Original Article

Changes in Lung Function Measures Following *Bhastrika Pranayama* (Bellows Breath) and Running in Healthy Individuals

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Abstract

Background: The purpose of this study was to observe the effect of *bhastrika pranayama* (bellows breath) and exercise on lung function of healthy individuals. **Materials and Methods:** A total of thirty male participants were recruited and randomly divided into two groups, i.e., yoga breathing group (YBG, n = 15) and physical exercise group (PEG, n = 15), and the participants' ages ranged between 18 and 30 years (group age mean ± standard deviation, 22.5 ± 1.9 years). YBG practiced *bhastrika pranayama* for 15 min, whereas PEG practiced running for 15 min, 6 days in a week, over a period of 1 month. The participants were assessed for (i) forced vital capacity (FVC), (ii) forced expiratory volume in the first second (FEV1), (iii) peak expiratory flow rate (PEFR), and (iv) maximum voluntary ventilation (MVV) functions of lungs. **Results:** Repeated-measures analyses of variance with Bonferroni adjustment *post hoc* analyses of multiple comparisons showed that there was a significant increase in YBG for all variables, i.e., FVC, FEV1, PEFR, and MVV ($P < 0.001$, $P < 0.001$, $P < 0.01$, and $P < 0.001$, respectively), whereas there was a significant increase in PEFR and MVV ($P < 0.05$ and $P < 0.01$, respectively) only, among PEG. However, the change in PEG was less of magnitude as compared to YBG. **Conclusions:** These findings demonstrate that incorporating *pranayama* in sports can enhance the efficiency of healthy individuals and athletes by enhancing the ventilatory functions of lungs, especially for those who partake in aerobic-based sports and require efficient lungs to deliver sufficient oxygen uptake.

Keywords: *Bellows breath, running, ventilatory function, yogic breathing exercise*

Introduction

Breath regulation or control is crucial to the practice of yoga and is emphasized in later six out of the eight aspects, or "limbs" of yoga as follows: *yama* (universal ethics), *niyama* (individual ethics), *asana* (physical postures), *pranayama* (breath control), *pratyahara* (control of the senses), *dharana* (concentration), *dhyana* (meditation), and *samadhi* (bliss).[1] Breath can be considered as the most important function of the body for indeed all the other functions depend on it.[2] When the breath stops permanently, life ends. Hence, *prana* (*chi*) or the breath is thus rightly called the life force energy. Moreover, the technique of manipulation of the normal pattern of *prana* (breath) through its conscious control is known as *pranayama* (yogic breathing exercise).[1] In view of its importance, the yogis from times immemorial developed this special system *"Pranayama"* and emphasized on the need of its regular practice. Its practice helps to reap maximum benefits by controlling the life force in a superior and extraordinary way by harmonizing body, mind, and spirit.[3] Schünemann *et al*.[4] reported in their study that pulmonary function is a long-term predictor of overall survival rates in both genders and could be used as a tool in general health assessment.

In a previous study, Pramanik *et al*.[5] revealed that after slow *bhastrika pranayamic* breathing (respiratory rate [RR] 6 breath/min) for 5 min, both the systolic and diastolic blood pressure decreased significantly with a slight fall in heart rate. Raju *et al*.[6] studied *pranayama* effect among athletes in two phases on exercise tests. Both phases, i.e., submaximal and maximal exercise tests revealed that the participants practicing *pranayama* could achieve significantly higher work rates with a reduction in oxygen consumption per unit work and without an increase in blood lactate levels. Another study assessing the combined effect of both *anulom vilom* and

How to cite this article: Budhi RB, Payghan S, Deepeshwar S. Changes in lung function measures following *bhastrika pranayama* (bellows breath) and running in healthy individuals. Int J Yoga 2019;12:233-9.

Received: July, 2018. **Accepted:** February, 2019.

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Access this article online

Website: www.ijoy.org.in

DOI: 10.4103/ijoy.IJOY_43_18

Quick Response Code:

bhastrika pranayama reported significant improvement in vital capacity and maximal ventilator volume.[7]

Prakash *et al*.[8] in a cross-sectional study found that the yogis and athletes had significantly better forced expiratory volume in the first second (FEV1). Further, yogis' peak expiratory flow rate (PEFR) was reported to be significantly better than that of both athletes and sedentary workers. Joshi *et al*.[9] reported that 6 weeks of *pranayama* improved ventilatory functions by lowering RR, increasing the forced vital capacity (FVC), FEV1, maximum voluntary ventilation (MVV), PEFR, and prolonging the breath holding time. Similarly, another study demonstrated a significant increase in FVC, FEV1, PEFR, and forced expiratory flow by 25%–75% after the practice of *pranava, nadishuddi and savitri pranayama*.[10] Apart from this, there was a comparative study between slow (*Nadisohana, Pranav pranayama, and Savitri pranayama*) and fast group *pranayama* (*kapalabhati, bhastrika, and kukkriya*) after training of 12 weeks on pulmonary function in young healthy volunteers reporting improvement in ventilatory functions.[11] Additionally, other comparative studies on slow and fast pranayama, *bhastrika* was included as one of the practices of fast group had reported improvement in hand grip strength and endurance,[12] reduced perceived stress and enhanced cognitive functions in healthy subjects.[13] Furthermore, fast pranayama's additional effects on the executive function of manipulation in auditory working memory, central neural processing, and sensory motor performance were observed. Apart from this, there are also studies on mukha *bhastrika* (a bellow-type *pranayama*) reporting decreased reaction time.[14]

However, all the previous studies had been limited to certain points such as (i) either combined effects of slow/fast group *pranayama* were explored or *pranayama* effect was cumulatively investigated with other multiple techniques of yoga practices, (ii) most studies were either done without a control group or rarely control group was present, and (iii) retrospective studies were reported. And eventually, there was no study which has examined *bhastrika pranayama* alone compared with exercise (running) on ventilatory functions of the lung. Higher lung capacity has been speculated to be a key variable for marathon performance in amateur runners in a previous study.[15] Hence, the present study aimed to assess the impact of 4-week (1 month) *bhastrika pranayama* compared with running as active control on four parameters of lung function, i.e., (i) FVC, (ii) FEV1, (iii) PEFR, and (iv) MVV on healthy volunteers, who were actively involved in sport activities.

Materials and Methods

Participants

Thirty healthy male participants with ages between 18 and 30 years (group average age ± standard deviation, 28.8 ± 7.8 years) were selected from North India. Only male participants were recruited in the study as pulmonary capacity varies with gender due to the influence of the reproductive hormones in females.[16] The sample size was calculated based on the FEV1 mean and standard deviation values of a previous study.[17] The G*Power software,[18] Version 3.0.10 (Heinrich Heine Universität Düsseldorf) was used, where alpha, power, and effect size were 0.05, 0.95, and 1.99 respectively, which generated a sample size of 7 in each group. It was decided to recruit 15 participants in each group to compensate for possible dropouts. Participants were randomly allocated using the web-based Research Randomizer[19] into yoga breathing group (YBG; n = 15) and physical exercise group (PEG; n = 15) after baseline data recording of the pulmonary function test (PFT). All participants were healthy, based on a routine case history and clinical examination, and none of them were on medication. They were actively involved in sports activities and ready to volunteer in the current study. The participants were excluded who had a history of major medical illness such as tuberculosis, hypertension, diabetes mellitus, bronchial asthma, history of major surgery in the recent past, smoking, alcohol consumption, and nonvegetarian diet. The study design was explained to all the participants, and their signed informed consent form was obtained. The study was approved by the Institutional Ethics Committee of Dev Sanskriti University, Haridwar, India.

Design

It is difficult to assess yoga practices in double-blind trials because the intervention requires the active participation of the individual and hence, the identities of the interventions become known after allocation.[18] However, the investigator who did the PFT was blind to the intervention. Therefore, it was a simple randomized controlled study. Consort flow diagram is explained in Figure 1.

Assessments

Baseline data of each participant for the PFT were measured using a precalibrated computerized spirometer-MEDSPIROR (RMS recorders and Med Sys Pvt. Ltd., Chandigarh, India) instrument by an expert lab technician. Participants were properly familiarized with the testing procedure before each test. The baseline and postdata recording was carried out in sitting position following a standard procedure[20] during morning hours (6:30 am to 8:00 am). While performing a test, participants were adequately encouraged to perform at their optimum level. The test was repeated three times, and the highest value was used for the statistical analyses. All readings were recorded at saturated body temperature and pressure.

For each measure, the maintenance of a tight seal between the lips and mouthpiece of the spirometer was ensured. All participants were assessed on the following parameters:

Forced vital capacity

In assessing FVC, participants were made to sit comfortably with normal breathing, with the mouthpiece of

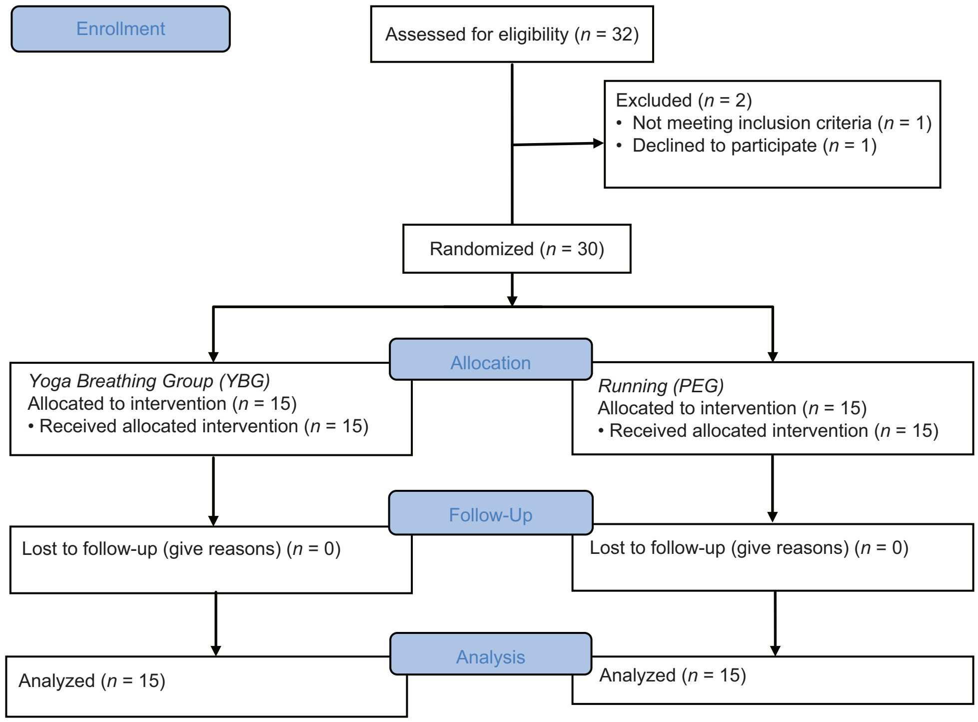

Figure 1: CONSORT flow diagram

a spirometer placed into the mouth. The participants were instructed to inspire to their maximum effort and blow all the air through the mouthpiece as rapidly, forcefully, and completely as possible.

Forced expiratory volume in the first second

FEV1 was the value in the first second of forceful expiration derived from FVC.

Peak expiratory flow rate

For the PEFR, participants were instructed to perform forceful expiration immediately after a full inspiration (i.e., with no postinspiratory pause). It is the maximum velocity in liters per minute with which air is forced out of the lungs.[21]

Maximum voluntary ventilation

For MVV assessment, participants were instructed to inhale and exhale with a maximum voluntary effort by breathing as quickly and deeply as possible for 10–20 s, and finally the highest volume from 10 to 20 s was corrected to 1 min.

Intervention

The YBG practiced *bhastrika pranayama* for 15 min, 6 days in a week for a month, in morning hour approximately at 8 "o" clock. There was no training or orientation before the intervention as participants were occasional practitioner of yogic practices. *Bhastrika pranayama* imitates the action of the *bhastra* or "bellows" and fans the internal fire heating the physical and subtle bodies. Inhalation and exhalation in this *pranayama* are equal and are the result of systematic and equal lung movements. The inhalation and exhalation were performed with little force.[3] All participants were asked to sit in any comfortable meditation pose, and *bhastrika pranayama* practice was started with Om chanting and ended with pacifying chanting called *shantipatha.* Every day, participants were asked to practice three rounds of *bhastrika pranayama* of 4–5 min each with approximately 1 min rest after each round. All the participants were trained and monitored by a certified yoga trainer.

The practice of *bhastrika pranayama* with medium or fast pace continuously for longer duration is not possible or very difficult, so volunteers were asked to start the practice with slow pace and gradually increase the speed with full efforts toward the ending of approximately 5 min.

Similarly, participants in the PEG were asked to run for 5 min thrice in an open environment and instead of complete rest, they were asked to walk as a rest in between approximately 1 min, after every 5 min. PEG practiced running like YBG for 15 min, 6 days in a week for a month, in morning hour approximately at 8:30 am. Initially, each participant was asked to run slowly and gradually increase their speed to full effort toward the end of approximately 5-min practice. PEG was also monitored by an investigator who was not involved in the analysis part.

Statistical analysis

Statistical analyses were performed using the Statistical Package for the Social Sciences (Version 18.0. SPSS Inc., Chicago, IL, USA). Data of (i) FVC, (ii) FEV1, (iii) PEFR, and (iv) MVV recorded were tested by Shapiro–Wilk test for normality, which showed that data were normally distributed. Therefore, repeated-measures analyses of

Table 1: Baseline and postdata obtained in lung function for yoga breathing group and physical exercise group

Parameters	Group							Percentage change
	Yoga (*n*=15)			Percentage change	Running (*n*=15)			
	Before (mean±SD)	After (mean±SD)	ES		Before (mean±SD)	After (mean±SD)	ES	
FVC (L)	2.52±0.61	3.48±1.22**	0.91	38.10	2.54±0.65	2.73±0.75	0.27	7.48
FEV1 (L/s)	2.37±0.59	2.95±0.46***,†	1.1	24.47	2.37±0.61	2.47±0.60	0.17	4.22
PEFR (L/s)	5.11±1.39	5.79±1.34**	0.5	13.31	4.87±1.39	5.48±1.64*	0.4	12.53
MVV (L/min)	114.0±32.44	157.67±24.23***,†	1.5	38.31	116.20±28.78	135.13±31.18**	0.63	16.29

Values are in group mean±SD. Repeated-measures ANOVA with Bonferroni adjustment *post hoc* analyses was performed for multiple comparisons, *P<0.05, **P<0.01, ***P<0.001, *Depicts comparison between post with respective pre means, †P<0.05 depicts comparison between post states of both groups. FVC=Forced vital capacity, SD=Standard deviation, FEV1=Forced expiratory volume in the first second, PEFR=Peak expiratory flow rate, MVV=Maximum voluntary ventilation, ES=Cohen's *d* effect size, ANOVA=Analysis of variance

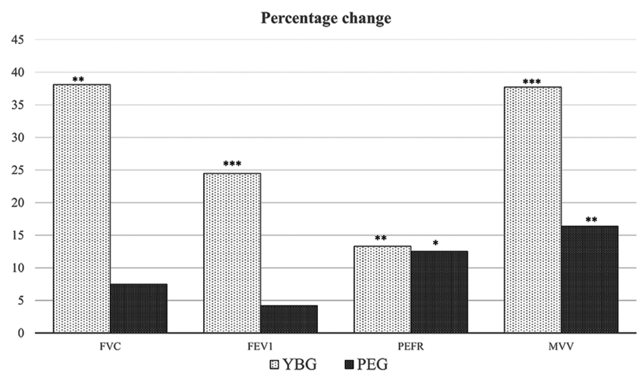

Figure 2: Graph showing the percentage change. *P<0.05, **P<0.01, ***P<0.001. FVC = Forced vital capacity, FEV1 = Forced expiratory volume in the first second, PEFR = Peak expiratory flow rate, MVV = Maximum ventilation volume, YBG = Yoga breathing group, PEG = Physical exercise group

variance (ANOVA) were performed. There was one within-subject factor, i.e., state (baseline and post) and one between-subjects factor, i.e., groups (YBG and PEG). *Post hoc* analyses with Bonferroni adjustment were used to detect significant differences between the mean values. Cohen's *d* effect size was calculated using G-power software (3.0.10 version).

Results

The baseline and postgroup mean and standard deviation for data obtained in the FVC, FEV1, PEFR, and MVV are shown in Table 1.

Forced vital capacity

The repeated-measures ANOVA showed a significant difference between the states for FVC ($F_{1,\ 28}$ = 10.37, P < 0.003). *Post hoc* analyses with Bonferroni adjustment were performed for multiple comparisons. After yoga sessions, there was a significant increase in FVC (P < 0.001; Cohen's d = 1.05) compared to baseline; in contrary to this, there was no significant increase in physical exercise sessions.

Forced expiratory volume in the first second

The repeated-measures ANOVA showed a significant difference between states for FEV1 ($F_{1,28}$ = 22.65, P < 0.001). *Post hoc* analyses with Bonferroni adjustment were performed, and there was a significant increase in FEV1 (P < 0.001; Cohen's d = 1.10) compared to baseline in YBG, whereas there were no significant changes in PEG.

Peak expiratory flow rate

The repeated-measures ANOVA showed a significant difference between states for PEFR ($F_{1,\ 28}$ = 15.17, P < 0.001). *Post hoc* analyses with Bonferroni adjustment for both yoga and physical exercise showed significant increase in PEFR (i.e., P < 0.01 and P < 0.05 and Cohen's d = 0.50 and 0.40 for YBG and PEG, respectively). However, a magnitude of change was more in YBG compared to PEG as shown in Figure 1.

Maximal voluntary ventilation

The repeated-measures ANOVA showed a significant difference between states for MVV ($F_{1,\ 28}$ = 79.96, P < 0.001). *Post hoc* analyses with Bonferroni adjustment for yoga and physical exercise practice showed significant increase in MVV (P < 0.001 and P < 0.01 and Cohen's d = 1.54 and 0.63 for YBG and PEG, respectively) compared to baseline; in this parameter also, the magnitude of change was more in YBG as compared to PEG as shown in Figure 2.

Discussion

In the present study, FVC, FEV1, PEFR, and MVV increased significantly after the 1-month practice of *bhastrika pranayama* (YBG) as compared to a physical exercise (PEG). The PEG also showed an increase in PEFR and MVV, but the magnitude of change was less compared to YBG. These findings are in line with earlier studies. However, the present study attempted to explore single *bhastrika pranayama* effect on healthy individuals in comparison with physical exercise. The regular breathing practices in yoga training[22] and Sudarshan Kriya[23] studies had reported significant improvement in all PFTs such as FVC, FEV1, PEFR, and MVV. The current study also showed improvement in FVC by 38.1% after 4 weeks' practice of *bhastrika*. The finding is in consistent with the previous study that has reported that *pranayama* training for 6-week improves ventilatory functions in the form of lowered RR and by increasing FVC, FEV1, MVV, and PEFR.[9]

One of the previous studies conducted on *bhastirka pranayama* had showed significant improvement in pulmonary function after 12 weeks of practice compared with baselines values. This study was limited with no control group.[22] In addition to this, there are studies reporting improvements in pulmonary function which investigated the effect of multiple *pranayamas.*[9-11] Whereas the current study observed only the single *pranayama* (*bhastrika*) practice effect on pulmonary functions compared with running.

FVC is an index of the state of elastic properties of the respiratory apparatus.[24] Whereas FEV1 is the expelling rate of breath from the lungs in the 1st s. It reflects the flow-resistive properties to air flow in airways that are >2 mm in diameter. FVC has been considered as a critical component of good health and survival important for the evaluation of normal subjects and patients with respiratory and cardiovascular conditions.[25] Kondam *et al*.[26] had reported that consistent practice of a variety of *asanas* constantly recruits muscles of the thoracic cavity. This recruitment may lead to greater musculature involvement and thereby result in improved FVC. Further, a study reported that yoga exercises improve respiratory breathing capacity by increasing chest wall expansion and forced expiratory lung volumes.[27] In both the studies, asanas were the intervention used, whereas in the present study, asanas were not at all practiced by the participants, and only *bhastrika pranayama* was intervened. Hence, improvement in the FVC and FEV1 could be due to recruitment and strengthening of respiratory muscles that might have enhanced elastic properties of the lungs and chest, incidental to the regular practice of *bhastrika pranayama.*[28] In contrast to this, there were no significant changes observed in the above variables among PEG.

PEFR is a measure of elastic recoil pressure changes or the resistance of small airways.[24] In several previous studies,[9-11,29] significant improvement in PEFR after yoga practice has been reported. An improvement in PEFR was also observed in the present study, but in both YBG and PEG, where YBG had a relatively greater magnitude of change [Table 1]. Although earlier PEFR was believed to be effort dependent, now it is accepted to be effort independent and is mainly dependent on lung volume and airway mechanics.[30] The *"Bhastrika Pranayama"* is one of the yogic well-regulated breathing exercises that involves the use of lung spaces that are not used up in normal shallow breathing, thereby it may increase the depth of breathing. Forceful or deep yogic breathing (*pranayama*) expands the lungs more than normal breathing that may recruit previously closed alveoli, resulting in an increased surface area of the respiratory membrane and air diffusion across the membrane.[31] The improved breathing pattern may widen respiratory bronchioles, leading to effective perfusion of alveoli in a large number.[32] Therefore, the increased PEFR in a higher magnitude of YBG than PEG might be a consequence of the opening of a small airway in lungs and decrease in airway resistance.

MVV is respiratory apparatus measuring the status of respiratory muscles, i.e., mechanical properties of lungs and chest, representing the flow-resistive properties of the system. MVV has a wide variability with the subject and is an effort-dependent test.[24] In the present study, during *bhastrika pranayama* practice, participants were asked and trained to inflate and deflate the lungs and chest to the fullest and deepest possible extent as in previous pranayama studies.[9] Hence, the practice of *bhastrika pranayama in* YBG may have helped to use diaphragmatic and abdominal muscles efficiently, leading to significant increase in MVV in higher magnitude than PEG.[33]

In addition to this, regular inspiration and expiration during yoga and pranayama practices for a prolonged period lead the lungs to inflate and deflate maximally that causes strengthening and enhancement of endurance of the respiratory muscles.[8] And further, maximal lung inflation is the major stimulus for releasing the lung surfactants[10] from the epithelial lining of alveoli and prostaglandins into the alveolar spaces by the parenchyma of the lungs.[34] This may have increased lung compliance and decreased bronchiolar smooth muscle tone, respectively. In other words, decreased bronchiolar smooth muscle tone or increased bronchiolar smooth muscle relaxation may increase the caliber of airways, leading to more airflow and less airway resistance. These all could be the possible mechanism for increasing the pulmonary function in a higher magnitude of YBG compared to PEG in the current study. Clinically, there are also few studies that have reported the beneficial effects of yoga and breathing practices on respiratory disorders such as asthma[31,35,36] and chronic obstructive pulmonary disease.[37,38]

This study assessed the direct effect of one particular breathing practice called *bhastrika pranayama* on lung functions and compared it with physical exercise. An important thing to be noticed in this study was that YBG had more significant effect than PEG. However, the study had the following limitations: (i) latest version equipment was not used for measurement, so lung volumes such as functional residual capacity and inspiratory capacity were not measured at rest and during exercise in the study; (ii) intensity is a crucial part of training and it would have been ideal to strictly control this parameter by monitoring energy expenditure while training sessions. As the study was comparing the effects of two different streams of training; (iii) the sample size was small, and further studies with larger sample size and longer duration can validate the findings with the underlying mechanism;

(iv) combined practice of yogic breathing and running as third group as well as control group as fourth added, would have been more ideal; and (v) demographic details of all participants were self-reported. In addition, the present study only recruited male participants; future studies can recruit both the genders in equal numbers for generalization of outcome.

Conclusions

The results of the study conclude that the practice of *bhastrika pranayama* can recruit normally unventilated lung spaces and help strengthen the respiratory muscles and increase the elastic properties of lungs and chest, thereby improving its ventilatory functions.

It was interesting to find that there was a more significant increase in YBG than the PEG. Therefore, yoga breathing, particularly *bhastrika pranayama,* may have a promising factor for those who partake in aerobic-based sports (such as athletes, swimmers, and trekkers) and require efficient lungs to deliver sufficient oxygen uptake.

Acknowledgment

The help given by Lalan Bhaiya (expert/senior lab technician) and Brahmavarchasva Sodsansthan, Haridwar, India, in carrying out the assessments is gratefully acknowledged.

In addition to this, Swami Vivekananda Anusandan Samsthana, Bengaluru, India, is also highly acknowledged for providing all the facilities to compose the research article.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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