. These results were in line with the results of Klentrou et al. (2002) and Larson-Meyer (2002). They emphasized the importance of aerobic fitness and exercises with medium intensity to keep or increase IgA concentration of the mothers' milk, and the efficiency of breast-feeding. But Fly, Uhlin, and Wallace (1998) and Lee and Kelleher (2016) reported no change in the compositions and the milk's protein as a result of exercises and short-term diet. O'Connor, Schmid, Carroll-Pankurst, and Olness (1998) reported no effect of relaxing exercises on the milk's IgA concentration, and Lovelady et al. (2003) reported no change in IgA concentration of the mother's milk following physical activity. In contrast, Gregory, Wallace, Gfell, Marks, and King (1997) reported that the IgA concentration of the mother's milk decreased following maximal graded activity. In the present research, the concentration of IgA changes during the starting period of exercises after delivery. The baseline average of the IgA concentration of the mother's milk equaled 25.6 mg/dl in the experimental group and 24 mg/dl in the control group. In addition, the participants were in their 6-8 weeks after delivery. Other researchers have reported that the average amount of baseline IgA concentration in mothers during 10-12 weeks after delivery equaled 0.7-2.0 gr/l in the milk (Lovelady et al., 2003).

The type of exercise, intensity and time-period of the activity are among the factors that stimulate the increase in the IgA concentration of the mother's milk. In the present study, due to certain intensity of aerobic

activities, which extended for 10 weeks, IgA concentration of the mother's milk increased significantly. Such an increase has specific importance in the primary immunological defense against topical infections in areas such as the digestive system, respiratory system, and mammary glands, and causes the maturity of secretory immunological system in the baby (Korhonen, Marnila, & Gill, 2000). The stimulation of IgA concentrations increase due to exercise and maintains a long time at high levels, it prevents the entrance of antigens into the intestine surface of the infant and stops the progress of food allergy (Järvinen et al., 2014). This in turn protects the baby against EPEC, which causes illness in the small intestine and causes acute diarrhea (Manjarrez-Hernandez, Gavilanes-Parra, Chavez-Berrocal, Navarro-Ocaña, & Cravioto, 2000) and makes improvements in microbial flora and activity against lister's antigen (Chen & Allen, 2001). On the other hand, stimulation of IgA concentrations increase due to exercise and the presence of IgA with high concentrations in the mother's milk has been effective in fighting Type 1 HIV virus (Duprat et al., 1994; Aparicio et al. 2018). It also decreases the risk of sudden infant death syndrome (Gordon et al., 1999) and protects the infant against stomach inflammation, middle ear's acute inflammation, urinary tract infection, flu, blood infections, and antrocolit necrosis (Hanson et al., 2002). Also, in this study, the intensity of activity was defined at maximal 70% reserve heart rate but intense activities (more than 70% HRR) were not included. Researchers reported the existence of stress hormones (cortisol, noradrenalin and adrenocorticothropic) and their effectiveness on suppression of the immune system (IgA concentration decrease) in intense activities (Hasić et al. 2017; Tartibian & Moazeni 2003). However, it is possible that low intensity physical activity may not increase the mentioned hormones (Lovelady et al., 2003). In the present research, analysis of body composition variables showed that, in general, among factors of group, time-period exercises, and group-time period exercises, the factors of group, and group-time period exercises were significant. Thus, control and experimental groups were different with respect to the relevant characteristics. This difference became more noticeable when mothers performed exercises with the intensity of 60% HRR (first five weeks) and 70% HRR (in the second five weeks). In other words, there were significant changes in weight, fat weight, lean body weight, body

density, percentage of fat, and body mass index variables due to the difference between both groups, and the impact of aerobic exercises and other external factors (time-period of the exercises) did not affect the aforementioned variables.

In addition, when the variables were analyzed separately, it was noticed that among the six variables, only body fat percentage (with respect to factors such as group: $p=0.013$, and group-time period exercises: $p=0.001$) and body density (with respect to factors such as group: $p=0.080$, and group-time period exercises: $p=0.006$) were significant. The changes occurred merely because of the impact of aerobic exercises and without limited calorie and malnourishment in the mothers participating in the research. In this regard, Bopp et al. (2005) reported a decrease in the fat percentage of breast-feeding mothers in the experimental group (21%) compared to the control group (27.9%), followed by aerobic exercises with the intensity of 70% predicted heart rate (Bopp et al., 2005). Dusdieker, Hemingway, and Stumbo (1994) reported weight reduction of about 0.48 kg per week, which extended for 10 weeks of aerobic exercises in breast-feeding mothers. In contrast, Bopp et al. (2005) and Prentice (1987) emphasized the lack of change in body density, fat mass percentage, and body weight in breast-feeding mothers, which was conducted with limited calorie.

Moreover, the findings of this research correspond to the recommendations of Europe-America Medical Institute based on the reduction of up to 2 kg of body weight per month after the first month of delivery (Korhonen et al., 2000). It appears that reduction in fat mass percentage, weight, and body fat mass, and an increase in the body density of the breast-feeding mother have been attributed to the impact of the kind of activity (aerobic), intensity of activity (60%-70% HRR), and the duration of exercise periods (10 weeks). It is possible that during breast-feeding, medium intense activity stimulated the catabolism of the fat tissue (Lee & Kelleher, 2016), which makes fat mass lipolysis in areas of the abdomen and thighs more noticeable (Bopp et al., 2005). Besides, some hormones cause a decrease in fat tissue mass and fat percentage in breast-feeding mothers who are involved in athletics (in contrast to sedentary women) (Lee & Kelleher, 2016). In these conditions, synthesis of some hormones such as prolactin increase in the mother's milk (Lovelady et al., 2003). On the other hand, limited calorie activates

hormonal mechanisms and affects the variable changes, but in the present research, the changes were due to exercise.

Unfortunately, there has been no research history on this field in Iran, and the range of research and studies on this subject have been few worldwide.

However, this study is a step toward the clarification of the mother's milk's immunity responses to intensity and duration of exercises, and it is possible that studies on other exercise patterns give different results. In addition, the study of other IgA subclasses and other immune indexes in the mother's milk is one of the most important subjects for future researches, which will lead to other findings.

CONCLUSIONS

In conclusion, these original findings give evidences that mothers' secretory immune systems' response is affected by the medium intensity of exercise, and the IgA concentration of the mother's milk increases. Therefore, it provides adjustable resistance against potential pathogenic injuries. The increase of this antibody in the mother's milk neutralizes infectious organisms and prevents the organism's colonization in the infant's intestine during breast-feeding. This type of exercise intensity does not contradict the mothers' ability to successfully breast-feed her babies and causes an increase in the infant's and mother's mucosal immune performance and efficiency. Moreover, the findings of this research indicate that a decrease in fat weight, fat percentage, as well as an increase in lean body weight and body density, due to the exercises and without calorie limit, make a secure margin for mothers who breast-feed and cause an increase in their level of aerobic fitness.

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