



Effect of the external nasal dilator on adolescent athletes with and without allergic rhinitis



Ricardo Reis Dinardi*, Cláudia Ribeiro de Andrade, Cássio da Cunha Ibiapina

Pediatric Pulmonology Unit, University Hospital, Federal University of Minas Gerais, Belo Horizonte, Brazil

ARTICLE INFO

Article history:

Received 10 January 2017

Received in revised form

4 April 2017

Accepted 4 April 2017

Available online 7 April 2017

Keywords:

External nasal dilator

Nasal patency

PNIF

Aerobic power

Nasal resistance

ABSTRACT

Objectives: The ability to effectively breathe through the nose is an important component of physical exercise. The goal of this study is to evaluate the effect of the external nasal dilator (END) on healthy adolescent athletes and those with allergic rhinitis.

Methods: Clinical trial, double-blind, crossover, in which we evaluated healthy adolescent athletes with allergic rhinitis, using experimental and placebo ENDs, submitted to a maximum cardio-respiratory test in randomized order. Predicted values for peak nasal inspiratory flow (PNIF%) and nasal resistance (NR) were obtained, and the rating of perceived exertion (RPE) was also assessed after the race test.

Results: 65 adolescents participated in the study, 30 of whom had allergic rhinitis. The use of experimental ENDs demonstrated a statistically significant improvement in peak nasal inspiratory flow values (predicted %), nasal resistance, maximal oxygen uptake value (VO₂Max.) and rating of perceived exertion, both in the healthy group and the one with allergic rhinitis.

Conclusion: Results suggested that END reduces nasal resistance, improves maximal oxygen uptake and rating of perceived exertion after a maximum cardio-respiratory test on healthy adolescents and those with allergic rhinitis.

© 2017 Elsevier B.V. All rights reserved.

1. Introduction

In recent decades, the prevalence of allergic diseases has increased worldwide, affecting approximately 30% of the population [1,2]. Allergic rhinitis is common in elite athletes and leaving it untreated can negatively impact recovery and performance [3–6]. Identifying allergic rhinitis in adolescent athletes is a challenge for coaches.

Of The World Anti-Doping Agency (WADA) [7], emphasizes two principles that must be taken into consideration when prescribing medicine for the treatment of allergic rhinitis in athletes: the prescribed medicine must not be prohibited in competition (on the doping list) and cannot have an adverse effect on sporting performance. Therefore, nasal dilators can be used as an alternative method of improving or maintaining sporting performance.

Horizontally fixed to the nasal cartilage, the external nasal dilator (END) consists of a narrow strip of adhesive tape with two parallel

layers of plastic, going from one nasal wing to the other and acting as a spring. The purpose of these strips is to prevent the collapse of the nasal valve during breathing and reduce air passage resistance [8]. At present, evidence of improvement in the performance of adolescent athletes who used the END is limited [9,10]. A review [11] carried out recently found that many studies have shown the END increases the area of the nasal valve's transverse section, reduces nasal resistance and inspiratory transnasal pressure, and stabilizes the lateral nasal vestibule, preventing its collapse during final inspiration. On the other hand there is a lack of studies that evaluated the effectiveness of the END in improving the sporting performance of adolescent athletes with allergic rhinitis. The studies carried out so far were on healthy adolescent athletes [9,10].

Some authors suggest that the END could lead to an improvement in peak inspiratory nasal flow rate [12], increased minute ventilation (MV), an increase in the partial pressure of oxygen in the alveoli, improved respiratory perception during exercise and a reduction in the perception of dyspnea (ventilatory exertion) [13,14]. These mechanisms create the conditions for an increase in the quantity of oxygen released to the respiratory muscles, enabling the athlete a better performance, due to the advantage in the production of energy during exercise. These effects may also facilitate

* Corresponding author. Departamento de Pediatria da Faculdade de Medicina, Universidade Federal de Minas Gerais, Avenida Professor Alfredo Balena, 190 / Sala 267, 30130-100 Belo Horizonte, Brazil.

E-mail address: dinardi06@bol.com.br (R.R. Dinardi).

breathing and are beneficial to patients with nasal congestion.

Several studies showed that the END was not effective during exercise for healthy adult populations [13–16]. It is possible that END would be useful for people with nasal congestion in the region of the nasal valve, a common characteristic among individuals with rhinitis.

The main objective of this study was to determine the effect of the external nasal dilator on nasal resistance and in the physical exercise of healthy athletes and those with allergic rhinitis.

2. Methods

2.1. Local design and period of study

A double-blind, crossover clinical trial, performed in the Santa Tereza Cachoeirinha Sports College, in Belo Horizonte-Brazil, in December of 2015 and April of 2016.

The convenience sample was composed of 35 healthy male adolescent athletes and 30 male athletes with persistent allergic rhinitis defined according to *Allergic Rhinitis and its Impact on Asthma* (ARIA) [2] initiative, consecutively chosen, aged between 12 and 15 years old, who practice football for 1 h and 30 min, three times per week.

2.2. Definition and classification of persistent allergic rhinitis

Persistent allergic rhinitis was classified through the presence of nasal pruritus, itchiness of the oropharynx, eye itch, serous or seromucous rhinorrhea, sneezing and nasal congestion, in isolation or association, for more than four days in the week and more than four consecutive weeks [2]. To evaluate rhinitis severity, we used a clinical score adapted from other researchers [17], which ranged from zero to 18 points. Each of these signs/symptoms received zero to three points, according to the intensity. Therefore, zero signified the absence of the symptom; 1 point indicated a slight symptom, which was tolerable and did not interfere with sleep or daily activities; 2 points indicated a more significant impact, which was bothersome and interfered with activities that demanded heightened concentration, while not upsetting the patient's routine; finally, 3 points signified a high intensity, which greatly interfered with the patient and his family, and was difficult to tolerate, compromising sleep and daily activities. Adding up the scores allowed us to classify the intensity of the allergic rhinitis as light, moderate and severe where the result was 0–6, 7 to 12 and 13 to 18 points, respectively.

2.3. Inclusion and exclusion criteria

Healthy adolescents with negative response in the *International Study on Asthma and Allergies in Childhood* (ISAAC) [18] questionnaire, in relation to questions on asthma and allergic rhinitis, were included. Those with positive response in the ISAAC questionnaire for sneezing, coryza (runny nose) or nasal obstruction symptoms in the last 12 months were included in the allergic rhinitis group. An inability to carry out the correct maneuver to obtain peak nasal inspiratory flow (PNIF), using rhinomanometry; not being able to fit the END; not presenting the informed consent agreement signed by the parents or guardian, non-completion of the Léger race test [19] or aerobic race test to a 20 m point and back, and failure to attend the second part of the test were the criteria for exclusion. Adolescents with any of the following were also excluded: moderate to severe adenoid hypertrophy; with bacterial sinusitis clinically diagnosed by the presence of purulent nasal discharge, postnasal drip, facial pain on percussion associated, or not, to headache and fever; nasal septum deviation, nasal polyps, any respiratory tract infection in activity on admission; and underlying illnesses of any nature.

3. Material, equipment and data collection procedures

3.1. Anthropometry

To collect anthropometric data, the variables of body weight (kg) and height (m) were used. Weight was measured on a Plenna® (São Paulo, SP, Brazil) digital weighing scale, with precision of 100 g and capacity of 150 kg. Height was measured using a measuring tape against a straight wall, with a precision scale of 0.1 cm. The body mass index (BMI) was calculated based on the equation: body weight (kg)/height² (m).

3.2. Cardio-respiratory test

To evaluate cardio-respiratory capacity, we used the Léger race test [19] or aerobic race test to a 20 m point and back, in an appropriate court or space. The test assessed the maximum aerobic capacity of the participants, and was performed in an open area where 20 m was measured out between two parallel lines. On the evaluator's mark, participants began running together (maximum of 10 people), at a pace determined by a CD specially recorded for this test. In the first stage, the speed was 8.5 km/h, which corresponds to a brisk walk, and was progressively speeded up by 0.5 km/h in each of the following stages. Each stage lasted approximately 1 min. Each stage had a duration of approximately 1 min. The CD made "beeps" at specific intervals in each stage. At each beep, the participant had to be crossing one of the two parallel lines with his foot, that is, starting out from one of the lines in the direction of the other, crossing it with at least one foot on hearing the beep and returning in the opposite direction.

The distance of 2 m before the parallel lines is the exclusion area (cutoff limit) of the test, that is, any participant who was yet to reach this section when the beep sounded was warned to accelerate his pace. But if the participant could no longer keep up the pace, he was excluded from the test, since the test finishes when the participant can no longer keep up with the pace set by the CD. The duration of the test depended on the cardio-respiratory performance of each participant. The goal of the test was to measure the VO₂Max, which is less intense at the start, becoming more intense at the end, in a total of up to 21 min. The maximal oxygen uptake value was calculated using the following formula:

$$Y = 31.025 + (3.238 \times A) - (3.248 \times B) + (0.1536 \times AB)$$

Whereas:

Y = VO₂ in mL/kg/min;

A = speed in km/h (in the stage achieved);

B = age in years.

3.3. Obtaining PNIF

Before verification of PNIF, the participant performed habitual nasal hygiene, lightly blowing the nostrils. In a standing position, the participant was carefully fitted with the facial mask. He was then instructed to carry out vigorous nasal inhalation, from the residual volume, with a closed mouth until total lung capacity was reached. The equipment used was the *In-check-inspiratory flow meter* (Clement Clarke, Harlow, England), illustrated in Fig. 1.

Three measurements were taken and the highest result was chosen. Based on the absolute values, the predicted values were obtained according to the reference curves proposed by Ibiapina et al. [20].



Fig. 1. Peak nasal inspiratory flow meter (PNIF).

3.4. Nasal resistance (NR)

Nasal airflow resistance was measured through anterior rhinomanometry at transnasal pressure of 150 Pa, using *Rhinomanometer: PDD-301/r* (Piston Medical, Budapest, Hungary), whose characteristics meet the specifications and requisites of the ATS/ERS Task Force: Standardization of lung function testing [21].

Anterior rhinomanometry records nasal airflow in cubic centimeters per second with reference to transnasal pressure and is expressed as the difference between the atmospheric pressure and the relative pressure in the nasopharynx. Nasal airflow resistance is calculated by dividing the transnasal pressure by the flow [22]. Measurements were carried out according to the manufacturer's instructions and device's calibration was done before each measurement.

3.5. Rating of perceived exertion (RPE)

The rating of perceived exertion rate was measured immediately after the cardio-respiratory test using the Borg [23] scale, which was developed to describe individuals' perception of physical exertion in a wide range of exercise types.

3.6. External nasal dilator (END)

The END used in the study is the ClearPassage[®], RJ, Brazil, available in three sizes: small, medium and large, which may be used by children, adolescents and adults (Fig. 2). The sizes used were small and medium, according to the each participant's need.



Fig. 2. External nasal dilator used in the study.

The nasal dorsum of each participant was cleaned with cotton moistened in alcohol, before the dilator was fitted to each side of the nostrils. Application of the END was carried out according to the manufacturer's instructions and it was inserted by one of the researchers, who did not performed participants evaluation before and after exercise. Participants were advised not to touch the device, which should be placed where they cannot see it.

3.7. Placebo external nasal dilator (END)

The placebo END was made from an adhesive plastic tape without the acrylic strip responsible for dilating the nostrils. The devices were similar in appearance (color, weight and shape) with the original one (Fig. 3).

3.8. Data collection protocol

The 65 volunteers participated randomly in two trial situations, one using the dilator and the other using the placebo. Data collection relating to state of health and anthropometry was performed before any activity. Evaluations took place at two distinct situations: the first involved the collection of anthropometric measurements, obtaining the PNIF and rhinomanometry. After randomization, the END (experimental or placebo) was applied, obtaining the PNIF and rhinomanometry, and we applied the cardio-respiratory test and rating of perceived exertion assessment immediately after the cardio-respiratory test carried out by independent examiners. The second part was two weeks later and at the same time of the day as the previous evaluation. Participants who had used the experimental END in the first evaluation used the placebo END in the second evaluation, and vice-versa. Before the exercise, PNIF and rhinomanometry with the experimental or placebo END was obtained, while rating of perceived exertion was assessed immediately after the cardio-respiratory test. Collections were not carried out on the same day because physical exertion compromised performance on the cardio-respiratory test. Participants did not know if the END was placebo or experimental and as soon as the race test was finished, the rating of perceived exertion (RPE) was evaluated and then the END of the participants was withdrawn.

3.9. Statistical analysis

Analysis of variance (ANOVA) based on a model of repeated measurements was used to analyze the effects between the groups (healthy and with rhinitis) and treatment (basal, placebo and



Fig. 3. Placebo external nasal dilator used in the study.

experimental) on the PNIF%, NR, RPE and VO₂Max, with significance set at $p < 0.05$. The *post hoc* LSD test was used to evaluate the differences found in relation to each of the significance factors. To verify the normality of residuals and constant variances we used the Kolmogorov-Smirnov test and Levene test, respectively. With aim of comparing two independent groups, the *Student t-test* was adopted for independent samples.

3.10. Ethical aspects

The protocol and informed consent agreement were approved by the Research Ethics Committee of the Federal University of Minas Gerais (UFMG).

4. Results

In total, 65 adolescents were selected, 35 were from the healthy group (H) and 30 from the rhinitis group (R).

Table 1 describes and compares the characteristics of the sample. Data show that there is no significant difference between the H and R groups in relation to age, body mass and height. Results are described as mean $\pm$ standard-deviation of the measurements for PNIF%, nasal resistance (NR), rating of perceived exertion (RPE) and VO₂Max (Table 2).

4.1. Peak nasal inspiratory flow percentage (PNIF%)

There was a statistically significant difference ($p < 0.05$) between the groups in the basal and placebo condition. When analyzed in the original END condition, the R group equaled the H group, that is, the END increased the PNIF% values in both groups (Fig. 4). The R group did not show a significant difference in the basal condition, compared to the placebo. However, these two conditions demonstrated significantly lower measurements,

Table 1

Descriptive and comparative measurements between the healthy group (H) and rhinitis group (R) in relation to age, body mass and height ($n = 65$; $S = 35$ and $R = 30$).

Variable	Group	Mean	SD ^a	Mean CI ^b (95%)	p
Age	Rhinitis	13.3	1.0	(13.0; 13.7)	0.096
	Healthy	13.8	1.1	(13.4; 14.1)	
Body mass	Rhinitis	53.6	7.2	(50.9; 56.3)	0.930
	Healthy	53.4	11.1	(49.6; 57.2)	
Height	Rhinitis	1.61	0.07	(1.58; 1.64)	0.457
	Healthy	1.63	0.10	(1.59; 1.66)	

^a Standard Deviation.

^b Confidence Interval.

Table 2

Mean $\pm$ standard deviation of measurements for PNIF%, nasal resistance, VO₂Max, and rating of perceived exertion ($n = 65$).

Variable		Rhinitis group ($n = 30$)	Healthy group ($n = 35$)
PNIF%	Basal	72.2 $\pm$ 18.8	88.0 $\pm$ 23.9
	Placebo	70.8 $\pm$ 16.1	81.3 $\pm$ 21.4
	Experimental	92.9 $\pm$ 20.9	99.1 $\pm$ 22.5
NR	Basal	0.24 $\pm$ 0.09	0.17 $\pm$ 0.06
	Placebo	0.23 $\pm$ 0.08	0.17 $\pm$ 0.06
	Experimental	0.19 $\pm$ 0.06	0.14 $\pm$ 0.05
VO ₂ Max	Placebo	33.2 $\pm$ 5.7	34.0 $\pm$ 9.2
	Experimental	34.8 $\pm$ 5.8	36.1 $\pm$ 9.1
RPE	Placebo	8.0 $\pm$ 1.2	7.5 $\pm$ 1.2
	Experimental	7.5 $\pm$ 0.6	7.2 $\pm$ 1.0

Peak nasal inspiratory flow %, nasal resistance, maximal oxygen uptake, rating of perceived exertion.

compared to the original END. The H group had significantly lower measurements when the placebo was used, compared to the basal and original END, respectively. In the basal condition, measurements of the participants were significantly lower, compared to the original END.

4.2. Nasal resistance (NR)

The R group showed significantly higher NR when compared to the H group in the three conditions analyzed. There was no significant difference between the basal and placebo conditions in both groups, but there was a significant difference when compared to the original END (Fig. 5).

4.3. Rating of perceived exertion (RPE)

There was no statistically significant difference when the groups were compared. However, the difference was significant when the participants used the original END compared to the placebo, regardless of the group analyzed (Fig. 6).

4.4. Maximal oxygen uptake (VO₂Max.)

There was no statistically significant difference in relation to the groups. Participants who used the placebo END demonstrated significantly lower means, compared to the original END, as shown on Fig. 7.

5. Discussion

The main objective of this study was to evaluate the effect of the external nasal dilator (END) on PNIF, nasal resistance and aerobic capacity in healthy adolescent athletes and those with allergic rhinitis. Data show that the use of the END significantly increased PNIF, reduced nasal resistance and improved aerobic capacity in the sample analyzed, both for the adolescents with rhinitis and the healthy ones.

This study is the first to evaluate the effect of the END on nasal airflow and physical exercise in adolescent athletes with allergic rhinitis, which therefore makes it difficult to compare it with data from other studies. It is not known if these data may be extrapolated for other adolescents or adults, since a series of factors could possibly interfere in these results.

The purpose of the END is to temporarily facilitate inspiratory respiration, reducing transnasal resistance, and improving inspiratory airflow in healthy individuals and those with nasal congestion [24]. In a recent systematic review [25], 33 brands of nasal dilator were found for sale on the market. Of these, five are “external” and only six were assessed for their effectiveness on nasal airflow. Authors concluded there are few studies proving the efficacy of these dilators. However, studies evaluating both healthy children and adolescents and those with allergic rhinitis are limited, particularly adolescent athletes.

A previous study [9] assessed the effect of the END on 54 healthy adolescents, with an improvement noted in PNIF, VO₂Max and subjective perception of dyspnea. These findings are similar to those of the present study, but the current one included adolescents with allergic rhinitis and an evaluation of nasal resistance using anterior rhinomanometry, the best objective assessment of nasal resistance, according to international consensus [22]. The procedures to evaluate PNIF were the same used in this study, but based on the absolute values we obtained the predicted values according to reference curves proposed by Ibiapina et al. [20]. Moreover, the cardio-respiratory test and subjective evaluation were different.

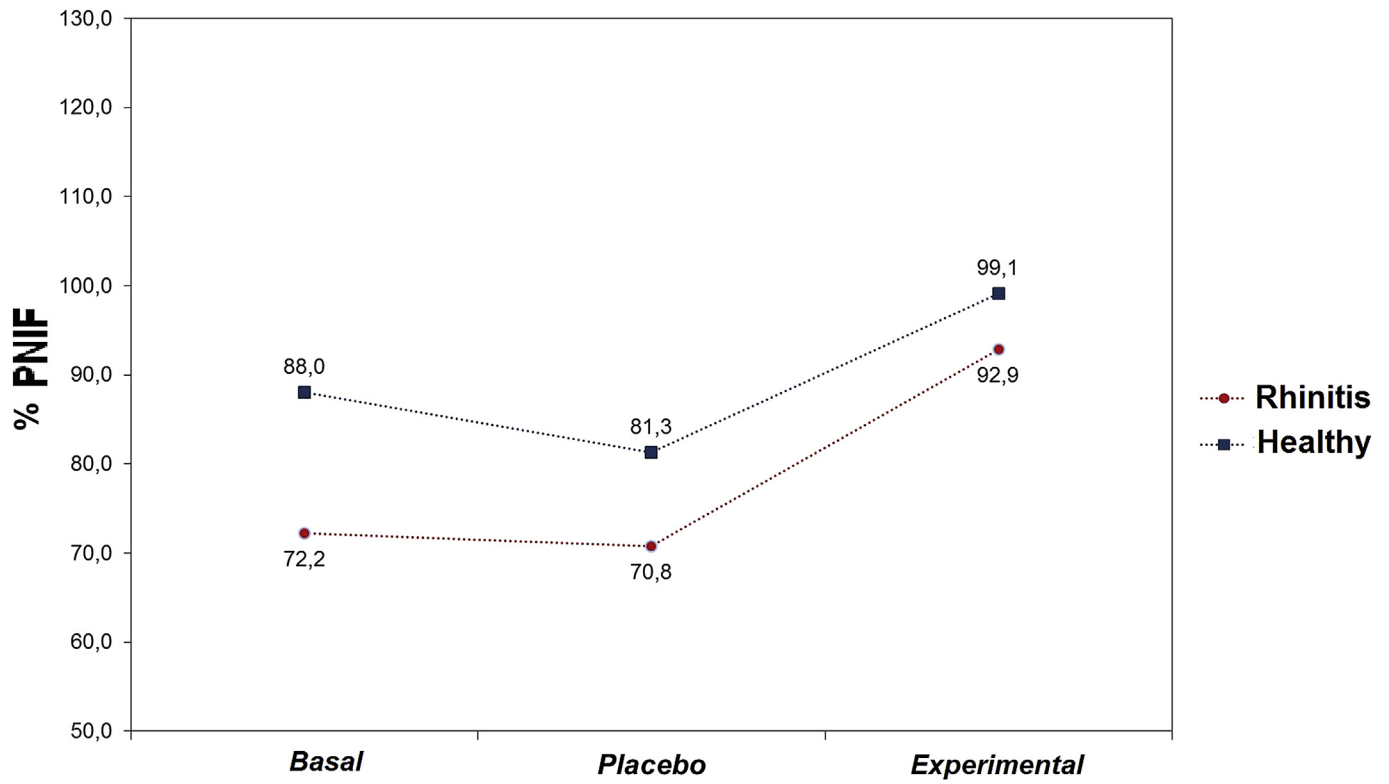


Fig. 4. Averages of the PNIF% measures in relation to the group and treatment factors.

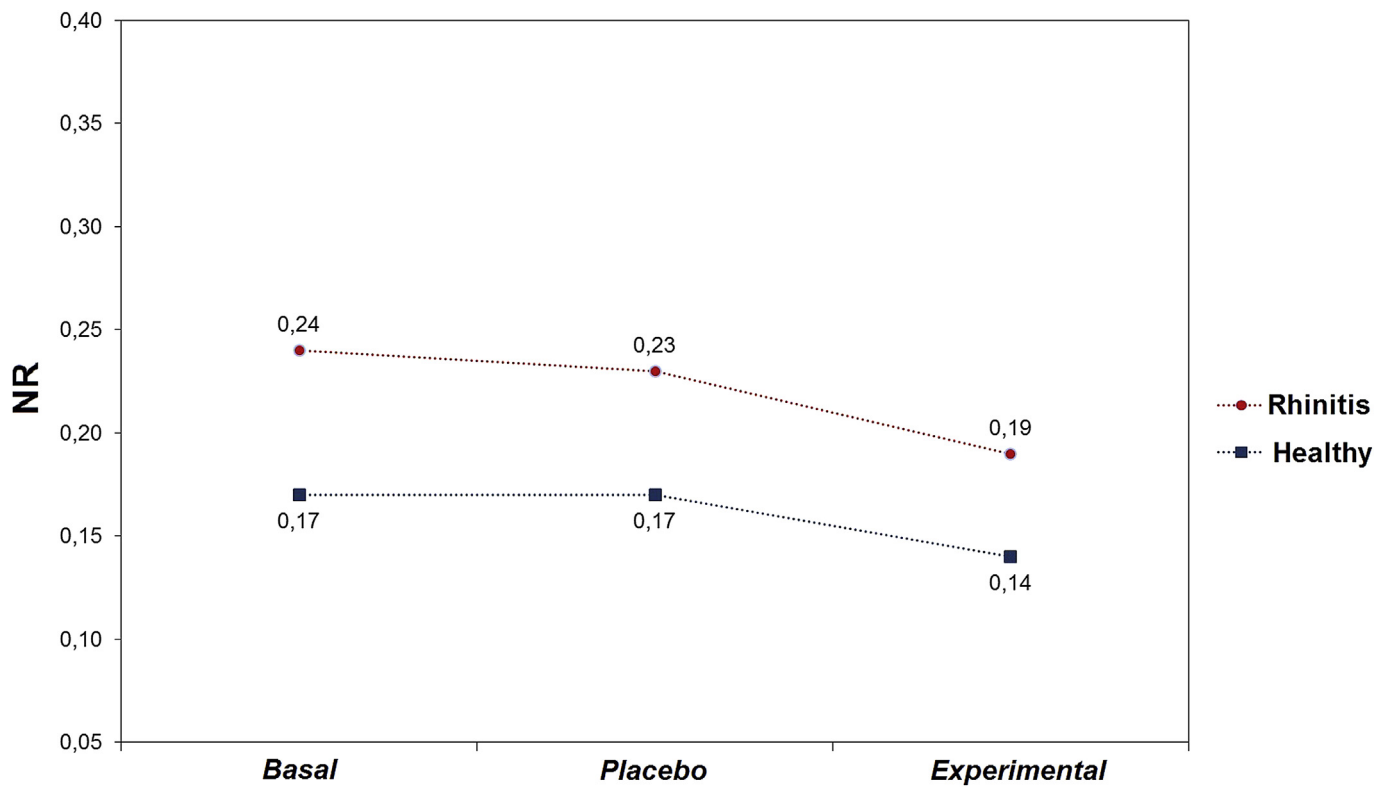


Fig. 5. Averages of the NR measures in relation to the group and treatment factors.

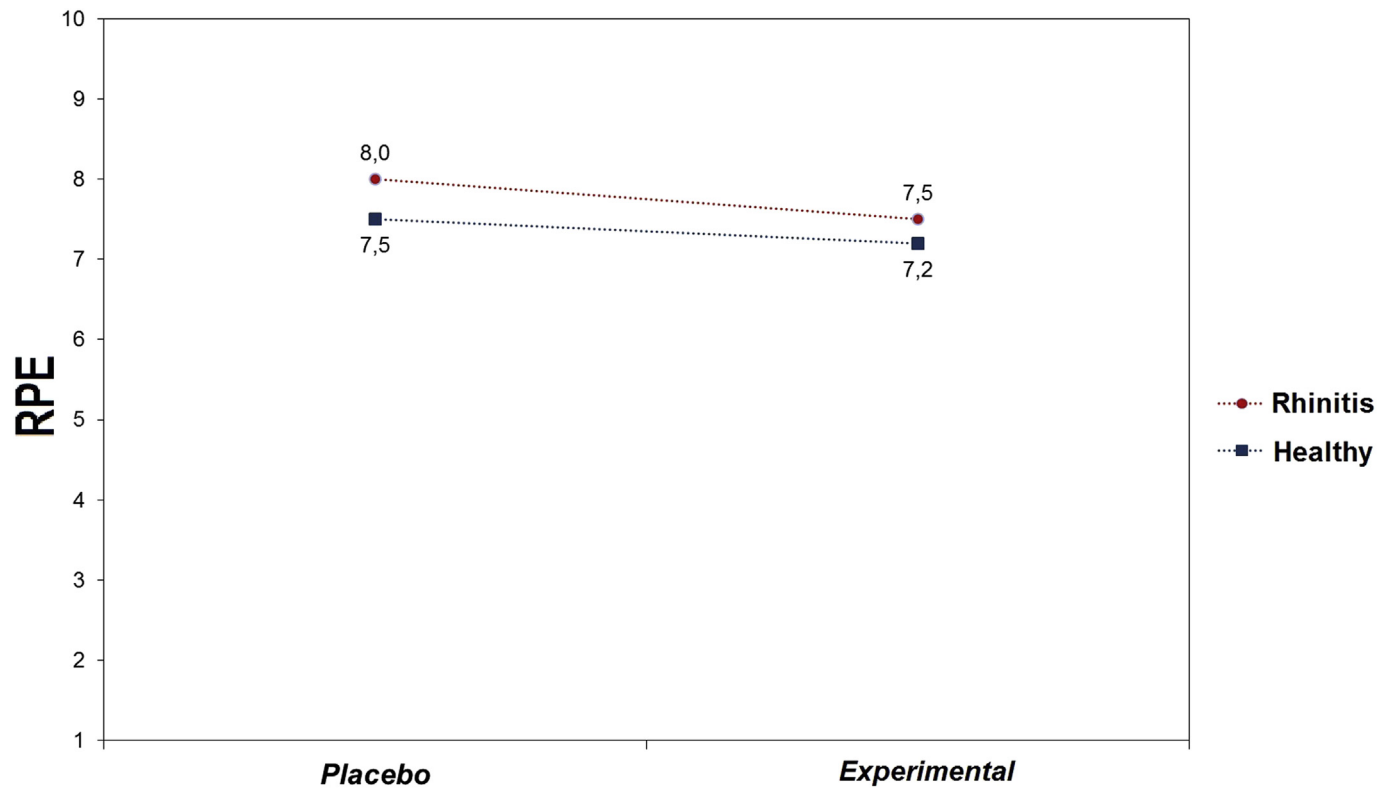


Fig. 6. Averages of the RPE measures in relation to the group and treatment factors.

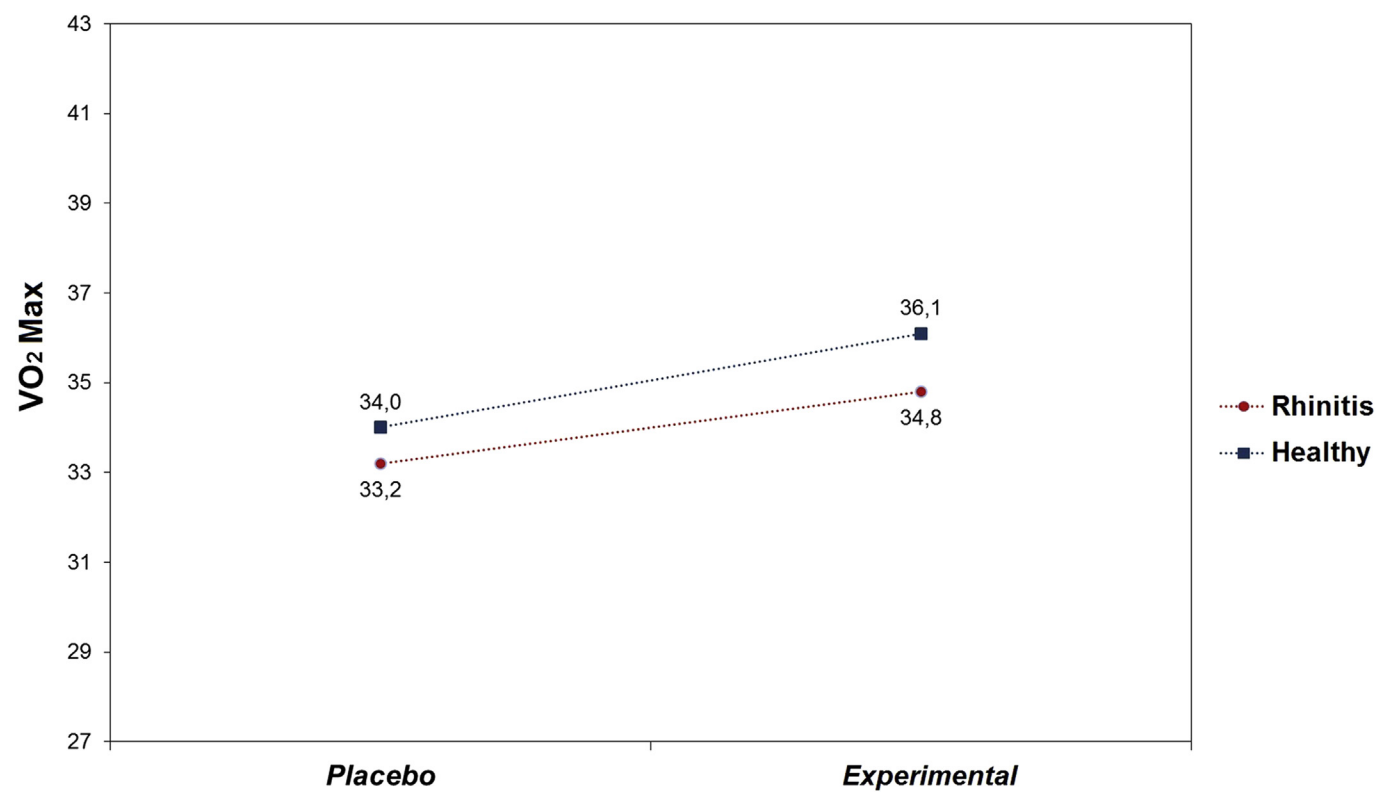


Fig. 7. Averages of the VO₂Max measures in relation to the group and treatment factors.

Recently, the effect of the END on 56 children aged between 6 and 12 years old [26] was analyzed. Of these, 30 were healthy and 26 demonstrated nasal congestion associated with allergic rhinitis. As an objective evaluation, the authors assessed PNIF, similar to this study. When they used the END on healthy children, they detected a significant increase in the two positions evaluated (seated and supine) and in children with nasal congestion, in the seated position only, compared to the basal. These inferences are similar to those of our study, which added important aspects: a) adolescents were assessed while standing upright and the predicted PNIF was used, that is, based on the absolute values we obtained the predicted values according to reference curves proposed by Ibiapina et al. [20]; b) the placebo END was used.

Johnson et al. [27] studied the effect of two ENDs (*The Kids strip* and *Regular strip*) on 39 children aged between 5 and 12 years old, with nasal congestion associated with allergic rhinitis. The hypothesis was that children between 5 and 8 years old would feel more comfortable with “*The Kids strip*” because of their smaller noses, while the children between 9 and 12 years old would use the “*Regular strip*”. This theory was confirmed with a subjective assessment. Researchers used PNIF as objective evaluation. In the basal condition, PNIF was higher in the seated position, compared to when lying down. There was no significant difference in the two positions with the ENDs.

Based on the assumption that there is a high prevalence of allergic diseases in the world [1,2] and in Brazil [28], the current study also evaluated adolescents with this condition. Our findings suggest that the END could be useful for people with nasal congestion, a common characteristic in patients with rhinitis.

Corroborating the findings of Macfarlane et al. [10] and Dinardi et al. [9] on healthy adolescents, the results found in the present study indicated that the END had a positive effect on the cardio-respiratory test, evaluated from a field test. This data was consistent with expectations, since one of this study's hypotheses is that END improves nasal patency, reduces resistance, leading to an increase in ventilation during exercise, making larger quantities of oxygen available for the respiratory muscles, enabling the athlete to a better recovering and exercise performance. Other researchers reinforce these hypotheses [10,13,14,29] that seems to be valid only during nasal respiration [30], unlike the current investigation, in which breathing was oronasal.

These data are conflicting in the literature, since in the adult population various studies [13–15] did not show an improvement in the aerobic capacity of participants, even while demonstrating an increase in nasal airflow. Another study [29] on healthy adult athletes, showed an increase in the area of the nasal valve's transverse section, a significant drop in parameters such as VO_2Max , heart rate, RPE and VE using the END in submaximal aerobic exercise of low intensity on ergometric bicycle.

Although ideally, objective evaluation methods that enable for simultaneous measuring of oxygen uptake, ventilatory parameters and heart rate could be used, we chose to analyze aerobic capacity through field test. This represents one of the limitations of this study. However, the test used is simple, low cost and scientifically valid [19].

In the present study, RPE was measured immediately after the cardio-respiratory test, according to guidelines established by Borg's [23] scale which was developed to assess individuals' perception of exertion in a broad variety of exercise types. Similarly to our findings, two studies reported positive effects in subjective perception of dyspnea and exertion, respectively, in healthy adolescent athletes using the END [9,10].

Regarding the validity of RPE as a reliable method to determine the stress of training Manoel et al. [31] evaluated thirteen healthy adolescent athletes. There was a correlation noted between heart

rate and RPE in the progressive maximal aerobic test continuous and staggered speed and resistance training and other types of training. The authors conclude that the RPE is a simple, low cost, valid and reliable method to evaluate the stress of training on adolescent athletes, particularly in aerobic exercises [31].

Another limitation of our study was the absence of a classification relating to the ethnicity of the studied population. One of the characteristic features of the ethnic composition of the Brazilian population is the wide variety of types, which makes precisely defining it a difficult task.

In healthy adults, there was a significant difference between the area of the nasal valve's transverse section in whites and blacks ($p = 0.002$ e $p = 0.001$, respectively), with and without the END [29]. The mean increase in area for whites (0.36 cm^2) was significantly higher in comparison with blacks (0.20 cm^2). This may justify our results, considering the greater prevalence of whites, for whom the effect of the END could be more evident.

6. Conclusion

A significant increase in nasal airflow was reported in healthy adolescent athletes and those with allergic rhinitis when using the external nasal dilator. This increase seems to influence aerobic exercise parameters, having a positive effect on VO_2Max and an improvement in rating of perceived exertion, evaluated in field test.

Authorship contribution

RRD: conceptualisation and design of the study, the acquisition, analysis and interpretation of data, statistical analysis, and the drafting of the paper. CRdA: conceptualisation and design of the study, the analysis and interpretation of data, statistical analysis, and the drafting of the paper. CdCI: conceptualisation and design of the study, the analysis and interpretation of data, statistical analysis, and the drafting of the paper. CdCI also supervised the study. All authors contributed to the critical revision of the paper and approved the final manuscript for publication.

Conflict of interest

The authors state they have no conflict of interest in relation to END' manufacturer and have not received financial support. The devices delivered to the patients were offered by the authors, without further interference in the elaboration and/or planning of the experiments.

Acknowledgements

We would like to thank the National Council of Technological and Scientific Development (CNPq) and professional Antonio Augusto da Silva Abreu for their valuable contribution. We would like to also thank the sports school Santa Tereza Cachoeirinha and its owner professor Marcelo Rosa.

References

- [1] P. Magnus, J.J. Jaakkola, Secular trend in the occurrence of asthma among children and young adults: critical appraisal of repeated cross sectional surveys, *BMJ* 314 (7097) (1997) 1795–1799.
- [2] Allergic rhinitis and its impact on asthma (ARIA) (in collaboration with the world health organization, GA(2)LEN and AllerGen), *Allergy* 63 (Suppl 86) (2008) 8–160.
- [3] A. Alaranta, H. Alaranta, M. Heliovaara, P. Alha, P. Palmu, I. Helenius, Allergic rhinitis and pharmacological management in elite athletes, *Med. Sci. Sports Exerc* 37 (5) (2005) 707–711.
- [4] C.H. Katelaris, F.M. Carrozzi, T.V. Burke, K. Byth, Patterns of allergic reactivity and disease in Olympic athletes, *Clin. J. Sport Med.* 16 (2006) 401–405.

- [5] S. Bonini, M. Bonini, J. Bousquet, V. Brusasco, G.W. Canonica, K.H. Carlsen, et al., Rhinitis and asthma in athletes: an ARIA document in collaboration with GA(2)LEN, *Allergy Eur. J. Allergy Clin. Immunol.* 61 (6) (2006) 681–692.
- [6] H.P. Dijkstra, P. Robson-Ansley, The prevalence and current opinion of treatment of allergic rhinitis in elite athletes, *Curr. Opin. Allergy Clin. Immunol.* 11 (2011) 103–108.
- [7] WADA, The World Anti-doping Code. The 2015 Prohibited List. International Standard (Effective January 1, 2015), 2016. Available in: <http://www.wada-ama.org>.
- [8] L.G. Portugal, R.H. Mehta, B.E. Smith, J.B. Sabnani, M.J. Matava, Objective assessment of the breathe-right device during exercise in adult males, *Am. J. Rhinol.* 11 (1997) 393–397.
- [9] R.R. Dinardi, C.C. Ibiapina, C.R. Andrade, Evaluation of the effectiveness of the external nasal dilator strip in adolescent athletes: a randomized trial, *Int. J. Pediatr. Otorhinolaryngol.* 77 (9) (2013) 1500–1505.
- [10] D.J. Macfarlane, S.K. Fong, Effects of an external nasal dilator on athletic performance of male adolescents, *Can. J. Appl. Physiol.* 29 (5) (2004) 579–589.
- [11] R.R. Dinardi, C.R. Andrade, C.C. Ibiapina, External Nasal dilator: definition, background and current uses, *Int. J. Gen. Med.* 7 (2014) 491–504.
- [12] E.M. Di Somma, S.N. West, J.R. Wheatley, T.C. Amis, Nasal dilator strips increase maximum inspiratory flow via nasal wall stabilization, *Laryngoscope* 109 (1999) 780–784.
- [13] J.A. O'Kroy, Oxygen uptake and ventilatory effects of an external nasal dilator during ergometry, *Med. Sci. Sports Exerc* 32 (8) (2000) 1491–1495.
- [14] J.A. O'Kroy, T. James, J.M. Miller, D. Torok, K. Campbell, Effects of an external nasal dilator on the work of breathing during exercise, *Med. Sci. Sports Exerc* 33 (3) (2001) 454–458.
- [15] V.N.G. Nunes, D.C.S. Barbosa, W.C. Damasceno, M. Fonseca, A.G. Andrade, E.R. Vieira, et al., External nasal dilator strip does not affect heart rate, oxygen consumption, ventilation or rate of perceived exertion during submaximal exercise, *J. Exerc Physiol.* 14 (1) (2011) 11–19.
- [16] K.M. Baker, D.G. Behm, The ineffectiveness of nasal dilator strips under aerobic exercise and recovery conditions, *J. Strength Cond. Res.* 13 (3) (1999) 206–209.
- [17] A.M. Wilson, O.J. Dempsey, E.J. Sims, B.J. Lipworth, A comparison of topical budesonide and oral montelukast in seasonal allergic rhinitis and asthma, *Clin. Exp. Allergy* 31 (2001) 616–624.
- [18] M.I. Asher, S. Montefort, B. Bjorksten, C.K. Lai, D.P. Strachan, S.K. Weiland, et al., ISAAC Phase Three Study Group. Worldwide time trends in the prevalence of symptoms of asthma, allergic rhinoconjunctivitis, and eczema in childhood: ISAAC Phases One and Three repeat multicountry cross-sectional surveys, *Lancet* 368 (9537) (2006) 733–743.
- [19] L.A. Léger, D. Mercier, C. Gadoury, J. Lambert, The multistage 20-meter shuttle run test for aerobic fitness, *J. Sports Sci. Med.* 6 (1988) 93–101.
- [20] C. Ibiapina, C.R. Andrade, P.A.M. Camargos, C.G. Alvim, Cruz AA. Reference values for peak nasal inspiratory flow in children and adolescents in Brazil, *Rhinology* 49–3 (2011) 304–308.
- [21] V. Brusasco, R. Crapo, G. Viegi, ATS/ERS Task Force: standardisation of lung function testing, *Eur. Respir. J.* 26 (2005) 153–161.
- [22] P.A. Clement, F. Gordts, Standardisation committee on objective assessment of the nasal airway, irs, and ERS. Consensus report on acoustic rhinometry and rhinomanometry, *Rhinology* 43 (3) (2005) 169–179.
- [23] G.A. Borg, Psychophysical bases of perceived exertion, *Med. Sci. Sports Exerc* 14 (1982) 377–381.
- [24] J.S. Kimbel, D.O. Frank-Ito, Mechanical nasal dilators for the management of nasal obstruction, *JAMA Facial Plast. Surg. Publ. online* (June 30, 2016), <http://dx.doi.org/10.1001/jamafacial.2016.0656>.
- [25] N. Kiyohara, C. Badger, T. Tjoa, B. Wong, A comparison of over-the-counter mechanical nasal dilators: a systematic review, *JAMA Facial Plast. Surg.* (June 30, 2016), <http://dx.doi.org/10.1001/jamafacial.2016.0291>. Published online.
- [26] E.O. Meltzer, S. Johnson, Objective and subjective responses to a mechanical external nasal dilator in healthy children and children with nasal congestion, *Allergy Asthma Proc.* 36 (2015) 481–486.
- [27] S.M. Johnson, A.M. Hamilton, L.A. Lauersen, A phase IV, single-center, cross-over evaluation of the efficacy of an external nasal dilator strip in children with nasal congestion, *Allergy Asthma Proc.* 37 (3) (2016) 242–247.
- [28] D. Solé, N.A. Rosário Filho, E.S. Sarinho, I.C. Camelo-Nunes, B.A. Barreto, M.L. Medeiros, et al., Prevalence of asthma and allergic diseases in adolescents: nine-year follow-up study (2003–2012), *J. Pediatr.* (91) (2015) 30–35.
- [29] J.W. Griffin, G. Hunter, D. Ferguson, M.J. Sillers, Physiologic effects of an external nasal dilator, *Laryngoscope* 107 (9) (1997) 1235–1238.
- [30] D.G. Whyte, A. Whitty, V.J. Rice, The effect of a novel mechanical nasal dilator on cycling performance, *J. Sports Med. Phys. Fit.* 56 (2016) 949–950.
- [31] F.A. Manoel, B.P. Melo, R. Cruz, C.A.R.S. Vilela, D.L. Alves, S.F. da Silva, et al., The utilization of perceived exertion is valid for the determination of the training stress in young athletes? *J. Exerc Physiol.* 19 (1) (2016) 27–32.