RBSO Revista Brasileira de Saúde Ocupacional
ISSN: 2317-6369 (online)
http://dx.doi.org/10.1590/2317-6369000004217

Short communication

Lung function and nasal mucociliary clearance in Brazilian sugarcane cutters exposed to biomass burning

Função pulmonar e depuração mucociliar nasal de cortadores de cana-de-açúcar brasileiros expostos à queima de biomassa

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The study received financial support (Auxílio à Pesquisa - Regular) from Fundação de Amparo à Pesquisa do Estado de São Paulo (Process 12/12901-0).

The authors declare no conflict of interest.

The study is not based on a thesis or dissertation and was not presented at a scientific meeting.

Abstract

Objective: to evaluate the effects of sugarcane burning on lung function and mucociliary clearance in sugarcane workers. *Methods:* sixteen sugarcane workers were evaluated in two sequential periods: during the non-harvest season, in April/2011, and during the sugarcane burning harvest season, in October/2011. Mean values (standard deviation) of lung function and mucociliary clearance were evaluated through spirometry and the saccharin transit time (STT) test, respectively. *Results:* lung function decreased $\%FEF_{25-75}$ [99.31 (23.79) to 86.36 (27.41); $p = 0.001$]; $\%FEV_1$ [92.19 (13.24) to 90.44 (12.76); $p = 0.022$]; and FEV_1/FVC [88.62 (5.68) to 84.90 (6.47); $p = 0.004$] during the harvest season compared with the non-harvest season. A significant decrease was found in saccharin transit time during the harvest [3 (1) min] season compared with the non-harvest season [8 (3) min] ($p < 0.001$). *Conclusion:* sugarcane workers present a decrease in $\%FEF_{25-75}$, $\%FEV_1$, FEV_1/FVC ratio, and increase in nasal mucociliary transport velocity at the end of the harvest season.

Keywords: rural worker; occupational health; mucociliary clearance; spirometry.

Resumo

Objetivos*: avaliar a função pulmonar e a depuração mucociliar nasal de cortadores de cana-de-açúcar.* Métodos*: foram avaliados dezesseis cortadores de cana-de-açúcar em dois períodos: durante o plantio da cana-de-açúcar, em abril/2011, e no final da safra, no período de queima e colheita manual da cana-de-açúcar, outubro/2011. A função pulmonar e a depuração mucociliar foram avaliadas por meio da espirometria e do teste de tempo de trânsito da sacarina (TTS), respectivamente.* Resultados*: a função pulmonar apresentou diminuição no* $\%FEF_{25-75}$ *[99,31 (23,79) para 86,36 (27,41);* $p = 0,001$*];* $\%VEF_1$ *[92,19 (13,24) para 90,44 (12,76);* $p = 0,022$*] e* VEF_1/CVF *[88,62 (5,68) para 84,90 (6,47);* $p = 0,004$*] no período da colheita em comparação ao de plantio. Também houve uma diminuição significativa no resultado do teste do TTS na colheita [3 (1) min] em comparação ao plantio [8 (3) min] (*$p < 0,001$*).* Conclusão*: os cortadores de cana-de-açúcar apresentaram diminuição do* $\%FEF_{25-75}$*,* $\%VEF_1$*, do índice* VEF_1/CVF*, e aumento da velocidade do transporte mucociliar nasal no final do período de colheita.*

Palavras-chave: *trabalhador rural; saúde do trabalhador; depuração mucociliar; espirometria.*

Received: 06/03/2017
Revised: 12/07/2017
Approved: 19/07/2017

Introduction

Brazil is the largest sugarcane producer in the world and the state of São Paulo is responsible for about 60% of the sugar and ethanol production[1,2]. Sugarcane burning is adapted to facilitate the manual harvest process, exposing workers to high concentrations of particulate matter (PM) throughout the season[3,4].

Sugarcane burning causes gas emissions and releases particles in much higher concentrations than the levels recommended by the World Health Organization (WHO)[5]. This pollution significantly leads to adverse effects on human health, both acutely and chronically[4], especially on rural workers who inhale noxious gases and PM for approximately forty-four hours per week during the harvest season[6].

Inhalation of pollutants produced by sugarcane burning along with the intense physical exertion require a higher ventilation rate. This results in a greater probability of nasal, pulmonary and systemic inflammation, and impaired mucociliary clearance (MC), known to be the main upper airway defense mechanism against inhaled particles and microorganisms. It affects the lower airways, which can lead to lung function impairment[7,8].

A study has shown that acute exposure to sugarcane burning causes decreased mucociliary transport time in workers[9]. However, long-term effects are expected to increase mucociliary transport time[10] and decrease lung function[11].

Thus, it is very important to know the effects of atmospheric pollutants, which can affect both MC and lung function, eventually leading to an increase in lung diseases and nasal symptoms[7,9-11]. The aim of this study was to evaluate the effects of sugarcane burning on sugarcane workers' lung function and mucociliary clearance.

Methods

The study followed a prospective cohort design, as an exploratory, preliminary approach to the problem. It was carried out with a small group of sugarcane workers from a Sugar and Ethanol Company located in the west of the state of São Paulo, Brazil, who volunteered to participate in the study. Only non-smokers were included, and the following conditions were defined as exclusion criteria; history of nasal surgery or trauma; any lung disease; nasal septum deviation; or recent episodes of upper airway infection. Each subject gave a written informed consent according to the Declaration of Helsinki. This study was approved by the Research Ethics Committee (15/2010) of São Paulo State University (UNESP).

The study was held in a sugarcane field in two sequential periods: during the manual sugarcane cultivation (non-harvest) in April 2011, and during harvesting after sugarcane burning in October 2011. An interview was conducted to record general information on the working process and each subject's clinical history. During the non-harvest and harvest seasons, we evaluated lung function was through spirometry; nasal MC through the saccharin transit time (STT) test; and exhaled carbon monoxide (CO) levels, which were measured to confirm smoking abstinence.

Spirometry followed the American Thoracic Society and European Respiratory Society guidelines[12], using a portable flow spirometer, Spirobank-MIR (version 3.6, MIR, Rome, Italy). The following parameters were recorded: absolute values and percentage of predicted values for forced vital capacity (FVC and %FVC); forced expiratory volume in the first second (FEV_1 and $\%FEV_1$), forced expiratory flow between 25% and 75% FVC (FEF_{25-75} and $\%FEF_{25-75}$), FEV_1/FVC ratio, and peak expiratory flow (PEF and %PEF). Reference values available for the Brazilian population were used for comparison[13].

The technique for measuring nasal MC has been described elswhere[9,14,15]. In brief, granulated sodium saccharin (250 μg) was deposited under visual control about 2 cm inside the right nostril. A timer was used to measure the saccharin transit time (STT) test. The STT test records the time elapsed from the moment the particles were placed until the moment the subject reports disguising the sweet taste of saccharine. Subjects were allowed to swallow freely and were asked to maintain normal ventilation, avoiding deep breaths, talking, sniffing, sneezing, eating, or coughing. If no response was reported after sixty minutes, the test was concluded after confirming, by placing saccharin powder directly on the subject's tongue, that was able to disguise the sweet taste normally. Participants were instructed not to use pharmacological agents, such as anesthetics, analgesics, barbiturates, tranquilizers, and antidepressants, and to avoid the ingestion of alcohol and caffeine-based substances, during the twelve hours preceding the test[14].

Exhaled CO levels were measured using a CO analyzer (Micro CO Meter, Cardinal Health, Basingstoke, UK)[16]. To confirm smoking abstinence, the sugarcane workers were instructed to hold their breath for twenty seconds and then exhale slowly from functional vital capacity through a mouthpiece[17]. Two successive recordings were produced and the highest value was used. A cutoff value of < 6 ppm was used to define abstinence from smoking[18].

For statistical analysis we used SPSS – Statistical Package for the Social Sciences (version 16.0; SPSS Inc; Chicago, USA) and R statistical software (version 2.13.0; R Foundation for Statistical Computing). The Shapiro-Wilk test was applied to verify data normality. To analyze lung function and STT results between the two seasons, we used, respectively, the paired Student's t test and the Wilcoxon test, considering a statistical significance of 0.05.

Results

Of the 40 recruited male workers who volunteered to participate in the study, 30 met the inclusion criteria and 10 smokers were excluded. Eleven of the 30 men were excluded because they did not return for reevaluation at harvest time, and three workers were excluded due to upper airway infections during the second evaluation. Results are presented as mean (standard deviation). A final group of sixteen sugarcane workers aged 25 (4) years, body mass index (BMI) 24 (3) kg/m^2, with exhaled CO of 2.1 (1.5) ppm were then evaluated in both non-harvest and harvest seasons. The average time the participants had been working in sugarcane harvesting was 3 (2) years.

Table 1 shows the spirometry values of the 16 subjects evaluated during the non-harvest seasons and the subsequent periods. A statistically significant decrease in FEF_{25-75} and $\%FEF_{25-75}$ was observed during the harvest season compared with the non-harvest season ($p = 0.002$; $p = 0.001$), respectively. A significant decrease was also found in FEV_1/FVC ratio and $\%FEV_1$ during harvest compared with the non-harvest season ($p = 0.004$; $p = 0.022$), respectively.

The STT test results showed a significant decreased time in the harvest season, 3 (1) minutes, compared with the non-harvest one, 8 (3) minutes ($p < 0.001$).

Table 1 Sugarcane cutters' (n=16) lung function values [average (standard deviation)] comparison between non-harvest season and harvest biomass burning season in a region of São Paulo State, Brazil, 2011

	Non-harvest	*Harvest*	*p**
FVC	4.49 (0.57)	4.46 (0.67)	0.874
%FVC	97.00 (14.43)	92.43 (12.56)	0.177
FEV_1	3.97 (0.45)	3.79 (0.60)	0.221
$\%FEV_1$	92.19 (13.24)	90.44 (12.76)	**0.022**
FEF_{25-75}	5.08 (1.05)	4.42 (1.30)	**0.002**
$\%FEF_{25-75}$	99.31 (23.79)	86.36 (27.41)	**0.001**
FEV_1/FVC	88.62 (5.68)	84.90 (6.47)	**0.004**
PEF	9.33 (1.24)	9.11 (1.82)	0.545
%PEF	92.19 (13.25)	89.81 (17.23)	0.507

FVC: forced vital capacity; FEV_1: forced expiratory volume in the first second; FEF_{25-75}: expiratory flow between 25% and 75% FVC; PEF: peak expiratory flow.
*Paired Student's t test, considering a statistical significance of 0.05.

Discussion

The results of this study showed that, despite the spirometry values being within normal limits during both evaluation periods, a significant decrease was observed in $\%FEF_{25-75,\ \%FEV1}$, and FEV_1/FVC during the harvest season.

Recent studies have shown that $\%FEF_{25-75}$ reduction represents the functional impairment of the peripheral airways, and even when the FEV_1 values are within normal limits, a decrease in $\%FEF_{25-75}$ may detect initial alterations in lung function[11,19].

For nonsmokers, Long-term exposure to PM results in pulmonary retention of fine particles and small airway remodeling[19]. Our results show that even after a short period of exposure some lung function impairment can be detected.

The study by Prado et al.[11] observed a reduction in in sugarcane workers' mean values of FEV_1, FEV_1/FVC, and FEF_{25-75} after the harvest season, despite all the values remaining within reference values. The most affected variable was the $\%FEF_{25-75}$, with reductions of about 31.1%. This decrease indicates the development of an initial obstructive disturbance in healthy subjects exposed to pollution, as observed in other studies[20-22].

One study that assessed agricultural exposure as a risk factor for the development of chronic obstructive pulmonary disease found a decreasing tendency for FEV_1 in parallel to an increase in exposure[23]. The fact that this study design involved only a small number of subjects with evaluations over only two periods of time does not allow any inference that the respiratory effects are progressive and irreversible. This hypothesis should be verified in a cohort study with a larger population and over a longer period of time.

Agarwal et al.[24] also demonstrated a reduction in FEV_1 in a study investigating the pulmonary effects of exposure to air pollution from wheat-residue burning on healthy inhabitants in Punjab, India. These results, along with those by Montaño et al.[25] and Po et al.[26], who showed a relationship between exposure to biomass burning pollution and airway disease, provide the basis for the hypothesis that chronic exposure to this kind of air pollution could be a significant risk factor for the development of chronic respiratory diseases.

A previous study also reported that firefighters who did not use protective respiratory equipment presented a progressive decline in $\%FEV_1$ and FEV_1/FVC[27]. It is important to emphasize that the subjects in this study did not use protective respiratory equipment.

In our study, the STT was shorter during the harvest season. Nasal MC is recognized as the first line of defense in the respiratory system, responsible for removing inhaled airborne particles and microorganisms. The efficiency of MC depends on three major components, among them the ciliary beat frequency (CBF)[28]. Acting as a barrier, the respiratory ciliary epithelium removes mucus from the airways, and regulates innate and adaptive immunity[29].

Inhalation of pollutants and physical exertion result in a greater probability of nasal, pulmonary[9,30] and systemic inflammation[31,32], as well as MC impairment[9,10].

The study by Ferreira-Ceccato et al.[9] evaluated the acute effects of exposure to particulate matter from biomass burning on nasal MC of sugarcane workers. The authors observed a significant decrease in STT, supposing that acute exposure to particulate matter might be associated with increased oxidative stress and production of nitric oxide by inflammatory cells, which would stimulate ciliary beat frequency. This reasoning may also explain our findings.

Riechelmann et al.[33] reported two possible mechanisms underlying the observed acceleration effect on mucociliary transport: an auto regulated increase in ciliary beat frequency in response to increased mucus load and epithelial lining fluid viscosity, and the activation of mucociliary transport as a consequence of mucosal irritation.

Unlike our findings, the study by Goto et al.[10] evaluated 27 sugarcane workers and observed that the harvest season was associated with a reduction of 80% MC, that is, an average prolonged saccharin transit time of 7.83 min (1.88 – 13.78; 95% confidence interval). However, these evaluations were not made in the field and data for both seasons were collected after a 5-day working week.

In short, this study suggests that sugarcane workers present a decrease in FEF_{25-75}, $\%FEF_{25-75}$, FEV_1/FVC ratio, and an increased nasal mucociliary transport velocity at the end of the harvest season. Such results may be further investigated by a prospective cohort design study involving a larger group of workers during a longer follow-up period.

Acknowledgments

To Instituto Nacional de Análise Integrada do Risco Ambiental (INAIRA) for the intellectual support to the development of this study.

Authors' contributions

The authors equally contributed to all steps of the research and to the conception and approval of the final version of the manuscript.

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