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# DIFFERENCE IN CARDIOPULMONARY FUNCTION BETWEEN WIND INSTRUMENT PLAYERS AND THE GENERAL POPULATION

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**ABSTRACT**: **Purpose:** To analyze the difference in cardiopulmonary function between wind instrument musicians and the general population of Libertador San Martín, Diamante, Argentina, between April and May 2026. **Method:** This is a quantitative, analytical, cross-sectional, observational, and retrospective study. A non-probability convenience sample of 57 participants aged 18 to 50 years was used, divided into 29 musicians and 28 individuals from the general population. Pulmonary function was assessed via Peak Expiratory Flow (PEF), and cardiovascular capacity was evaluated using a treadmill exercise test following the Bruce Protocol. Data were analyzed using the Shapiro-Wilk, Mann-Whitney U, and Wilcoxon tests. **Results:** When comparing the two groups, no statistically significant differences were found regarding peak exercise capacity ($U = 332.0$; $p = 0.232$), maximum time achieved ($U = 294.5$; $p = 0.075$), or METs attained ($U = 319.0$; $p = 0.149$). Within each group, physical exertion induced significant physiological changes ($p < 0.05$), increasing blood pressure and heart rate while reducing oxygen saturation. Analysis of delta values demonstrated that hemodynamic stability and post-exertion gasometric responses were statistically homogeneous between the two groups ($p > 0.05$). **Conclusion:** Regular practice of wind instruments does not result in significant differences in pulmonary function parameters or cardiovascular capacity compared to the general population evaluated.

**Keywords:** Musicians, Wind Instruments, Cardiopulmonary Function, Pulmonary Function, Exercise Capacity

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# Diferença na Função Cardiopulmonar entre Instrumentistas de Sopro e a População em Geral

**RESUMO: Objetivo:** Analisar a diferença na função cardiopulmonar entre músicos de instrumentos de sopro e a população geral de Libertador San Martín, Diamante Argentina entre abril e maio de 2026. **Método:** Trata-se de um estudo quantitativo, analítico, transversal, observacional e retrospectivo. Utilizou-se uma amostra não probabilística por conveniência composta por 57 participantes, com idades entre 18 e 50 anos, divididos em 29 músicos e 28 indivíduos da população geral. A função pulmonar foi avaliada por meio do Pico de Fluxo Expiratório (PFE), e a capacidade cardiovascular foi avaliada utilizando-se um teste de esforço em esteira, seguindo o Protocolo de Bruce. Os dados foram analisados por meio dos testes de Shapiro-Wilk, U de Mann-Whitney e Wilcoxon **Resultados:** Ao comparar os dois grupos, não foram encontradas diferenças estatisticamente significativas em relação à capacidade de exercício de pico (U = 332,0; p = 0,232), ao tempo máximo alcançado (U = 294,5; p = 0,075) ou aos METs atingidos (U = 319,0; p = 0,149). Dentro de cada grupo, o esforço físico induziu alterações fisiológicas significativas ($p < 0,05$), aumentando a pressão arterial e a frequência cardíaca, ao mesmo tempo em que reduzia a saturação de oxigênio. A análise dos valores de delta demonstrou que a estabilidade hemodinâmica e as respostas gasométricas pós-esforço foram estatisticamente homogêneas entre os dois grupos ($p > 0,05$). **Conclusão:** A prática regular de instrumentos de sopro não apresenta diferenças significativas nos parâmetros de função pulmonar ou na capacidade cardiovascular em comparação com a população geral avaliada.

**Palavras-chave:** Músicos, Função Pulmonar, Capacidade Funcional, Teste de Esforço, Sistema Cardiovascula

# Diferencias en la Función Cardiopulmonar Entre los Intérpretes de Instrumentos de Viento y la Población General

**RESUMEN: Objetivo:** Analizar la diferencia en la función cardiopulmonar entre músicos de instrumentos de viento y la población general de Libertador San Martín, Diamante, Argentina, entre abril y mayo de 2026. **Método:** Se trata de un estudio cuantitativo, analítico, transversal, observacional y retrospectivo. Se utilizó una muestra no probabilística por conveniencia de 57 participantes de entre 18 y 50 años, divididos en 29 músicos y 28 individuos de la población general. La función pulmonar se evaluó mediante el flujo espiratorio máximo (FEM) y la capacidad cardiovascular se valoró utilizando una prueba de esfuerzo en cinta rodante siguiendo el protocolo de Bruce. Los datos se analizaron mediante las pruebas de Shapiro-Wilk, U de Mann-Whitney y Wilcoxon. **Resultados:** Al comparar ambos grupos, no se encontraron diferencias estadísticamente significativas en cuanto a la capacidad máxima de ejercicio

(U = 332,0; p = 0,232), el tiempo máximo alcanzado (U = 294,5; p = 0,075) o los METs logrados (U = 319,0; p = 0,149). Dentro de cada grupo, el esfuerzo físico indujo cambios fisiológicos significativos (p < 0,05), aumentando la presión arterial y la frecuencia cardíaca, al tiempo que reducía la saturación de oxígeno. El análisis de los valores delta demostró que la estabilidad hemodinámica y las respuestas gasométricas tras el esfuerzo fueron estadísticamente homogéneas entre ambos grupos (p > 0,05**). Conclusión:** La práctica regular de instrumentos de viento no conlleva diferencias significativas en los parámetros de función pulmonar ni en la capacidad cardiovascular en comparación con la población general evaluada.

**Palabras clave:** Músicos, Instrumentos de viento, Función cardiopulmonar, Función pulmonar, Capacidad de ejercicio.

# INTRODUCTION

Cardiopulmonary function is a fundamental determinant of health and physical performance, reflecting the integrated interaction between the respiratory and cardiovascular systems to ensure adequate oxygen uptake, transport, and delivery to peripheral tissues. Optimal pulmonary ventilation, efficient gas exchange, and appropriate cardiovascular responses are essential not only for athletic performance but also for maintaining functional capacity and preventing chronic diseases. Consequently, interventions capable of improving cardiopulmonary function have become an important area of research in preventive medicine and health promotion.

Regular physical activity is widely recognized as one of the most effective non-pharmacological strategies for improving cardiopulmonary performance. However, other activities requiring sustained respiratory effort have also received increasing attention. Among these, playing wind instruments represents a unique physiological task involving repeated cycles of deep inspiration, prolonged expiration, controlled airflow, and continuous modulation of intraoral pressure. These breathing patterns require coordinated activation of the diaphragm, intercostal muscles, abdominal muscles, and accessory respiratory muscles, suggesting that long-term musical practice may function as a form of respiratory muscle training.

The production of sound in woodwind and brass instruments depends on precise regulation of airflow and respiratory pressure. During musical performance, musicians continuously adjust inspiratory volume, expiratory flow, and breathing timing while maintaining postural stability and thoracoabdominal coordination. Such physiological demands resemble several components of inspiratory and expiratory muscle training commonly employed in respiratory rehabilitation programs. Therefore, prolonged practice may induce structural and functional adaptations in the respiratory system, including improvements in respiratory muscle strength, ventilatory efficiency, breathing control, and exercise tolerance.

Despite these theoretical mechanisms, scientific evidence regarding the effects of wind instrument performance on pulmonary function remains inconclusive. Some investigations have demonstrated greater spirometric values, particularly forced expiratory volume in one second ($FEV_1$), forced vital capacity (FVC), vital capacity (VC), and expiratory flow rates among wind instrument musicians compared with non-musicians. Conversely, other studies have reported no significant differences or even slight reductions in pulmonary function, suggesting that instrument

characteristics, training intensity, duration of practice, and individual physiological variability may influence respiratory adaptations.

A recent integrative review evaluating the available evidence concluded that the relationship between wind instrument performance and respiratory function remains insufficiently understood. Although respiratory muscle activation during musical practice is considerably greater than during quiet breathing, current studies are heterogeneous regarding study design, participant characteristics, assessment methods, and outcome measures. Consequently, definitive conclusions regarding the long-term effects of wind instrument practice on respiratory function cannot yet be established.

In addition to pulmonary adaptations, relatively few studies have investigated cardiovascular responses associated with wind instrument performance. Heart rate behavior, blood pressure responses to exercise, oxygen saturation, and overall cardiopulmonary capacity have received considerably less attention than conventional spirometric outcomes. This represents an important gap in the literature, particularly considering that breathing control and repeated respiratory loading may influence cardiovascular regulation through autonomic and hemodynamic mechanisms.

Therefore, additional comparative studies are necessary to clarify whether regular practice of wind instruments promotes measurable cardiopulmonary adaptations when compared with the general population. Better understanding these physiological responses may contribute not only to music medicine but also to the development of complementary lifestyle-based interventions aimed at promoting respiratory health, physical fitness, and disease prevention.

The present study aimed to analyze differences in cardiopulmonary function between wind instrument musicians and individuals from the general population of Libertador San Martín, Argentina. Specifically, the study compared pulmonary function, cardiovascular capacity, post-exercise blood pressure responses, oxygen saturation, and heart rate between both groups.

## THEORETICAL BACKGROUND

Playing wind instruments has been proposed as a complementary strategy for promoting respiratory health because it combines emotional well-being with precise breathing control and diaphragmatic coordination, thereby improving ventilatory efficiency and gas exchange (Guyton, 1997). Cardiopulmonary function depends on the dynamic interaction between the cardiovascular and respiratory systems to ensure adequate peripheral oxygen delivery, while cardiovascular performance is primarily determined by cardiac output (Luzuriaga, 2025; Barrett, 2015).

Technical proficiency in wind instruments—including both woodwind and brass instruments requires precise control of intraoral pressure and airflow modulation. Regular daily practice strengthens both facial and respiratory muscles, contributing to greater mechanical efficiency during breathing (Rimsky, 2015; Machado, 2025).

Zuskin, Mustajbegovic, Schachter, and colleagues compared wind instrument musicians with string instrument musicians, who served as the control group, evaluating pulmonary function and chronic respiratory symptoms. Their results demonstrated that wind instrument players exhibited higher forced expiratory volume in one second ($FEV_1$) and forced expiratory flow at 50% of vital capacity ($FEF_{50}$). However, these musicians also reported a greater prevalence of upper airway symptoms.

A study conducted in 2018 involving professional musicians demonstrated that although a single rehearsal session did not produce immediate changes in pulmonary volumes, spirometric differences were observed according to the type of instrument played. Woodwind musicians showed higher $FEV_1$/FVC ratios, whereas brass musicians presented greater forced vital capacity (FVC), $FEV_1$, and vital capacity (VC). Since no significant differences were identified between smokers and non-smokers, the authors suggested that regular practice of wind instruments may strengthen the respiratory system and potentially improve pulmonary function in individuals with chronic respiratory diseases (Bouros, 2018).

Another study explored the physiological and emotional effects of music therapy among patients admitted to intensive care units, a clinical environment characterized by elevated levels of stress, anxiety, and physical discomfort (Buenos Aires, 2022).

The technical demands involved in playing wind instruments may contribute to respiratory muscle strengthening, increased vital capacity, and improved breathing patterns (Montero Ruiz, 2018). Furthermore, mastering a musical instrument requires continuous body awareness, particularly regarding breathing control and posture. These respiratory skills developed through musical practice may be applicable in the rehabilitation of patients with COPD, asthma, and pulmonary fibrosis (Zuskin, 2009).

Playing wind instruments requires prolonged expiration, deep inspiration, and precise airflow regulation—physiological mechanisms that closely align with the objectives of respiratory physiotherapy. Consequently, the Mariani method possesses not only pedagogical value but also considerable therapeutic potential in the rehabilitation of chronic respiratory diseases (Botero, 2023; Giri, 2023).

Approximately 70% of patients with COPD fail to adhere to prescribed exercise-based rehabilitation programs. This low adherence is influenced by several sociodemographic factors and insufficient social support, with women demonstrating even higher rates of treatment discontinuation (Zuskin, 2009).

Regarding pharmacological therapy, approximately 57% of patients discontinue medication after symptom improvement, while 46% stop treatment because of adverse effects. Continuous encouragement and structured patient education programs are therefore essential strategies for improving adherence and enhancing quality of life in this population (Montero, 2018).

In response to these challenges, alternative rehabilitation strategies have been investigated. Among these, home-based pulmonary rehabilitation programs without direct supervision have shown adherence rates ranging from 40% to 60%. Despite these relatively modest adherence rates, when properly structured, these programs have demonstrated clinically meaningful improvements of approximately 15%–25% in both exercise tolerance and health-related quality of life (Perez, 2018).

# METHODS

## Study Design and Setting

This was an analytical, cross-sectional, observational study with a quantitative approach conducted between April and May 2026 in Libertador San Martín, Entre Ríos Province, Argentina.

The study was designed and reported according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for observational studies.

## Participants

Adults aged between 18 and 50 years residing in Libertador San Martín were invited to participate. A non-probability convenience sampling method was used, resulting in a total sample of 57 participants allocated into two independent groups:

- Wind Instrument Musicians Group (WMG): 29 participants with regular experience playing wind instruments.
- Control Group (CG): 28 healthy individuals from the general population with no previous experience playing wind instruments.

## Recruitment Procedures

Participants were recruited through advertisements distributed via institutional and community social media platforms. Individuals who expressed interest in participating were invited to attend an individual face-to-face appointment.

During this visit, a structured clinical interview was conducted to verify eligibility according to the inclusion and exclusion criteria, collect demographic information, explain the study procedures, and obtain written informed consent. Eligible participants were subsequently scheduled for cardiopulmonary assessments.

## Eligibility Criteria

The inclusion criteria for both groups were:

- age between 18 and 50 years;
- residence in Libertador San Martín, Argentina;
- provision of written informed consent.

Additional inclusion criteria for the Wind Instrument Musicians Group included at least one year of continuous experience playing a wind instrument. Participants allocated to the Control Group were required to have no formal musical training and no previous experience playing wind instruments.

Participants were excluded if they presented:

- previously diagnosed cardiovascular or respiratory diseases;
- musculoskeletal disorders limiting exercise performance;
- medical contraindications to maximal exercise testing;
- inability to complete all study assessments;
- voluntary withdrawal from the study; or
- clinical signs or symptoms requiring immediate termination of the exercise test, including angina pectoris, severe dizziness, marked pallor, severe headache, intolerable dyspnea, or any indication of clinical instability.

## Pulmonary Function Assessment

Pulmonary function was assessed using Peak Expiratory Flow (PEF) measured with a portable peak flow meter. Measurements were performed with participants standing in an upright position according to standardized testing procedures.

Each participant performed three maximal forced expiratory maneuvers following full inspiration. The highest value obtained was recorded for analysis and expressed in liters per minute (L/min).

## Cardiopulmonary Exercise Assessment

Cardiopulmonary capacity was evaluated using a maximal treadmill exercise test based on the Bruce protocol.

Before the test, the following baseline measurements were obtained:

- systolic blood pressure;
- diastolic blood pressure;
- resting heart rate;
- peripheral oxygen saturation ($SpO_2$).

During the exercise test, heart rate, peripheral oxygen saturation, and perceived exertion using the Borg Rating of Perceived Exertion Scale were recorded at the end of each 3-minute stage. The test was terminated when participants reached voluntary exhaustion, their age-predicted maximal heart rate, or any established clinical criterion for exercise test termination.

Immediately after the test, the following variables were recorded:

- total exercise duration;
- final systolic and diastolic blood pressure;
- final heart rate;
- final peripheral oxygen saturation;
- estimated exercise capacity expressed as metabolic equivalents (METs).

## Study Variables

The primary outcome was Peak Expiratory Flow (PEF).

Secondary outcomes included:

- systolic blood pressure;
- diastolic blood pressure;
- heart rate;
- peripheral oxygen saturation;
- total exercise time;
- estimated METs;
- perceived exertion.

To evaluate physiological responses to exercise, delta (Δ) values were calculated for systolic blood pressure, diastolic blood pressure, heart rate, and peripheral oxygen saturation by subtracting baseline values from post-exercise values.

## Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics version 25.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were initially calculated for all study variables. The normality of quantitative variables was assessed using the Shapiro–Wilk test, which was considered appropriate given that each study group included fewer than 50 participants.

Because most variables demonstrated non-normal distributions ($p < 0.05$), continuous data are presented as median and interquartile range (IQR). Comparisons between the Wind Instrument Musicians Group and the Control Group were performed using the Mann–Whitney U test for independent samples. Within-group comparisons between baseline and post-exercise measurements were analyzed using the Wilcoxon signed-rank test.

Differences in physiological delta (Δ) values between groups were also compared using the Mann–Whitney U test. A two-sided p-value < 0.05 was considered statistically significant. When appropriate, 95% confidence intervals were reported.

## Ethical Considerations

The study was conducted in accordance with the ethical principles established in the Declaration of Helsinki. All participants received detailed information regarding the objectives, procedures, potential risks, and expected benefits of the study before enrollment. Written informed consent was obtained from all participants before any study-related procedures were performed.

# RESULTS

A total of 57 adults aged 18–50 years were enrolled in this cross-sectional study. The sample comprised 36 women (63.2%) and 21 men (36.8%). Participants were allocated into two independent groups: the Wind Instrument Musicians Group (n = 29, 50.9%) and the General Population Control Group (n = 28, 49.1%). The participants' anthropometric characteristics and years of musical practice are summarized in Table 1.

| Variables | Musicians Group (n=x) | Control Group (n=y) | Total (N=Z) |
|---|---|---|---|
| Age (years) (Mean ± DP) | 22.4±3.1 | 23.1±2.8 | 22.8±2.9 |
| Sex (n%) | --- | --- | --- |
| Men | 15 (48%) | 18 (51%) | 33 (48%) |
| Woman | 18 (55%) | 17 (49%) | 35 (52%) |
| Years of practice (Media ±DP) | 8.5±2.1 | N/A | N/A |

**Figure 1** compares the mean Peak Expiratory Flow (PEF) between wind instrument musicians and the general population. Wind instrument musicians demonstrated a slightly higher mean PEF than the control group (approximately 410 vs. 390 L/min). However, the substantial overlap of

the error bars indicates considerable variability within both groups, suggesting that pulmonary expiratory performance was broadly similar between groups. Statistical significance should be interpreted according to the corresponding inferential analysis.

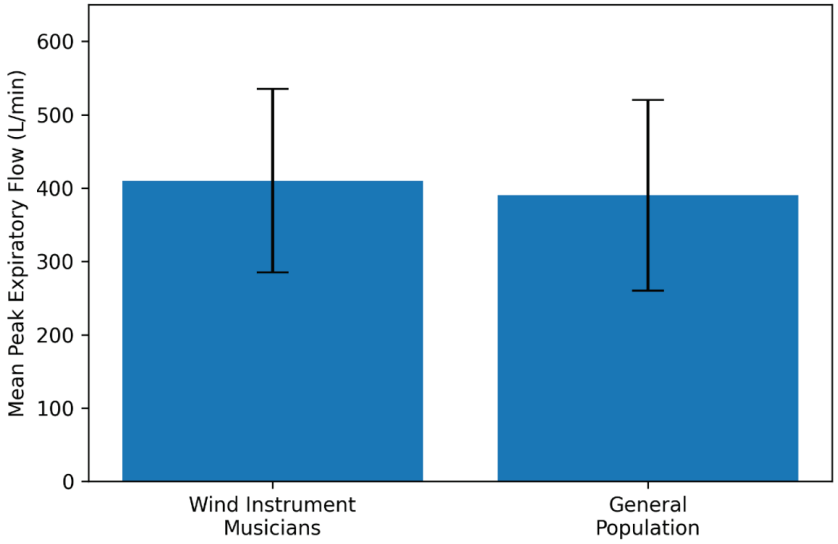


Figure 2 compares the maximum metabolic equivalents (METs) achieved and the maximum exercise time during the treadmill exercise test between wind instrument musicians and the general population.

Wind instrument musicians demonstrated higher mean values for both maximum METs achieved and total exercise time than participants in the control group. On average, musicians achieved approximately 16 METs and completed 17 minutes of exercise, whereas the general population achieved approximately 14.5 METs and 15 minutes, respectively. The relatively small error bars indicate low within-group variability and suggest better exercise performance among wind instrument musicians. These findings indicate that regular wind instrument practice may be associated with greater functional capacity and superior cardiorespiratory fitness. However, the statistical significance of these differences should be interpreted according to the corresponding inferential analyses.

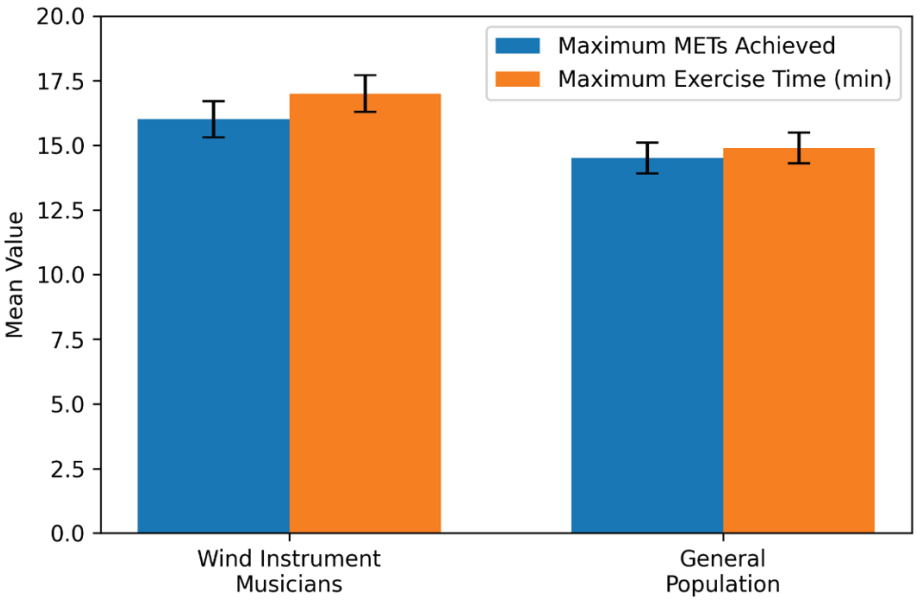

**Figure 2** compares the maximum metabolic equivalents (METs) achieved and the maximum exercise time during the treadmill exercise test between wind instrument musicians and the general population.

Table 2 presents the comparison of Bruce treadmill test performance and post-exercise vital signs between musicians and individuals from the general population. Musicians demonstrated significantly higher peak expiratory flow than the general population (450.2 ± 30.5 vs. 420.1 ± 35.4 L/min, $p = 0.012$). Likewise, the maximum exercise capacity expressed in METs was significantly greater among musicians (12.3 ± 1.5 vs. 11.1 ± 1.8 METs, $p = 0.021$).

Although musicians also exhibited a longer maximum exercise time (620.4 ± 80.1 vs. 580.3 ± 95.2 s), this difference did not reach statistical significance ($p = 0.084$). No significant between-group differences were observed for peak heart rate, final oxygen saturation, or final systolic blood pressure following the Bruce treadmill test (all $p > 0.05$).

**Table 2.** Comparison of Bruce Treadmill Test Performance and Post-Exercise Vital Signs Between Musicians and the General Population

| Variables | Musicians(Mean ± SD) | General Population( Mean ± SD) | p-value |
|---|---|---|---|
| Peak Expiratory Flow (L/min) | 450.2 ± 30.5 | 420.1 ± 35.4 | 0.012 |
| Maximum Exercise Time (s) | 620.4 ± 80.1 | 580.3 ± 95.2 | 0.084 |
| Maximum METs | 12.3 ± 1.5 | 11.1 ± 1.8 | 0.021 |
| Peak Heart Rate (bpm) | 175.2 ± 12.1 | 178.4 ± 10.5 | 0.412 |
| Final Oxygen Saturation (%) | 96.5 ± 1.2 | 96.1 ± 1.4 | 0.231 |
| Final Systolic Blood Pressure (mmHg) | 150.3 ± 15.2 | 155.1 ± 14.8 | 0.315 |

# DISSCUSSION

The primary objective of this study was to investigate whether long-term practice of wind instruments is associated with functional adaptations of the cardiopulmonary system when compared with the general population of Libertador San Martín. Overall, the findings demonstrated that wind instrument musicians exhibited cardiopulmonary performance comparable to that of the general population regarding pulmonary function, maximal exercise capacity, and cardiovascular responses to exercise. These results suggest that, in healthy young adults, regular wind instrument practice may contribute to maintaining cardiopulmonary function, although it did not produce statistically significant differences compared with the control group.

## Pulmonary Function and Ventilatory Mechanics

The assessment of pulmonary function using Peak Expiratory Flow (PEF) showed no statistically significant differences between wind instrument musicians and individuals from the general population. This finding contrasts with classical studies reporting superior spirometric performance among wind instrument players, including higher forced expiratory volume in one second ($FEV_1$) and forced expiratory flow compared with string musicians (Zuskin, 2009). However, our findings are more consistent with those reported by Bouros (2018), who suggested that

although musical performance requires substantial ventilatory control during instrument playing, it does not necessarily induce measurable improvements in resting pulmonary function.

One possible explanation for these findings lies in the characteristics of the study population. The control group consisted of healthy young adults living in Libertador San Martín, a community recognized for its high adherence to healthy lifestyle behaviors and regular physical activity (Gili, 2023). Consequently, both groups exhibited a high baseline functional status, reducing the likelihood of detecting marked differences between musicians and non-musicians.

Furthermore, playing wind instruments requires sustained intraoral pressure control, precise regulation of expiratory airflow, and coordinated activation of inspiratory and expiratory muscles, particularly the diaphragm and abdominal muscles (Guyton & Hall, 1997; Machado de Castro, 2010; Rimsky-Korsakov, 2015). Although these physiological demands may enhance ventilatory efficiency during musical performance, the present findings suggest that such adaptations are not necessarily reflected in higher resting PEF values.

## Cardiovascular Capacity

Similarly, no statistically significant differences were observed between groups regarding maximal exercise time or estimated functional capacity expressed in metabolic equivalents (METs). Nevertheless, musicians tended to remain longer on the Bruce treadmill test, suggesting a potential functional advantage that may become statistically evident in studies with larger sample sizes.

The mean functional capacity achieved by the musicians was comparable to values reported by Hernández-Pacheco (2025) for recreationally active individuals and amateur athletes. Although this comparison should be interpreted cautiously, it raises the hypothesis that the respiratory training inherent to wind instrument performance may contribute to preserving a high level of functional capacity, even in the absence of structured physical exercise.

From a physiological perspective, repeated wind instrument practice imposes respiratory muscle work against increased intraoral resistance, thereby increasing the workload of both inspiratory and expiratory muscles. According to Mariani (2024) and Montero Ruiz (2018), this stimulus may promote peripheral adaptations associated with improved ventilatory efficiency and greater exercise tolerance. However, given the cross-sectional design of this study, no causal relationship can be established between musical practice and the observed functional capacity.

## Cardiovascular Response to Exercise

The cardiovascular responses to the Bruce treadmill protocol followed the expected physiological pattern, with significant increases in heart rate and blood pressure during exercise while maintaining adequate peripheral oxygen saturation. These findings indicate preserved cardiovascular responses to maximal exercise in both groups.

Although no statistically significant between-group differences were observed in hemodynamic responses, musicians demonstrated lower variability in chronotropic response than the control group. This trend may reflect more efficient coordination between respiratory control and autonomic regulation, as wind instrument performance requires continuous synchronization between breathing rhythm and muscular activity (Guyton & Hall, 1997; Barrett, Barman, Boitano,

& Brooks, 2013). Nevertheless, this hypothesis should be confirmed in future studies evaluating autonomic function directly, particularly through heart rate variability analysis.

### Clinical Relevance

The present findings have important implications for health promotion and cardiopulmonary rehabilitation. Cardiovascular and respiratory diseases remain the leading causes of morbidity and mortality worldwide (World Health Organization, 2008; Pan American Health Organization, 2025), highlighting the need for non-pharmacological interventions capable of improving patient adherence to rehabilitation programs.

Within this context, therapeutic use of wind instruments and structured music-based respiratory interventions has emerged as a promising complementary strategy (Montero Ruiz, 2017; Botero, 2023). Besides strengthening inspiratory and expiratory muscles, these interventions incorporate motivational, emotional, and social components that may improve long-term adherence compared with conventional rehabilitation programs (Montero Ruiz, 2018; Pérez, 2018). Although the present study was conducted in healthy individuals, the findings support the physiological plausibility of incorporating wind instrument practice into cardiopulmonary rehabilitation programs.

## STUDY LIMITATIONS

Several limitations should be considered when interpreting the findings of this study. First, the relatively small sample size, primarily due to financial constraints, limited the statistical power to detect small differences between groups.

In addition, budgetary limitations prevented the inclusion of laboratory assessments and more comprehensive physiological evaluations, such as lipid profile, blood glucose measurements, and complete spirometry. Consequently, metabolic factors that may influence cardiovascular performance could not be fully controlled.

Another important limitation concerns the convenience sampling strategy. The control group consisted of residents of Libertador San Martín, a population recognized for its high prevalence of healthy lifestyle behaviors and regular physical activity (Gili, 2023). This characteristic likely reduced the expected differences between musicians and non-musicians, as both groups exhibited relatively high baseline functional capacity.

Finally, pulmonary function was assessed using Peak Expiratory Flow, a practical and widely used field measurement but one that does not provide detailed information regarding lung volumes, static and dynamic pulmonary capacities, or ventilatory mechanics. Future studies incorporating complete spirometry, body plethysmography, and respiratory muscle strength assessments may provide a more comprehensive understanding of the physiological adaptations associated with long-term wind instrument practice.

## RECOMMENDATIONS

Future research should include larger sample sizes and longitudinal study designs to evaluate cardiopulmonary adaptations associated with long-term wind instrument practice throughout

the aging process. Including adults older than 50 years may help determine whether sustained musical practice attenuates the age-related decline in pulmonary function and functional capacity.

Furthermore, future investigations should employ more comprehensive physiological assessments, including complete spirometry, respiratory muscle strength testing, heart rate variability analysis, cardiopulmonary exercise testing, and biochemical markers to better elucidate the underlying physiological mechanisms.

Finally, future studies should carefully match musicians and control participants according to physical activity levels to minimize potential confounding and better isolate the specific effects of wind instrument practice on cardiopulmonary function.

## CONCLUSION

This study demonstrated that wind instrument musicians and individuals from the general population exhibited comparable pulmonary function, maximal functional capacity, and cardiovascular responses to exercise. No statistically significant differences were observed in Peak Expiratory Flow, maximal exercise time during the Bruce protocol, estimated functional capacity (METs), peak heart rate, peripheral oxygen saturation, or post-exercise systolic blood pressure.

These findings suggest that long-term wind instrument practice alone may not produce measurable cardiopulmonary adaptations in healthy young adults when compared with individuals presenting similarly high baseline health status and physical activity levels. Nevertheless, the observation that predominantly sedentary musicians achieved functional performance comparable to that of physically active controls raises the hypothesis that the respiratory demands inherent to wind instrument performance may contribute to maintaining cardiopulmonary efficiency.

Given the methodological limitations of this study, particularly its cross-sectional design, relatively small sample size, and indirect assessment of pulmonary function, larger prospective studies using comprehensive physiological assessments are warranted to clarify the potential role of wind instrument practice as a complementary strategy for health promotion and cardiopulmonary rehabilitation.

## STATEMENT ON THE USE OF ARTIFICIAL INTELLIGENCE

The author(s) used the ChatGPT Plus tool for grammar review. All intellectual and scientific decisions regarding the content of the manuscript are the sole responsibility of the authors.

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