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Pulmonary Function Differences between Trained Padel Players and Physically Inactive Young Adults in Saudi Arabia: A Cross-Sectional Study

Faisal A Barwais [1]

[1]Department of Sport Science, Faculty of Education, Umm Al-Qura University, Makkah, Saudi Arabia

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Abstract

This study aimed to assess and compare pulmonary function parameters between trained padel players and physically inactive young adult males in Saudi Arabia. Forty-eight participants (23 padel players, 25 untrained controls), aged 20.8 ± 1.67 years, underwent spirometry testing using the MIR New Spirolab device following international standards and scholarly exercise physiology frameworks and guidelines. The assessments included static lung volumes, dynamic capacities, and maximal ventilatory performance. The trained padel players demonstrated significantly higher values in inspiratory reserve volume, expiratory reserve volume, inspiratory capacity, vital capacity, forced expiratory volume in one second, peak expiratory flow, and maximal voluntary ventilation compared to the control group ($p <$ 0.001). The study revealed no differences between the groups regarding tidal volume measurements and forced expiratory volume to forced vital capacity ratios. The study results show that regular padel training leads to better pulmonary function, which suggests the sport can enhance respiratory fitness in active people.

Keywords: pulmonary adaptation, respiratory volume, intermittent sport, spirometry testing, exercise physiology.

[1] Department of Sport Science, Faculty of Education, Umm Al-Qura University, Makkah, Saudi Arabia.
Correspondence to: fabarwais@uqu.edu.sa , https://orcid.org/0000-0002-5146-7255

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Introduction

Padel is a contemporary racket sport that unites elements of tennis and squash. It is a doubles sport played on a confined court. The game was developed in Mexico in the late 1960s, but has seen its popularity grow worldwide and experienced rapid expansion in recent decades, mainly in Europe and the Middle East. Padel has become increasingly popular in Saudi Arabia under the framework of Vision 2030, which promotes community sports and well-being. The sport fits into the category of intermittent high-intensity physical activity because it demands quick movements and sustained bursts of acceleration and deceleration, thus it engages both the aerobic and anaerobic energy systems (Escudero-Tena et al., 2024).

Participation in sustained high-intensity or endurance-based sports leads to cardiopulmonary system adaptations that improve athletes' respiratory efficiency and ventilatory performance. The adaptations caused by endurance training resulted in enhanced chest wall flexibility and strengthened respiratory muscles, together with better alveolar ventilation (Hackett, 2020; McArdle, Katch, & Katch, 2015; Vainshelboim, 2016). The respiratory system adapts to increased vital capacity alongside inspiratory reserve volume and expiratory reserve volume while improving dynamic airflow parameters, such as forced vital capacity, forced expiratory volume in one second, and peak expiratory flow (Razzaq et al., 2016; Shadmehri et al., 2021). Previous research has demonstrated that trained athletes, especially those who participate in endurance and intermittent sports, show better pulmonary function test results than people who do not exercise (Marangoz et al., 2016). A study by Yasul et al. (2022) revealed that male sport climbers demonstrated larger inspiratory reserve volume and maximal voluntary ventilation than untrained controls, because climbing activities require frequent ventilatory efforts. Similarly, Ahsan and Ali (2023) found that athletes who played randomly intermittent dynamic sports like futsal had significantly higher physiological measures, including peak inspiratory and expiratory flows, and forced vital capacity, compared to athletes in other sports, indicating that sport-specific ventilatory demands may drive respiratory adaptations. Exercise physiology research supports these findings by showing that training improves pulmonary diffusion capacity while reducing ventilatory effort at submaximal exercise levels (McArdle et al., 2015).

Research on the pulmonary profiles of padel athletes remains extremely rare, despite the extensive knowledge available about athletic respiratory profiles. Currently, literature lacks any study that evaluates both static and dynamic pulmonary function tests of trained padel players compared to inactive individuals. This lack of understanding about the topic requires an investigation to study padel's effects on respiratory health and capacity specifically among youth and recreational athletes.

The present study assessed different pulmonary function indicators between Saudi Arabian padel players who trained regularly and people who stayed physically inactive. The study results enhance our understanding of sports-related respiratory adjustments while serving to develop initiatives for using padel to boost respiratory wellness. The results of this study will have a substantial effect on the development of padel; thus, it is a crucial piece of research.

Methods

Study Design and Participants

This study used a cross-sectional approach to evaluate how trained padel players compare to inactive individuals in terms of pulmonary function. The padel group consisted of people who practice padel at private clubs (at least three times per week) and perform both aerobic and anaerobic exercises that are typical of padel match play. The study included 48 male participants between the ages of 18 and 26, divided into two groups: 23 trained padel players recruited from private clubs in the Western Region of Saudi Arabia, and 25 physically inactive individuals recruited from Umm Al-Qura University, in Makkah. The data collection was conducted at the Exercise Physiology Laboratory in the Department of Sport Sciences, College of Education, at Umm Al-Qura University, between January and March 2025 and took place across nine data-collection sessions.

The trained group consisted of padel players who met four conditions for participation: they had to have been training and competing in padel for at least three years, with an average of 12 training and competitive hours per week; be nonsmokers; have no respiratory or cardiovascular diseases; and have no active respiratory tract infections. The physically inactive participants (untrained controls) underwent the same screening process to rule out smoking, medical conditions, and recent illnesses, and to confirm that they were not connected with any particular sport and did not engage in a regular exercise program. The study received ethical approval from the institution, and all participants received information about the research goals and methods before testing and signed a written consent form.

Anthropometric Assessments

The first data-collection visit included measurements of participants' height in centimeters and weight in kilograms. The digital physician scale (Model: MDW-250L, Adam Equipment, United Kingdom) used in this study followed the International Society for the Advancement of Kinanthropometry (ISAK) protocols for measurements (Esparza-Ros et al., 2019). The calculation of body mass index (BMI) requires weight in kilograms, divided by height in meters squared (kg/m²).

Pulmonary Function Testing

The MIR New Spirolab device (Medical International Research, Italy), a portable turbine-based spirometer for clinical and research purposes, was used to administer pulmonary function tests. This device meets the technical standards of the American

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Thoracic Society (ATS) and European Respiratory Society (ERS) for accuracy and reproducibility (Exarchos et al., 2020; Miller et al., 2005). The tests were conducted according to ATS/ERS guidelines in controlled settings where room temperatures stayed at 22 °C and relative humidity was maintained between 30% and 60%.

The participants completed the spirometry tests while seated, using a disposable mouthpiece and a nasal clip to stop nasal air leakage. They received instructions for maximal respiratory efforts followed by at least three test repetitions. The analysis selected the most reproducible test result, which satisfied the <5% variability margin criterion.

The measured variables led to functional classification-based groupings for reporting purposes according to international standards and scholarly exercise physiology frameworks (McArdle, Katch & Katch, 2015). The nine pulmonary variables were organized as follows:

1. Static Lung Volumes (Volume Parameters): These represent air volumes associated with normal and maximal respiratory movements:

- Tidal Volume (VT): The amount of air that moves in or out of the lungs with each respiratory cycle. Unit: Liters (L)
- Inspiratory Reserve Volume (IRV): The maximum volume of air that can be inhaled after the end of a normal inspiration. Unit: Liters (L)
- Expiratory Reserve Volume (ERV): The volume of gas that can be maximally exhaled from the end-expiratory lung volume during tidal breathing. Unit: Liters (L)
- Inspiratory Capacity (IC): Maximal volume that can be inspired after a normal expiration (VT + IRV). Unit: Liters (L)
- Vital Capacity (VC): Total air exhaled after a maximal inspiration. Unit: Liters (L) (Ponce et al., 2023)

2. Forced Expiratory Parameters (Dynamic Lung Function): These parameters assess the speed of airflow and the degree of airway resistance during maximal forced breathing maneuvers:

- Forced Expiratory Volume in 1 Second (FEV_1): The volume of air forcibly exhaled during the first second of a maximal expiration following full inspiration (reflects the degree of airway obstruction). Unit: Liters (L)
- FEV_1/FVC Ratio (%): The proportion (%) of the total forced vital capacity (FVC) that is exhaled in the first second (used to differentiate between obstructive and restrictive lung diseases). Unit: Percentage (%)

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- Peak Expiratory Flow (PEF): The highest flow rate achieved during a forced expiration starting from full lung inflation (reflects large airway function and effort-dependent).

3. Maximal Ventilatory Capacity: This parameter combines the power of the respiratory muscles with the ventilatory system's ability to sustain effort.

- Maximal Voluntary Ventilation (MVV): The greatest amount of air that can be breathed in and out during one minute through forceful and deep breathing. The test measures air volume for 12 seconds before calculating the one-minute value. The test evaluates total ventilatory capacity, while airway resistance, lung compliance, and neuromuscular effort affect the results. Unit: Liters per minute (L/min)

Statistical Analysis

Statistical analyses were performed using SPSS Version 24.0 (IBM Corp., Armonk, NY, USA) and MedCalc Statistical Software Version 12.218 (MedCalc Software Ltd., Ostend, Belgium). The data distribution was evaluated using multiple approaches, including the Kolmogorov–Smirnov test, visual inspections of histograms and Q–Q plots, and statistical evaluations of skewness and kurtosis.

Variables that were normally distributed were expressed as mean ± standard deviation (SD). Independent samples *t*-tests were applied to assess between-group differences. The threshold of statistical significance was set at $p < 0.05$. Effect sizes were calculated using Cohen's *d* and interpreted as small (0.2), moderate (0.5), or large (0.8), in accordance with Cohen's (1988) guidelines.

A post-hoc power analysis was conducted using G*Power 3.1 (*t*-tests: difference between two independent means, two-tailed), assuming a large effect size (Cohen's $d = 0.80$). Based on the final sample of 23 trained padel players and 25 untrained controls, the analysis yielded an achieved power of 0.81 ($1–\beta = 0.805$) at an alpha level of $\alpha = 0.05$, confirming sufficient sensitivity to detect significant differences in pulmonary function measures between groups.

Results

The research participants' demographic information appears in Table 1. As previously noted, the study involved 48 male participants, 23 trained padel players and 25 physically inactive controls. Participants ranged in age from 18 to 26 years; the average age of the entire study population was 20.8 ± 1.67 years. Participants had an average height of 172.2 ± 2.51 cm, and their mean body weight was 74.0 ± 4.26 kg. The mean BMI across all participants was 24.9 ± 1.48 kg/m².

The groups showed no significant statistical differences in age (p = 0.462), height (p = 0.180), weight (p = 0.610), or BMI (p = 0.843), which confirmed their demographic similarity at the beginning of the study.

Table 1 Participants' Demographic Characteristics (N = 48)

Variables	Overall (N = 48)	Trained padel players (N = 23)	Untrained controls (N = 25)	*t*	*p*-value
Age (years)	20.8 ± 1.67	21.0 ± 1.95	20.6 ± 1.38	0.731	0.462
Height (cm)	172.2 ± 2.51	172.7 ± 3.03	171.7 ± 1.85	1.335	0.180
Weight (kg)	74.0 ± 4.26	74.3 ± 5.20	73.6 ± 3.73	0.507	0.610
BMI ($kg \cdot m^{-2}$)	24.9 ± 1.48	24.9 ± 1.62	25.0 ± 1.38	0.843	0.843

Figure 1 illustrates the differences in VT values between the trained padel players and the untrained controls. Independent samples t-tests were conducted to determine whether there were significant differences in VT testing between the groups. The results showed no significant differences in VT; $t(45.88) = 0.67$; $p = 0.506$, two-tailed; $d = 0.10$; or 95% CI [-0.099, 0.186].

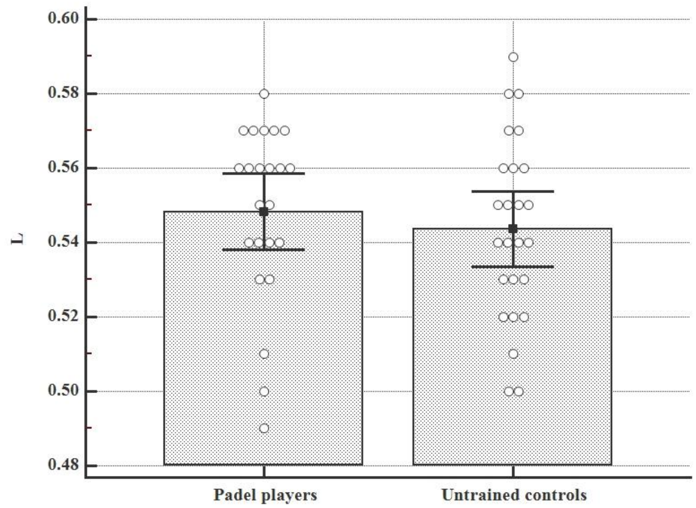

Figure 1. Comparison of tidal volume (VT) between trained padel players and untrained controls.

In contrast to the above, as Figure 2 shows, a significant difference was observed in IRV values between the trained padel players (2.276 ± 0.243 liters) and the untrained controls (1.768 ± 0.242 liters): $t(45.67) = 7.26$; $p < 0.001$, two-tailed; $d = 2.14$; 95% CI [0.367, 0.648].

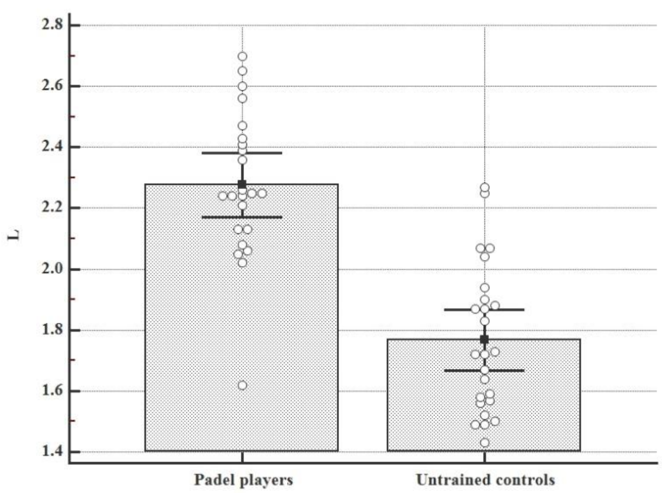

Figure 2. Comparison of reserve volume (IRV) between trained padel players and untrained controls.

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Regarding ERV, as shown in Figure 3, trained padel players (1.770 ± 0.152 liters) displayed significantly higher values than untrained controls (1.222 ± 0.173 liters): $t(45.89) = 11.63$, $p < 0.001$ (two-tailed); $d = 3.42$; 95% CI [0.452, 0.641].

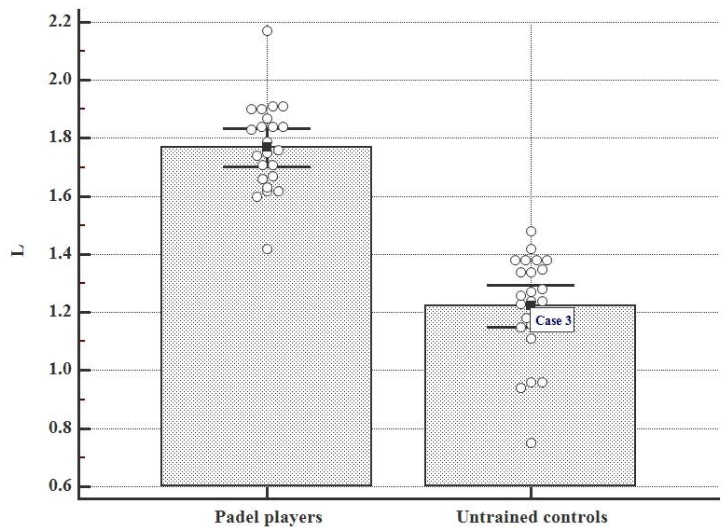

Figure 3. Comparison of expiratory reserve volume (ERV) between trained padel players and untrained controls.

As shown in Figure 4, trained padel players (3.978 ± 0.478 liters) had significantly higher IC values than their untrained counterparts (3.473 ± 0.496 liters): $t(45.01) = 3.59$; $p < 0.001$, two-tailed; $d = 1.06$; 95% CI [0.222, 0.788].

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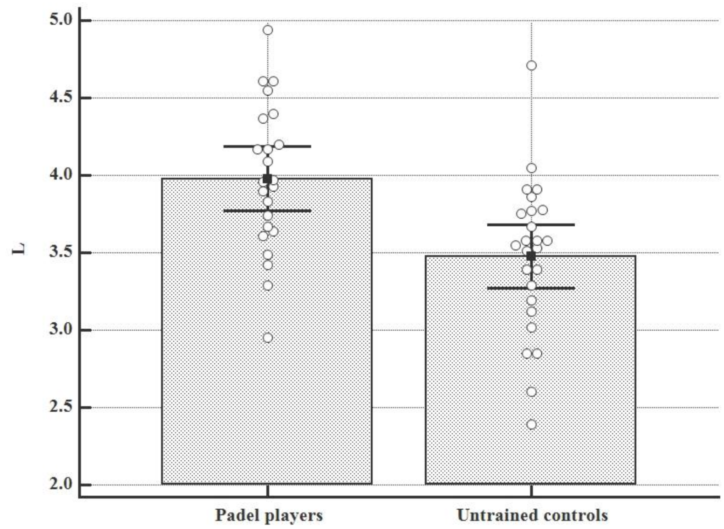

Figure 4. Comparison of inspiratory capacity (IC) between trained padel players and untrained controls.

Figure 5 presents the comparison of VC values between the trained padel players (6.527 ± 0.462 liters) and untrained controls (5.441 ± 0.585 liters). VC values were significantly higher in the trained group: $t(44.99) = 5.38$; $p < 0.001$, two-tailed; $d = 2.09$; 95% CI [0.511, 1.122].

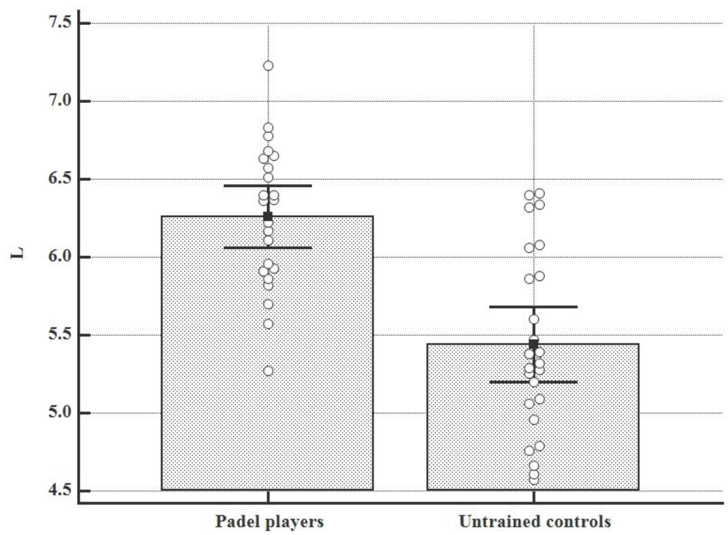

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Figure 5. Comparison of vital capacity (VC) between trained padel players and untrained controls.

Figure 6 shows that trained padel players (4.502 ± 0.189 liters) had significantly higher FEV1 values than untrained controls (4.225 ± 0.260 liters): $t(43.79) = 4.23$; $p < 0.001$, two-tailed; $d = 1.24$; 95% CI [0.145, 0.408].

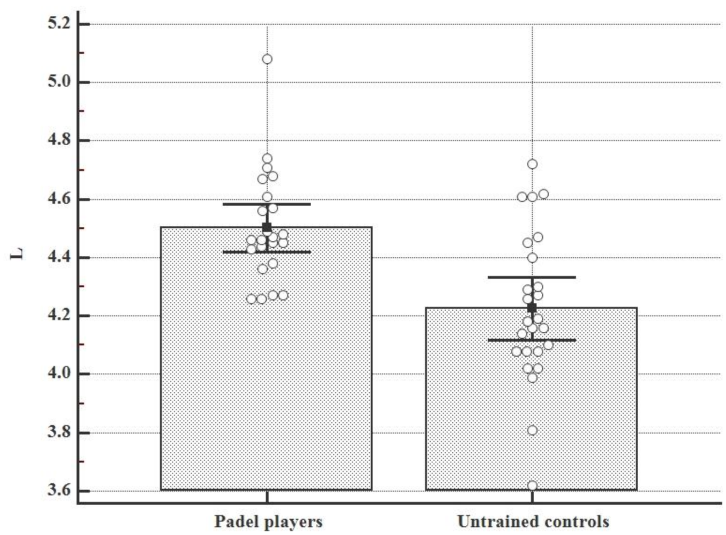

Figure 6. Comparison of forced expiratory volume in 1 second (FEV1) between trained padel players and untrained controls.

Figure 7 illustrates the differences in $FEV_1/FVC\%$ values between trained padel players (81.480 ± 1.645%) and untrained controls (80.548 ± 2.828%). The results showed no significant difference: $t(39.12) = 1.40$; $p = 0.175$, two-tailed; $d = 0.41$; 95% CI [-0.406, 2.270].

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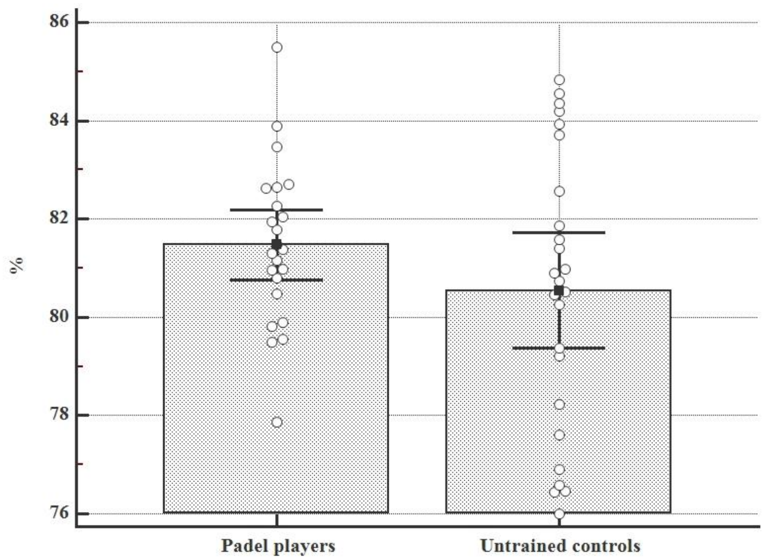

Figure 7. Comparison of total forced vital capacity (FEV_1/FVC%) between trained padel players and untrained controls.

Regarding PEF, as Figure 8 shows, trained padel players (6.144 ± 0.221 L/sec) displayed significantly higher values than untrained controls (5.733 ± 0.296 L/sec): $t(44.21) = 5.46$; $p < 0.001$ (two-tailed); $d = 1.60$; 95% CI [0.259, 0.563].

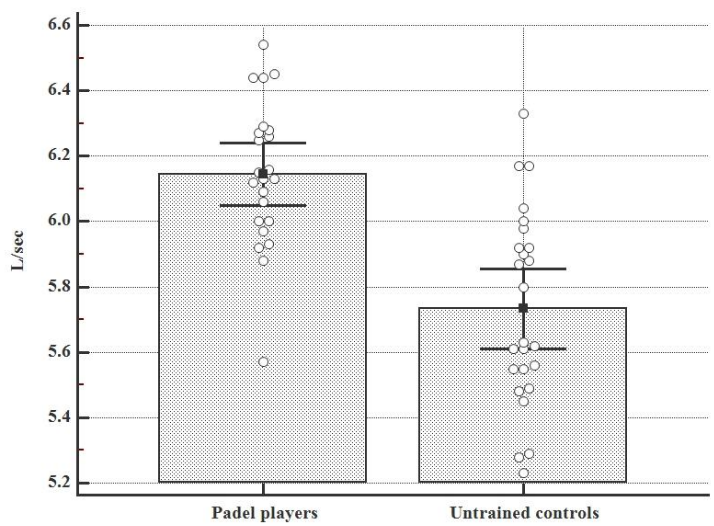

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Figure 8. Comparison of peak expiratory flow (PEF) between trained padel players and untrained controls.

As shown in Figure 9, trained padel players (122.284 ± 4.298 L/min) had significantly higher MVV values than their untrained counterparts (106.678 ± 7.802 L/min): $t(37.94) = 8.67$; $p <$ 0.001, two-tailed; $d = 2.50$; 95% CI [11.962, 19.249].

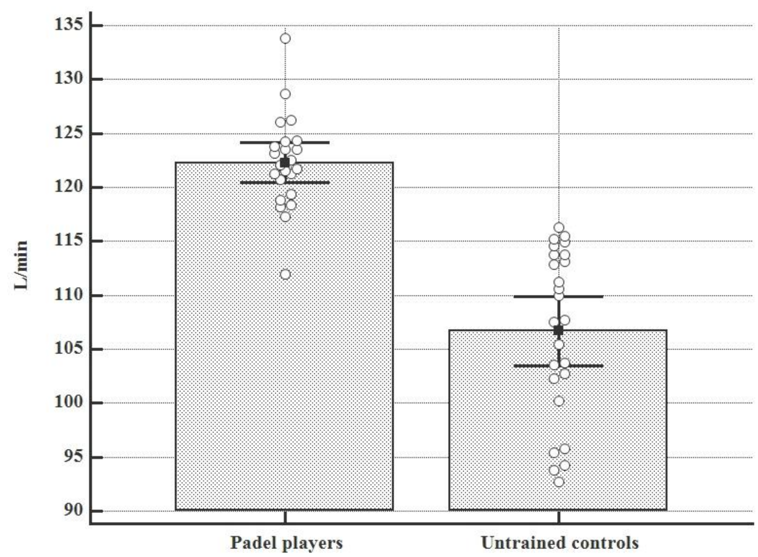

Figure 9. Comparison of maximal voluntary ventilation (MVV) between trained padel players and untrained controls.

Discussion

The research findings demonstrated that trained padel players achieved better pulmonary function results than inactive controls. The measured variables, ERV, IRV, VC, and MVV, showed large effect sizes, with d values of 3.42, 2.14, 2.09, and 2.50, respectively, which indicated significant physiological changes. Previous studies established that intermittent high-intensity efforts similar to padel match play led to better ventilatory efficiency and stronger respiratory muscles (Marangoz et al., 2016).

The trained players showed improved values in MVV, PEF, and FEV_1, compared to the inactive controls, but VT and the FEV_1/FVC ratio remained the same between the groups. The respiratory adaptations in this study were observed in dynamic ventilation parameters, rather than resting capacity, which is supported by the lack of significant group differences in VT and the FEV_1/FVC ratio. Soccer athletes participating in longer-duration high-intensity training demonstrated similar patterns of elevated FVC, FEV_1, and PEF values (Minaeifar, Rasekh, & Karirmi, 2020; Razzaq, Al-Madfai, & Saeed, 2016). A study by Ahsan and Ali (2023) supports this by showing that athletes who play randomly intermittent dynamic sports, such as soccer and rugby, have higher PEF and FVC values compared to athletes in other similar sports (e.g., volleyball and futsal), which demonstrates the respiratory benefits of sport-specific training.

In trained padel players, the VC and IC values increased because of the combined effects of increased alveolar recruitment and better thoracic compliance, which improved expiratory muscle function from the repeated maximal inspiratory and expiratory efforts in padel match play. Bouldering athletes have shown similar sport-specific improvements in lung volumes, according to Yasul, Öner, and Akçınar (2022), because their respiratory demands are both intensive and intermittent. The physiological changes observed match previous research findings, which demonstrate that forced breathing cycles enhance alveolar elasticity and stabilize intrapulmonary pressure dynamics (Delgado & Bajaj, 2021; Lofrese et al., 2021).

The combination of padel's intermittent high-intensity efforts, frequent directional changes, and repeated muscle activations leads to significant cardiorespiratory adaptations in trained players. Padel athletes develop better ventilatory capacity than inactive individuals because of the sport-specific neuromuscular and respiratory conditioning. Previous research demonstrated that playing padel regularly improves oxygen transport while boosting VO_2max and enhancing pulmonary ventilation efficiency, particularly during prolonged rallies and high-intensity phases (Martín-Miguel et al., 2025; Müller & Del Vecchio, 2018).

These physiological benefits match the sports characteristics described in Martín-Miguel et al.'s (2025) work because of the intermittent multidirectional movements and the hybrid aerobic-anaerobic characteristics of padel. Aerobic capacity remains a crucial performance factor in padel, but the observed high MVV values indicate a well-developed ventilatory reserve, which can delay fatigue in prolonged matches or rallies (Müller & Del Vecchio, 2018). The present study's findings enrich the scarce research on pulmonary adaptations in racket sports by demonstrating that padel provides an effective method for enhancing respiratory performance in young adults.

Limitations and Directions for Future Study

This research focused on healthy young adult males, using spirometric measures as its only assessment tool. The parameters used in this study offer essential information about pulmonary function, but they do not show changes in respiratory muscle strength or gas exchange efficiency. Future research should include female participants, as well as participants from different age groups and training backgrounds. Research designs that follow participants over time are also required, to determine how respiratory improvements change with training volume and intensity and whether they persist in the long term.

Conclusions

The research demonstrates that padel training enhances dynamic pulmonary function parameters in healthy young adult males. The research indicates that sport-specific respiratory requirements lead to quantifiable improvements in ventilation. Future research should aim to determine if similar adaptations occur in different populations and over extended training periods while using more extensive assessment tools to measure respiratory muscle strength and gas exchange efficiency changes.

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