

# Nasal response after exercise in swimmers, runners and handball players

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## Abstract

**Objective:** The aim of this study was to investigate the effects of different physical activities on nasal response.

**Methods:** Young non-professional university teams (male, 20 to 24 years old) were enrolled in this study. Nasal functions were measured with an active anterior rhinomanometry and the saccharine transport method (nasal transport times, NTT) before and immediately after the exercise. After the initial measurements, the first group swam 30 minutes in the swimming pool. The second group (outdoor runners) ran 10 kilometers in approximately 30 minutes. The third group played handball for 30 minutes. The initial findings were compared statistically with the data obtained after exercise.

**Results:** When the reductions in nasal resistance were compared before and after exercise, the inspiration and expiration values of all groups were statistically significant. These three groups were similar regarding the comparison of nasal resistance change percentages. When the NTTs were compared before and after exercise, the decreases in the amount of time were statistically significant in all these three groups after exercise. When the change percentages of the decrease in nasal transport time were compared, the decrease in handball players was statistically significant compared to runners.

**Conclusion:** Nasal resistance reductions and the decreases in NTT were not affected by the type of sports being played or the air quality of the environment.

**Keywords:** Nasal resistance, active anterior rhinomanometry, nasal transport times, running, swimming, handball.

## Özet: Yüzücülerde, koşucularda ve hentbol oyuncularında egzersiz sonrası nazal yanıt

**Amaç:** Çalışmanın amacı nazal yanıt üzerine farklı fiziksel aktivitelerin etkilerini araştırmaktır.

**Yöntem:** Bu çalışmaya genç amatör üniversite takımları (erkek 20–24 yaşlarında) katıldı. Nazal fonksiyonlar bir aktif anterior rinomanometriyle ölçüldü ve egzersizden önce ve hemen sonra sakkarin transport yöntemi (nazal transport zamanı, NTZ) uygulandı. İlk ölçümlerden sonra birinci grup yüzme havuzunda 30 dakika yüzdü, ikinci grup (açık hava koşucuları) yaklaşık 30 dakikada 10 km koştu, üçüncü grup 30 dakika hentbol oynadı. İlk bulguları istatistiksel olarak egzersiz sonrası elde edilen verilerle karşılaştırıldı.

**Bulgular:** Egzersiz öncesi ve sonrası nazal dirençteki azalmalar karşılaştırıldığında, tüm grupların inspirasyon ve ekspirasyon değerleri istatistiksel açıdan anlamlı idi. Bu üç grup nazal direnç değişikliği yüzdeleri açısından benzerdi. Egzersiz öncesi ve sonrası NTZ'ler karşılaştırıldığında, bu üç grubun tümünde egzersizden sonra NTZ'de azalmalar istatistiksel açıdan anlamlı idi. Nazal transport zamanındaki yüzde azalmalar karşılaştırıldığında koşuculara göre hentbol oyuncularının NTZ'sindeki azalma da istatistiksel açıdan anlamlı idi.

**Sonuç:** Nazal direnç ve NTZ'deki azalmalar ortamdaki havanın kalitesi ve yapılan sporun cinsinden etkilenmemiştir.

**Anahtar sözcükler:** Nazal direnç, aktif anterior rinomanometre, nazal transport zamanları, koşma, yüzme, hentbol.

Exercise today is becoming more and more popular not only for in pursuit of a healthy life but for recreational purposes. Related to sympathetic activity that notably increases during exercise, nasal resistance decreases and the rate and

depth of breathing increase.<sup>[1,2]</sup> To meet the air requirement that increases during exercise, mouth breathing starts and harmful particles in the air go deep inside the lungs easily without getting caught in the filtration of the nose.<sup>[2]</sup>

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Due to the increasing need for air during exercise, outdoor athletes like runners are exposed more to harmful substances in the air, such as carbon monoxide, nitrogen oxide, sulphur dioxide, ozone and emission-derived particulate matter, etc.<sup>[3,4]</sup> Among athletes who are chronically exposed to these harmful air pollutant particles, exercise-induced bronchospasm, asthma, airway damage, and allergic rhinitis are seen more frequently.<sup>[5,6]</sup> It might be thought as a rule that indoor athletes are affected less by air pollution. Although this is rare, in indoor exercising places like ice arenas, skating athletes might often experience carbon monoxide and nitrogen dioxide (NO<sub>2</sub>) induced airway disorders caused by fossil-fueled resurfacing machines and exercise-induced bronchospasm.<sup>[7]</sup> Swimming is recommended, especially at schools, for pregnant women, overweight people, and people with vertebra disease. Swimmers are exposed to (chlorine) chloramine and NCl<sub>3</sub> gases used to disinfect pools.<sup>[8]</sup> As a result, swimmers experience asthma, allergic rhinitis, non-allergic rhinitis, and lower airway hyperreactivity more frequently.<sup>[8]</sup>

Respiratory system diseases caused by harmful particles in the air have been discussed in many studies. However, the nasal response to different physical types of exercise is as important as the quality and content of the air inhaled by athletes in sports areas because, depending on the reduction in nasal resistance and changes in mucociliary activity during exercise, the respiratory tract will be affected more by the inhaled air in accordance with sports conditions. The aim of this study was to investigate and compare the effects of different physical activities on nasal response.

## Materials and Methods

This prospective study was conducted in Faculty of Medicine, Eskişehir Osmangazi University between January and December 2013. This study was conducted according to the rules outlined in the Declaration of Helsinki. Signed informed consent was taken from all participants.

### Study design

The study was commenced once ethics board approval was obtained. Young non-professional university teams were enrolled in this study. All subjects were male and between 20 and 24 years old. The study was conducted with the participation of three exercise groups. The first group included 20 swimmers to observe the effect of water. The second group included 20 runners doing outdoor sports, and the third group included 20 handball players doing indoor sports.

The participants in the study were non-smoker athletes who have never had nasal surgery and had no allergic symptoms. They were healthy individuals who had no septal devi-

ation, nasal polyposis, sinusitis, or concha hypertrophy, with normal nasal endoscopy results. None of the patients were on any medication. They were all completely healthy.

### Measurements

**Active anterior rhinomanometry:** Nasal resistances were measured with active anterior rhinomanometry before and immediately after exercise. The Homoth Rhino 2002 rhinomanometer (Hamburg, Germany) was utilized. All the measurements were performed three times and their average was taken. Nasal resistance was calculated as Pa-sec/ml according to the rules of the International Standards Committee.

**Nasal transport times (NTT):** The nasal transport time was also measured after rhinomanometric evaluations. Mucociliary transport measurement was performed by the same person using the saccharin transit time test described by Andersen et al.<sup>[9]</sup> The patients were situated in a seated position and their heads slightly extended. Five milligrams of granulated sodium saccharin was placed 1 cm inside the nostril using anterior rhinoscopy examination. The first sweet taste patients felt in their mouths was recorded in terms of its duration as seconds. The patients were not allowed to move their heads, swallow, sneeze, speak, or take a deep breath. If a patient had not yet experienced the sweet taste within 60 minutes, saccharin was placed on the tongue to make sure that the sense of taste existed and the measurement was postponed.

### Methods

After the initial measurements, the first group swam 2 kilometers in 30 minutes. Their swimming speeds were set to reach a period of thirty minutes. The second group ran 10 kilometers in approximately the same amount of time. The third group played handball for 30 minutes. After these exercises in three groups, active anterior rhinomanometry and NTT were measured again.

### Statistical analyses

Number Cruncher Statistical System (NCSS) 2007 and Power Analysis and Sample Size (PASS) 2008 software (Utah, USA) programs were applied for the statistical analyses. While assessing the data, in addition to descriptive statistical methods (mean, standard deviation, median, frequency and ratio), a one-way ANOVA test was used in the between-group comparison of parameters showing normal distribution, while a Kruskal-Wallis test was used in the comparison of percentage changes according to group and the Mann-Whitney U test in the identification of the group causing the difference. In the in-group comparisons of parameters showing normal distribution, a t test (paired sample t test) was

**Table 1.** Inspiration measurements of active anterior rhinomanometry in the groups.

Inspiration measurements (Pa-sec/ml)		Runner	Swimmer	Handball player	p
		Mean±SD	Mean±SD	Mean±SD	
Left side	Before exercise	343.9±68	340.4±70.4	346.9±70.3	0.957*
	After exercise	475.0±90.1	445.5±74.4	452.3±76.6	0.485*
	p	0.001 <sup>†,‡</sup>	0.001 <sup>†,‡</sup>	0.001 <sup>†,‡</sup>	
	Alteration (%)	40.8±26.2	34.4±28.6	33.7±26.9	0.481 <sup>§</sup>
Right side	Before exercise	343.2±68.5	332.3±74.5	359.5±67.4	0.471*
	After exercise	447.1±69.5	456.7±82.3	451.6±71.5	0.921*
	p	0.001 <sup>†,‡</sup>	0.001 <sup>†,‡</sup>	0.001 <sup>†,‡</sup>	
	Alteration (%)	33.4±24.2	41.5±30.2	28.8±26.7	0.406 <sup>§</sup>
Left/Right	Before exercise	0.958 <sup>†</sup>	0.334 <sup>†</sup>	0.074 <sup>†</sup>	
	After exercise	0.085 <sup>†</sup>	0.448 <sup>†</sup>	0.950 <sup>†</sup>	

\*One-way variance analysis, <sup>†</sup>Paired samples t test, <sup>‡</sup>p<0.01, <sup>§</sup>Kruskal-Wallis test

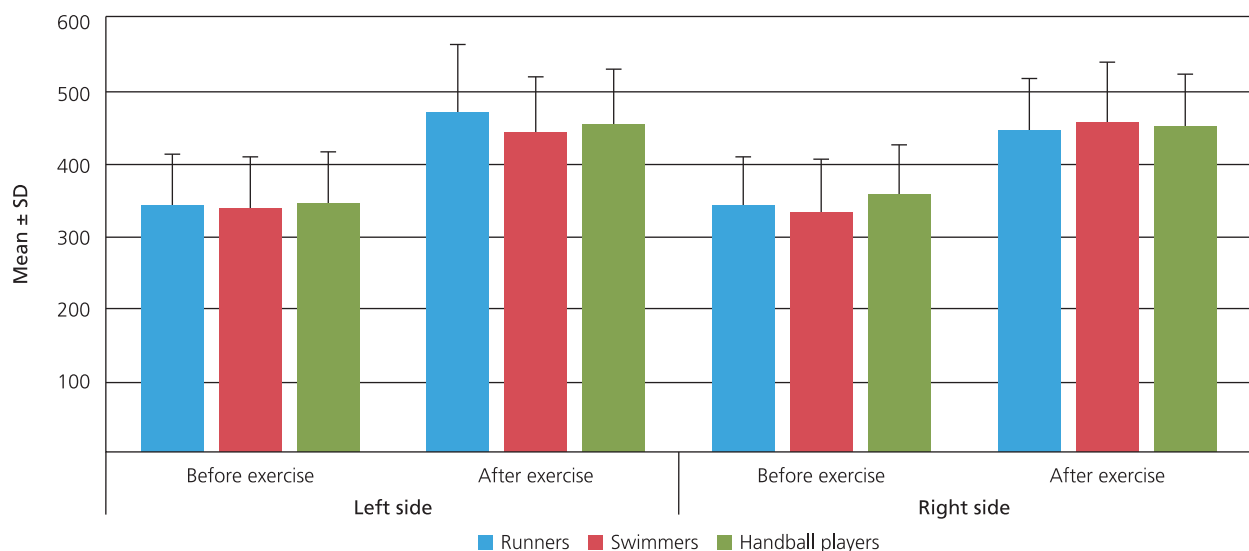
used in dependent groups. The results were evaluated at a 95% confidence interval and a significance level of p<0.05.

### Results

Three groups aged between 20 and 24 were included in the study. There were 20 runners in the first group, 20 swimmers in the second group, and 20 handball players in the third group.

*Inspiration measurements of active anterior rhinomanometry in the groups* were shown on Table 1 and Fig. 1. When the inspiration levels of athletes were compared, the values before the exercise in all three groups were similar on the right and left sides (p>0.05). The values after exercise were

also similar on the right and left sides in the three groups (p>0.05). In each of the three groups separately, when the inspiratory values before and after exercise were compared, the change percentages on the left and right side increased in a statistically significant manner: runners (40.8%) – (33.4%), swimmers (34.4%) – (41.5%), and handball players (33.7%) – (28.8%) (p<0.01). When the inspiratory change percentages after exercise were compared with those recorded before exercise, there was no statistical difference between the left- and right-side change percentages (p>0.05). When the right and left nose were compared in runners, swimmers, and handball players, the inspiration levels of the left and right sides in the measurements performed before and after exercise were similar (p>0.05) (Table 1 and Fig. 1).



**Fig. 1.** Distribution of inspiration measurements of active anterior rhinomanometry. Values were given as Pa-sec/ml.

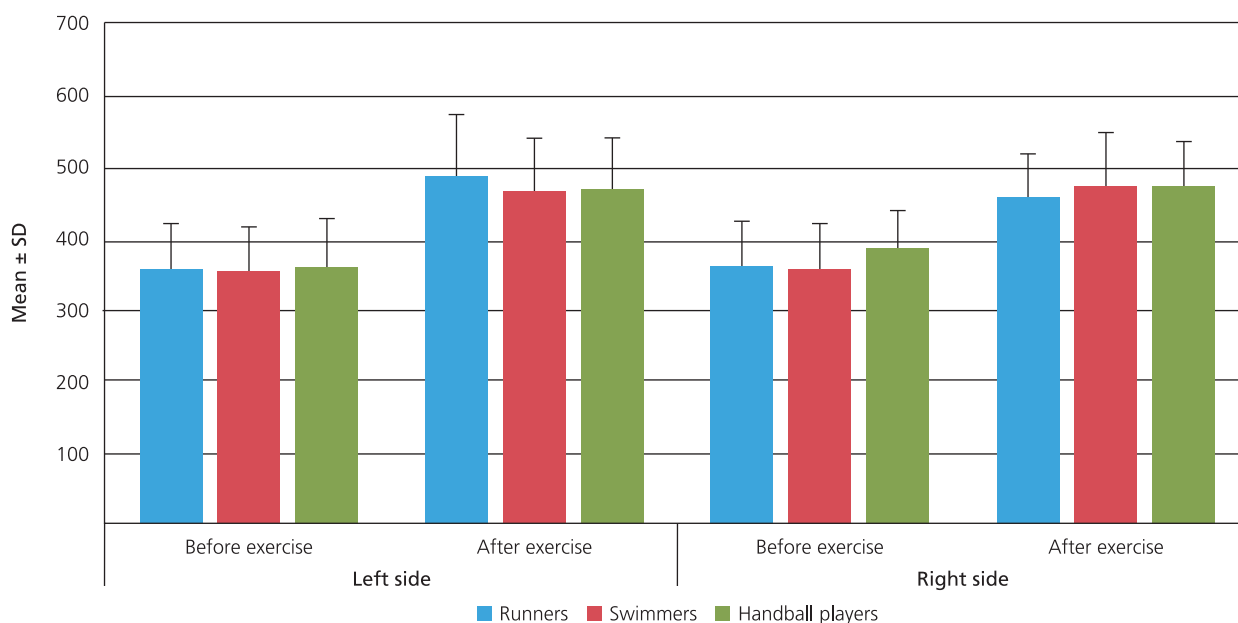
**Table 2.** Expiration measurements of active anterior rhinomanometry in the groups.

Expiration measurements (Pa-sec/ml)		Runner	Swimmer	Handball player	p
		Mean±SD	Mean±SD	Mean±SD	
Left side	Before exercise	357.2±63.9	353.8±66.4	361.4±67.8	0.935*
	After exercise	489.9±81.7	468.1±71.3	469.7±68.7	0.588*
	p	0.001 <sup>†,‡</sup>	0.001 <sup>†,‡</sup>	0.001 <sup>†,‡</sup>	
	Alteration (%)	39.3±22.6	35.7±28.4	33.2±25.8	0.567
Right side	Before exercise	358.8±68.1	357.7±63.4	382.3±56.9	0.384*
	After exercise	460.3±60	477.1±69.9	475.2±61.4	0.661*
	p	0.001 <sup>†,‡</sup>	0.001 <sup>†,‡</sup>	0.001 <sup>†,‡</sup>	
	Alteration (%)	31.4±22.8	35.6±21.7	26.4±21.8	0.428
Left/Right	Before exercise	0.909 <sup>‡</sup>	0.633 <sup>‡</sup>	0.040 <sup>‡,§</sup>	
	After exercise	0.060 <sup>‡</sup>	0.497 <sup>‡</sup>	0.623 <sup>‡</sup>	

\*One-way variance analysis, <sup>†</sup>p<0.01, <sup>‡</sup>Paired samples t test, <sup>§</sup>p<0.05

Expiration measurements of active anterior rhinomanometry in the groups were shown on Table 2 and Fig. 2. When the expiration levels of three groups were compared, the values before the exercise in all the three groups were similar on the right and left sides (p>0.05). The values after exercise were similar on right and left sides in the three groups (p>0.05). In each of the three groups separately, the change percentages in the expiration levels before and after exercise on the left and right sides were statistically significant for runners (39.3%) – (31.4%), swimmers (35.7%) – (35.6%) and handball players (33.7%) – (26.4%), respectively

(p<0.01). When the percentage changes for expiration after exercise were compared with those measured before exercise, there was no statistical difference between the left- and right-side percentage changes (p>0.05). When the right and left nose were compared in runners, swimmers, and handball players, the expiration levels of the left and right sides in the measurements performed before and after exercise were similar (p>0.05). Although the change in the expiration measurements between the right side and left side in handball players was significant, this can be ignored (p<0.05) (Table 2 and Fig. 2).

**Fig. 2.** Distribution of expiration measurements of active anterior rhinomanometry. Values were given as Pa-sec/ml.

Evaluation of groups' nasal transport time was shown on Table 3 and Fig. 3. When NTT is examined, the nasal transport times of runners, swimmers, and handball players before exercise are similar ( $p>0.05$ ). The nasal transport times of runners, swimmers, and handball players after exercise are similar ( $p>0.05$ ). In addition, the decrease in nasal transport time before and after exercise in each of the runners, swimmers, and handball players are 9.43%, 12%, and 24.75%, respectively, and the decrease in this time is statistically significant in all three groups ( $p<0.05$ ). When the percentage changes in NTT were compared by pairwise comparison, the NTT decrease percentage of handball players were found to differ at a significant level compared to in runners ( $n=0.038$ ). No statistically significant difference was observed between the times of runners and swimmers, and swimmers and handball players ( $p>0.05$ ).

### Discussion

Moistening air reaching the lower airway of the nose ensures heating. In addition, thanks to the nose's barrier feature, particles of specific sizes cannot pass through it and are cleared with mucociliary clearance.<sup>[10]</sup> To meet the air requirement which increases during exercise, nasal resistance decreases and the amount and speed of the air that passes through the nose increases.<sup>[1,2]</sup> Drying in the mucosa and thickened secretions cause changes in mucociliary transport mechanisms.<sup>[11]</sup> In addition, to meet the increasing air requirement, mouth breathing starts after a short time. As a result, by bypassing nasal filtration mechanisms, the air consisting of cold, unmoistened, and harmful particles reach the lungs directly and may cause lower respiratory diseases. Within the first 10 minutes of exercise, the reduction in nasal resistance is maximized and returns to a resting position 20 minutes after exercise.<sup>[12]</sup> This process is the time when the athlete is exposed the most to the particles in the air.

In the light of this information, we are more exposed to harmful particles in the air while exercising than compared to resting. In our study, the reduction in nasal resistance in inspiration and expiration among runners, swimmers, and handball players is statistically significant and similar. The similarity between the nasal response of athletes in outdoor, indoor, and swimming pool environments has shown us that the content of the inhaled air and the type of sports is not significant in nasal resistance. It has also been observed that the reduction in nasal resistance is more related to exercise.

There are too few studies that investigate NTT after exercise among healthy people. Ottaviano et al.<sup>[13]</sup> found increased NTT among swimmers compared to other athletes (tennis players, soccer players, runners, etc.) in their

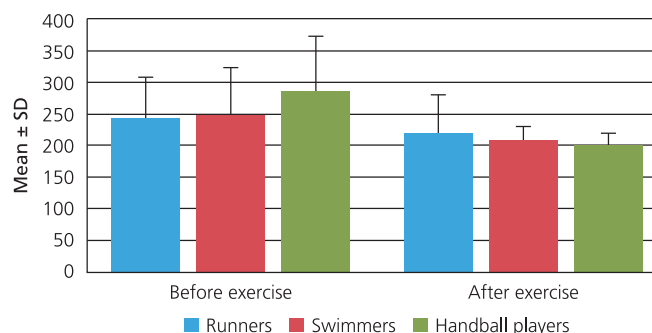
**Table 3.** Evaluation of groups' nasal transport time.

Nasal Transport time (second)	Runners	Swimmers	Handball players	p
	Mean±SD	Mean±SD	Mean±SD	
Before exercise	245.5±63.9	249.5±74.1	288.7±86.4	0.144*
After exercise	220.8±58.8	208.8±20.8	202.6±16.4	0.299*
P	b0.002†	0.006†,‡	0.001†,‡	
Alteration (%)	9.43±10	12.46±14.6	24.75±19.1	0.041§

\*One-way variance analysis, † $p<0.01$ , ‡Paired samples t test, § $p<0.05$

study. But in this study, NTT was measured, on average, 2.8 days after the last exercise. Passàli et al.<sup>[11]</sup> found in their study that the NTT of swimmers is longer than that of runners and skiers. However, the time interval when NTT was measured was not mentioned in this study. Unlike the studies of Ottaviano et al.<sup>[13]</sup> and Passàli et al.,<sup>[11]</sup> in our study, NTT was measured before and immediately after swimming and a significant decrease in NTT was observed in swimmers. Müns et al.<sup>[14]</sup> found a significant decrease in NTT in long-distance runners in their study. But they performed the measurements 1 week before and 1 week after exercise. Olseni et al.<sup>[15]</sup> could not find any difference in NTT after bicycle ergometer exercise. Wolff et al.<sup>[16]</sup> detected a slight increase in mucociliary clearance after exercising.

Our study is the first one to measure NTT before and immediately after exercise in athletes (runners, swimmers, and handball players). When NTT was compared before and immediately after exercise in runners, swimmers, and handball players in our study, the decrease was statistically significant in all three groups ( $p<0.05$ ). The decrease percentages were similar between runners and swimmers, and swimmers and handball players. But the NTT percentage decreases of handball players were found to be significantly different from those of runners. Although observed in all



**Fig. 3.** Distribution of nasal transport time values before and after exercise. Values were given as Pa-sec/ml. Nasal transport time values were given as seconds.

three groups, the NTT decrease was the most prominent in handball players (indoor athletes). It might be assumed that the difference is caused by swimmers' exposure to chlorinated water and runners' exposure to polluted air.

There are still some shortcomings compared to our study. In most of the related studies, the athletes have respiratory system diseases (allergic rhinitis, asthma, etc.). In that case, it would not be accurate to measure the nasal resistance and NTT of athletes. As the athletes were selected out of completely healthy people in our study, we believe that their nasal functions were better measured. In other studies, it is either not mentioned how much later than exercising the NTT was measured or it was measured a long time after exercising. In our study, NTT measurements were performed immediately after exercising. Also differing from other studies, our study included rhinomanometric measurements that were performed immediately after exercise, so the changes during exercise were evaluated more accurately.

## Conclusion

Reduction in nasal resistance and decreases in NTT are not affected by the type of sports or the air quality of the environment. As the athletes of all exercise types are more exposed to the air in the environment based on their resting conditions, the content of the inspired air while exercising is as important as resting.

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**Conflict of Interest:** No conflicts declared.

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