Influence of Indoor and Outdoor Sports Training to Cardio-respiratory Parameters of Athletes. A cross-sectional study at the University of Port Harcourt

Abstract

Sports training plays a vital role in enhancing athletic performance and supporting overall health. The study aims to evaluate the **Influence of indoor and outdoor sports training to** cardio-respiratory parameters of athletes.

Methods: This study employed a descriptive cross-sectional design to examine the cardio-respiratory parameters of 75 male and female athletes (aged 17-35) engaged in indoor and outdoor sports at the University of Port Harcourt, Nigeria. Using a semi-structured questionnaire, blood pressure, anthropometric measures, and lung function parameters such as FVC, FEV1, and peak expiratory flow rate were assessed with a digital spirometer. Data were analyzed using IBM SPSS (version 25), with results presented as mean±SD, and statistical significance determined at $p<0.05$ through T-tests and Pearson correlation.

Results: This study of 75 athletes (63.2% male, predominantly aged 18–23) examined the effects of indoor and outdoor sports training on cardio-respiratory parameters. While most participants exhibited normal cardiovascular characteristics, males had higher FVC and FEV1 values than females across both training settings, though both sexes maintained normal FEV1/FVC ratios. Outdoor training slightly improved respiratory outcomes compared to indoor training, with statistically significant differences in FEV1 and FEV1/FVC ratios observed among females but not males. Correlation analysis revealed positive links between indoor FVC, FEV1, and systolic blood pressure in females, suggesting sex-based variations in respiratory responses to training environments.

Conclusion: This study highlights gender-specific differences in respiratory responses to exercise, with males showing higher lung capacity and females demonstrating better peak expiratory flow rates and greater sensitivity to environmental changes.

Introduction

Sports training plays a vital role in enhancing athletic performance and supporting overall health [1]. The setting in which athletes train whether indoors or outdoors significantly shapes their physical and physiological responses [2]. Indoor environments offer consistent and controlled conditions, allowing athletes to train without worrying about the weather [3]. On the other hand, outdoor training provides natural benefits like fresh air, sunlight, and open spaces, which can improve endurance and adaptability. Understanding how these different environments influence lung function, specifically forced vital capacity (FVC) and forced expiratory volume (FEV), is essential for creating effective training programs tailored to athletes' needs [4].

Lung function measures such as FVC and FEV are critical indicators of respiratory health and fitness [5]. For athletes, strong respiratory performance is vital because it ensures efficient oxygen delivery during intense physical activity [6]. Despite their importance, the impact of training settings on lung function is not fully understood, particularly when factors like body mass index (BMI), genotype, blood pressure, and age are taken into account. These variables may influence how athletes benefit or face challenges—from indoor or outdoor training environments [7].

Both training environments come with their own set of challenges. While indoor training provides protection from weather extremes, it can expose athletes to issues like poor ventilation and increased indoor pollutants, potentially harming respiratory health over time [8]. Outdoor training, though offering fresh air, can expose athletes to environmental allergens, air pollution, and fluctuating weather, all of which might negatively impact lung function [9]. This highlights the need to investigate how training environments and individual characteristics together shape respiratory outcomes.

This research is especially timely given the growing emphasis on personalized training programs for athletes. The way individuals respond to training settings varies significantly based on factors such as BMI, which influences lung volume; genotype, which affects vulnerability to respiratory conditions; blood pressure, which is tied to cardiovascular health; and age, which impacts lung elasticity and capacity. Exploring these factors can help create more customized training regimens to optimize performance for athletes of diverse backgrounds.

The findings of this study could have far-reaching implications for sports science, public health, and athletic training. By identifying how different environments affect lung function, we can design better strategies to protect athletes from respiratory risks. Additionally, this knowledge can guide safe and effective training practices in schools, sports academies, and gyms, benefiting both recreational and professional athletes.

In examining the effects of indoor and outdoor training environments alongside key sociodemographic variables on FVC and FEV, this study addresses an important gap in research. It offers the potential to enhance training practices, improve respiratory health, and deepen our understanding of how environmental and individual factors influence athletic performance.

Materials and Method

Study Design

This study adopted a descriptive cross-sectional design to generate data on athlete cardio-respiratory parameters for indoor and outdoor sports. A total of 75 athletes were randomly sampled across two sexes (male and female) and the study uses an age interval of 17-35 years. Age and sex were useful criteria to determine age and sex dependency on the impact of forced vital capacity and forced expiratory volume of the athletes in their outdoor and indoor training. University of Port Harcourt, Nigeria was used as a study frame and athletes were sampled using a simple random sampling technique

Sample Size Determination

Cochran's formula with finite population correction (William G. Cochran 1977), from a population of 75, a sample size of 75was determined for the study.

To calculate the sample size (n) using the given values and the formula you provided

n= {Nz^2pq} {E^2(N-1) + z^2pg}]

Substitute the given values into the formula

- N (population size) = 75

- z (confidence level) = 1.96

- E (margin of error) = 0.03

- p (probability of success) = 0.5

- q (probability of failure) =0.5

Now, plug these values into the equation:

n = {75 \ (1.96)^2 0.5\0.5} {(0.03^2(75-1)) + (1.96^2 \0.5\0.5)}

Now, calculate each part of the equation:

1. Calculate the numerator:

n= {75\3.8416\0.25} 0.0009\79) + (3.8416\0.25)}

2. Calculate the denominator :

n= {76.832} {1.0315}

3. Calculate the terms in the denominator :

n= {76.832} {1.0315}

4. Finally, divide to find n:

n= 74.47 ~~ 75

Selection criteria

Data was collected directly from all the athletes sampled in the study, who were all Nigerian residents of Choba within the age interval of 17-31 years. The study excludes athletes with cardio-respiratory diseases and athletes who were not physically fit.

Method of Data Collection

A semi-descriptive questionnaire was issued following a written consent form. The blood pressure was measured by trained research personnel using a sphygmomanometer and appropriate-size cuffs, weight and height were measured using a seca weighing balance and a stadiometer respectively. A portable Micro Loop digital spirometer (CareFusion UK 232 LTD) was used to evaluate lung capacities such as vital capacity (VC), forced vital capacity (FVC), Inspiratory capacity as well as Functional residual capacity. Lung volumes such as tidal volume, Expiratory reserved volume, Inspiratory reserved volume, forced expiratory volume (FEV1) as well as Peak Expiratory flow rate was also measured automatically by the machine. The participants had been adequately trained for the lung function test. This was accomplished by having the participants breathe three times into the mouthpiece, both violently and gently and the machine automatically computed the lung function parameters and it is printed out with the help of a printer connected to the machine [10].

Method of Data Analysis

The data obtained were analyzed using International Business Machine Statical Package for Social Science (IBM SPSS version 25) and results were presented as mean±SD. T-test and Pearson correlation were used as inferential statistics. A probability less than 0.05 was considered statistically significant ($p<0.05$)

RESULTS

In this study there were 75 participants involved, out of which majority of them were males 48 (63.2%), and most of the participants were aged between 18 and 23 years 44 (57.9%). These are shown in Table.1.

Table 2 shows the Cardiovascular system characteristics of study participants and the findings present that regarding their cardiovascular system characteristics, it was identified that 62.5% of the male cohort presented with normal systolic blood pressure, with mean SBP of 114.75±14.08 mmhg, while 79.2% presented with normal diastolic blood pressure, with mean DBP of 72.90±14.78 mmhg. Also, 81.3% of the male cohort presented with normal mean arterial pressure, with mean MAP of 86.84±13.14, and all of them presented with normal heart rate values, with mean HR of 65.58±3.16 beats per minute. Among the females, it was identified that as much as 82.1% of them presented with normal systolic blood pressure, with mean SBP of 105.07±14.14 mmhg, while 85.7% presented with normal diastolic blood pressure, with mean DBP of 68.29±14.74 mmhg. In addition, 78.6% of the female cohort presented with normal mean arterial pressure, with mean MAP of 80.98±13.39, and all of them presented with normal heart rate values, with mean HR of 64.93±3.11 beats per minute.

This study also identified that most persons in both male and female cohorts had normal BMI (male cohort: 66.7% mean BMI: 24.24±3.82 kg/m2; female cohort: 71.4%, mean BMI: 22.45±2.93 kg/m2). Also, the sickle cell trait was present in 77.1% of the participants in the male cohort and present in 82.1% of the participants in the female cohort. This is shown in Table 3.

Table 4 shows the Respiratory parameters of participants (for outdoor exercise) and the finding present that Regarding the participants' respiratory parameters when involved in outdoor exercise, it was identified that the forced vital capacity (FVC) of participants in the male cohort was 2.35±1.03 and the FVC of participants in the female cohort was 1.98±1.05. The Forced Expiratory Volume 1 (FEV1) of participants in the male cohort was 1.95±0.89 and the FEV1 of participants in the female cohort was 1.90±0.71. Most of the male participants 41 (85.4%) and female participants (27 (96.4%) were found to have normal FEV1/FVC ratios (mean: 0.87±0.20; 1.00±0.18 respectively). In addition, only 47.9% of the male cohort presented with a normal peak expiratory flowrate (PEF), mean PEF: 3.38±2.09; while up to 57.1% of the female cohort presented with normal PEF, mean PEF: 3.56±1.36.

Regarding the participants' respiratory parameters when involved in indoor exercise, it was identified that the forced vital capacity (FVC) of participants in the male cohort was 2.09±0.85 and the FVC of participants in the female cohort was 1.68±1.13. The Forced Expiratory Volume 1 (FEV1) of participants in the male cohort was 1.82±0.78 and the FEV1 of participants in the female cohort was 1.37±0.56. Most of the male 41 (85.4%) and female (24 (85.7%) participants however had normal FEV1/FVC ratios (mean: 0.88±0.18; 0.90±0.19 respectively). In addition, only 35.4% of the male cohort presented with a normal peak expiratory flowrate (PEF), mean PEF: 3.07±1.73; while up to 46.4% of the female cohort presented with normal PEF, mean PEF: 3.15±1.35. These are shown in Table 5.

Assessment of the differences in the mean lung function parameters of male athletes between outdoor and indoor environments revealed that there was no statistically significant difference in the FVC, FEV1, FEV1/FVC ratio, and PEF values between both cohorts (p-value > 0.05). These are shown in Table 6.

Assessment of the differences in mean lung function parameters of female athletes between outdoor and indoor environments revealed that there were statistically significant differences in the FEV1 and FEV1/FVC ratio values between both cohorts (p-value < 0.05). These are shown in Table 7. And Assessment of the correlation between respiratory and physiological parameters of male athletes in this study revealed that no significant correlations existed between the tested parameters as seen in Table 8.

Assessment of the correlation between respiratory and physiological parameters of female athletes in this study revealed that a significant positive and moderate correlation existed between the indoor forced vital capacity and the age of the participants (r: 0.387. p-value: 0.042). Also, significant positive and moderate correlations existed between the indoor forced expiratory volume 1 (FEV1) and the systolic blood pressure of the participants (r: 0.417, p-value: 0.027) as well as the indoor forced vital capacity and the systolic blood pressure of the participants (r: 0.431, p-value: 0.022). These can be seen in Table 9.

Table 1: Sociodemographic details of study participants

Variable	Frequency	Percentage (%)
Sex		
Male	48	63.2
Female	28	36.8
Age (years)		
<18	3	3.9
18-23	44	57.9
24-29	23	30.3
30 and above	6	7.9
Mean±S.D.	23.1±4.2 years	

Table.2: Cardiovascular system characteristics of study participants

Variable	Male		Female	
	Frequency	Percentage (%)	Frequency	Percentage (%)
Systolic Blood pressure (mmhg)				
Normal	30	62.5	23	82.1
High	18	37.5	5	17.9
Mean±S.D.	**114.75±14.08 mmhg**		**105.07±14.14 mmhg**	

Diastolic Blood pressure (mmhg)				
Normal	38	79.2	24	85.7
High	10	20.8	4	14.3
Mean±S.D.	72.90±14.78 mmhg		68.29±14.74 mmhg	
Mean Arterial Pressure				
Normal	39	81.3	22	78.6
High	8	16.7	4	14.3
Low	1	2.1	2	7.1
Mean±S.D.	86.84±13.14		80.98±13.39	
Heart rate (60 beats/min)				
Normal	48	100.0	28	100.0
Low	0	0.0	0	0.0
Mean±S.D.	65.58±3.16		64.93±3.11	

Table 3: Body mass index (BMI) and Genotype of study participants

Variable	Male		Female	
	Frequency	Percentage (%)	Frequency	Percentage (%)

Body Mass Index (kg/m^2)				
Underweight	1	2.1	1	2.1
Normal	32	66.7	20	71.4
Overweight	10	20.8	7	25.0
Obese	5	10.4	0	0.0
Mean±S.D.	24.24±3.82		22.45±2.93	
Genotype				
AA	37	77.1	23	82.1
AS	11	22.9	5	17.9

Table 4: Respiratory parameters of participants (for outdoor exercise)

Variable	Male		Female	
	Frequency	Percentage (%)	Frequency	Percentage (%)
Forced Vital Capacity (FVC)	2.35±1.03		1.98±1.05	
Forced Expiratory Volume 1 (FEV1)	1.95±0.89		1.90±0.71	
FEV1/FVC ratio				

Normal	41	85.4	27	96.4
Below normal	7	14.6	1	3.6
Mean±S.D.	0.87±0.20		1.00±0.18	
Peak Expiratory Flowrate (PEF)				
Normal	23	47.9	16	57.1
Below normal	25	52.1	12	42.9
Mean±S.D.	3.38±2.09		3.56±1.36	

Table 5: Respiratory parameters of participants (for indoor exercise)

Variable	Male		Female	
	Frequency	Percentage (%)	Frequency	Percentage (%)
Forced Vital Capacity (FVC)	2.09±0.85		1.68±1.13	

Forced Expiratory Volume 1 (FEV1)	1.82±0.78		1.37±0.56	
FEV1/FVC ratio				
Normal	41	85.4	24	85.7
Below normal	7	14.6	4	14.3
Mean±S.D.	0.88±0.18		0.90±0.19	
Peak Expiratory Flowrate (PEF)				
Normal	17	35.4	13	46.4
Below normal	31	64.6	15	53.6
Mean±S.D.	3.07±1.73		3.15±1.35	

Table 6: Comparison of the effect of outdoor and indoor training on lung function of male athletes

	Outdoor	Indoor	
	Male Mean ± SD	Male Mean ± SD	t-test (p-value)
Forced Vital Capacity (FVC)	2.35±1.03	2.09±0.86	1.299 (0.213)

Forced Expiratory Volume 1 (FEV1)	1.95±0.89	1.82±0.79	0.732 (0.466)
FEV1/FVC ratio	0.86±0.20	0.88±0.18	-0.452 (0.653)
Peak Expiratory Flowrate (PEF)	3.38±2.09	2.99±1.67	1.002 (0.319)

Table 7: Comparison of the effect of outdoor and indoor training on lung function of female athletes

Variable	Outdoor	Indoor	
	Female Mean ± SD	Female Mean ± SD	t-test (p-value)
Forced Vital Capacity (FVC)	1.96±1.07	1.68±1.13	0.952 (0.346)
Forced Expiratory Volume 1 (FEV1)	1.89±0.72	1.37±0.56	2.949 (0.005)*

FEV1/FVC ratio	1.00±0.19	0.90±0.19	2.012 (0.049)*
Peak Expiratory Flowrate (PEF)	3.49±1.33	3.15±1.35	0.939 (0.352)

Table.8: Correlation between respiratory and physiological parameters of male athletes

Variable	Variable	Correlation factor (r)	p-value
Age (years)	FEV1 (outdoor)	-0.129	0.383
	FVC (outdoor)	0.029	0.844
	FEV1/FVC ratio (outdoor)	-0.184	0.211
	PEF (outdoor)	-0.220	0.133
	FEV1 (indoor)	-0.065	0.659
	FVC (indoor)	0.041	0.780
	FEV1/FVC ratio (indoor)	-0.160	0.276
	PEF (indoor)	-0.066	0.656
Systolic BP	FEV1 (outdoor)	-0.094	0.527
	FVC (outdoor)	-0.191	0.194

FEV1/FVC ratio (outdoor)	0.165	0.264
PEF (outdoor)	-0.085	0.568
FEV1 (indoor)	-0.167	0.257
FVC (indoor)	-0.233	0.111
FEV1/FVC ratio (indoor)	0.024	0.873
PEF (indoor)	-0.203	0.166

Table.9: Correlation between respiratory and blood pressure parameters of female athletes

Variable	Variable	Correlation factor (r)	p-value
Age (years)	FEV1 (outdoor)	0.205	0.295
	FVC (outdoor)	0.207	0.291
	FEV1/FVC ratio (outdoor)	0.126	0.522
	PEF (outdoor)	-0.079	0.689
	FEV1 (indoor)	0.329	0.087
	FVC (indoor)	0.387	0.042*
	FEV1/FVC ratio (indoor)	-0.234	0.231
	PEF (indoor)	0.236	0.227
Systolic BP	FEV1 (outdoor)	0.359	0.061
	FVC (outdoor)	0.337	0.080
	FEV1/FVC ratio (outdoor)	-0.097	0.624
	PEF (outdoor)	0.271	0.163
	FEV1 (indoor)	0.417	0.027*
	FVC (indoor)	0.431	0.022*
	FEV1/FVC ratio (indoor)	-0.355	0.063
	PEF (indoor)	0.168	0.393

Discussion of findings

The findings of this study provide a nuanced understanding of the cardiovascular and respiratory characteristics of young participants, highlighting gender-based differences and the impact of environmental conditions during exercise. Both male and female cohorts demonstrated overall healthy cardiovascular profiles, with males showing a slightly higher prevalence of normal systolic, diastolic, and mean arterial pressures. This observation aligns with the known baseline physiological differences in cardiovascular risks between genders at younger ages. The positive correlations between systolic blood pressure and indoor lung function parameters (FVC and FEV1) in females suggest a potential interplay between cardiovascular fitness and respiratory efficiency under controlled indoor conditions. This finding highlights the need to explore targeted interventions to enhance cardiovascular-respiratory synergy, particularly in female athletes.

The respiratory assessments revealed significant gender-based variations and sensitivity to exercise environments. While male participants showed marginally higher respiratory volumes (FVC and FEV1) during outdoor exercise compared to indoor settings, these differences were not statistically significant. In contrast, females exhibited significant changes in FEV1 and FEV1/FVC ratios between indoor and outdoor conditions, suggesting greater environmental sensitivity. These findings echo insights from Nazaroff et al. [11], who emphasized the influence of ventilation and environmental conditions on indoor air quality and respiratory health. The results imply that optimizing indoor exercise environments, particularly for females, could mitigate adverse impacts such as suboptimal ventilation or higher CO_2 and humidity levels, as previously observed by Mazoteras-Pardo et al. [12].

Comparing this study’s findings with existing literature, the interplay of air quality and exercise outcomes becomes evident. While controlled indoor environments may offer consistent air quality, as highlighted by Salonen et al. [13], outdoor exercise under varying conditions, such as those explored by Ozbay et al. [14], can have distinct metabolic and physiological benefits. For instance, outdoor training in colder environments was associated with improved biomarkers like HDL-C, demonstrating broader systemic advantages beyond respiratory metrics. However, these benefits must be weighed against potential respiratory inefficiencies due to environmental strain, as suggested by O’Connor et al. [15], where outdoor heat and solar radiation increased physiological demands on athletes.

Peak expiratory flowrate (PEF) findings add another layer of complexity, with males showing a lower percentage of normal PEF during both indoor and outdoor exercises compared to females. This difference may reflect variations in airway mechanics or the acute respiratory response to exercise intensity. The interplay of environmental stressors, airway resistance, and respiratory efficiency underscores the need for tailored exercise regimens and further investigation into individual variability.

The study emphasizes the critical role of environmental factors and physiological differences in shaping exercise outcomes. By aligning with prior research, it reinforces the importance of optimizing air quality, tailoring training environments, and understanding gender-specific responses to exercise. Future research should integrate air quality metrics, environmental exposures, and longitudinal assessments to develop comprehensive guidelines for indoor and outdoor training, ultimately improving exercise safety and effectiveness for diverse populations."

Conclusion

This study sheds light on the unique cardiovascular and respiratory differences between young males and females and how exercise environments affect their performance. Both groups showed healthy cardiovascular profiles and normal BMI, with males generally having higher lung capacity (FVC and FEV1) and females achieving better peak expiratory flow rates (PEF). females, however, were more sensitive to environmental changes, with noticeable differences in their lung function (FEV1 and FEV1/FVC ratios) between indoor and outdoor exercise settings. Interestingly, a connection between indoor lung function and blood pressure in women hints at a close link between the heart and lungs under controlled conditions. These findings highlight the importance of creating tailored training programs and optimizing exercise environments to meet the specific needs of both men and women.

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