RESEARCH ARTICLE

Resting lung function capacity in elite Manipuri distance runners

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ABSTRACT

Background: Regular endurance training results in physiological adaptations that improve lung function. This study investigates the resting lung function capacity of elite Manipuri distance runners to evaluate their pulmonary efficiency. *Methods*: An observational study involved 12 elite Manipuri distance runners (six males and six females). Resting spirometry measurements included forced vital capacity (FVC), Forced Expiratory Volume in one second (FEV_1), Tiffeneau-Pinelli Index (FEV_1/FVC), peak inspiratory flow rate (PIFR), and peak expiratory flow rate (PEFR). *Results*: Male athletes exhibited significantly higher values of FVC, FEV_1, PIFR, and PEFR than their female counterparts ($p < 0.01$). However, the FEV1/FVC ratio did not show a significant difference between the males and females. Comparisons with predicted values indicated no significant deviations, except for FEV_1/FVC, which was noticeably higher than expected ($p < 0.01$). *Conclusion*: The spirometry values of elite Manipuri runners align with predicted norms, except for a higher-than-expected FEV_1/FVC ratio, indicating superior airway efficiency.

Keywords: Forced vital capacity, Tiffeneau-Pinelli index, Peak inspiratory flow rate, Spirometry, Peak expiratory flow rate.

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INTRODUCTION

Endurance training is known to induce significant physiological adaptations in the cardiorespiratory system, particularly in lung function. Regular aerobic exercise enhances pulmonary ventilation efficiency, gas exchange, and respiratory muscle endurance, all of which contribute to improved athletic performance.[1] Long-distance runners who undergo sustained aerobic training often exhibit optimized pulmonary function, including higher forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), and peak expiratory flow rate (PEFR).[2] However, variations in lung function exist based on factors such as genetics, training intensity, altitude, and ethnicity.[3]

The assessment of lung function through spirometry provides crucial insights into an athlete's respiratory efficiency. Peak expiratory flow rate (PEFR) was first introduced as an index of ventilatory function by Hadorn in 1942 and has since been widely used in pulmonary function testing.[4] Previous studies have established that elite athletes, particularly endurance runners and military personnel, tend to exhibit higher spirometry parameter values compared to non-athletes.[5,6] This is attributed to stronger respiratory muscles, greater lung compliance, and enhanced oxygen uptake capacity.[7] However, lung function values can differ significantly among populations with varying environmental exposures and genetic backgrounds.[8]

Manipuri athletes represent a unique group of endurance runners who train in a low-altitude environment and compete at national and international levels. Despite their prominence in distance running, there is a limited amount of research on their baseline lung function. A study on Kashmiri athletes[9] and Himalayan Sherpas[10] found that high-altitude training is associated with larger lung volumes and higher PEFR values due to chronic hypoxic exposure. In contrast, studies on North and South Indian athletes[11,12] suggest that sea-level populations may exhibit lower lung volumes due to environmental differences.

Given these variations, this study aims to assess the resting pulmonary function of elite Manipuri distance runners and compare their spirometry values with predicted norms and previously studied populations. Understanding their lung function characteristics could provide valuable insights into respiratory adaptations in endurance athletes from low-altitude regions.

METHODS

Study Design

This observational study examined the resting pulmonary function of elite Manipuri long-distance runners (≥3 km). The participant's demographic and athletics achievements are shown in Table 1. Twelve elite Manipuri distance runners (six males and six females) were recruited for the study. All participants had a history of competitive running at the state or national level. Ethical approval for the study was granted by the Institutional Human Ethics Committee, Manipur (IHECM)

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Table 1: Participants' demographic details and their athletic achievements (N=12)

Subject	*TA**	*Personal Best$*	*Notable Achievements*
Female 1 (29 Years)	~10	00:18:44 (Half Marathon)	8× Manipur Mega Marathon Champion; State Record Holder; Top 25 in Delhi Half Marathon
Female 2 (18 Years)	~4	00:45:48 (10K)	Best time in 10K Cherrapunji (2015); 3rd in Manipur Mega Marathon (2014)
Female 3 (19 Years)	~5	01:27:14 (Half Marathon)	2nd in Hornbill Marathon (2013); National Games participant
Female 4 (20 Years)	~4	01:42:16 (Half Marathon)	5th in Manipur Mega Marathon (2016); National Race Walking representative
Female 5 (27 Years)	~8	01:43:24 (Half Marathon)	National-level athlete; 7th in Manipur Mega Marathon (2016)
Female 6 (17 Years)	~3	00:20:58 (5K)	1st in 5K State Age Group (2014); 4th in Manipur Mega Marathon (2016)
Male 1 (33 Years)	~12	01:08:11 (Half Marathon)	1st in Manipur Mega Marathon; National Games & NE Games medalist; Nationals Police Games participant
Male 2 (32 Years)	~10	00:45:09 (Cross Country)	NE Games medalist; All India Police Cross Country representative
Male 3 (19 Years)	~4	01:18:02 (Half Marathon)	10th in Manipur Mega Marathon (2016); National Games participant
Male 4 (21 Years)	~5	00:09:18 (3K)	1st in 3K, & State Age Group Championship (2014)
Male 5 (20 Years)	~5	00:33:29 (10K Road)	1st in 10K NE Games; National Games & BSF team representative
Male 6 (19 Years)	~4	00:16:19 (5K)	1st in 5K NE Games; 2nd in 3K Steeplechase,& State Championship (2014)

*TA = Training age (years) is estimated based on competitive history and athlete profile. $ Time indicated as (hr:min:sec)

at Manipur University. Prior to data collection, written and signed informed consent with a witness was obtained from all participants, including formal consent from the Athletic Association, the athletes, and their respective coaches, in accordance with the ethical guidelines laid out by the Clinical Trials Registry of India (CTRI). The study is registered with the CTRI under the registration number CTRI/2014/07/004745.

Sample Size Justification

Given the specialized population of elite Manipuri distance runners, the sample size was constrained by the availability of high-level athletes. While small, the sample is representative of this niche athletic group.

Spirometry Protocol: A PC-based spirometer (RMS Helios 401, India) was used to assess lung function. Participants were seated upright, and spirometry was performed three times after a demonstration and trial attempt (Figure 1). The highest of the three values was recorded for analysis. The spirometer was sterilized between uses with a 10% potassium permanganate solution.

Statistical Analysis

Due to the small sample size (n = 12), the Mann-Whitney U test was used to compare male and female groups. Pearson correlation analysis was used to assess the relationships between spirometry parameters. A significance level of $p < 0.05$ was applied.

Figure 1: Athlete performing Spirometry test

RESULTS

Resting spirometry parameter data were collected from 12 participants (6 males, 6 females). Male runners had significantly higher FVC compared to female runners ($p < 0.05$). Male runners had significantly higher FEV_1($p < 0.01$), PEFR ($p < 0.01$), and PIFR ($p < 0.01$). However, the FEV_1/FVC ratio did not differ significantly between genders ($p > 0.05$), as shown in Table 2.

The predicted and actual spirometric values were comparable, except for FEV1/FVC, which was significantly higher than predicted ($p < 0.01$), indicating enhanced airway efficiency in these athletes, as shown in Table 3.

DISCUSSION

The results of this study indicate that elite Manipuri distance runners exhibit lung function parameters that are comparable primarily to predicted values, except for an elevated FEV_1/FVC ratio. This finding suggests a potential adaptation to endurance training, which may enhance airway efficiency and respiratory control. The present study also revealed significant gender differences, with male runners displaying higher FVC, FEV_1, PEFR, and PIFR than female runners. These differences align with existing research, which indicates that males typically have greater lung volumes and expiratory flow rates due to physiological factors such as a larger thoracic cavity size, greater muscle strength, and higher airway diameters.[5]

The FVC values reported in this study (3.3 L in males, 2.4 L in females) are lower than those observed in elite South Asian athletes (4.7 L in males, 3.4 L in females).[10] Similarly, Kashmiri endurance athletes[9] exhibited higher FVC values (4.42 L in males, 3.12 L in females). This discrepancy may be attributed to differences in altitude, genetics, and adaptations in lung capacities. Kashmiri and Himalayan populations are accustomed to higher altitudes, which necessitate greater lung volumes to compensate for reduced oxygen availability. In contrast, Manipuri athletes train at lower altitudes, which may limit their lung expansion capacity over time.

The PEFR values observed in this study (8.5 L/s in males, 5.2 L/s in females) are similar to those reported in Kashmiri athletes (8.2 L/s in males, 5.4 L/s in females).[9] However, elite Turkish endurance athletes[13] demonstrated higher PEFR values (8.42 L/s), which may be attributed to differences in training regimens and respiratory muscle strength. Furthermore, elite South Asian athletes have been reported to exhibit PEFR values as high as 9.8 L/s,[14] as shown in Table 4.

These suggest that training at high intensity for extended periods can further enhance peak expiratory flow. These results suggest that elite Manipuri distance runners exhibit lung function characteristics similar to those of other trained endurance athletes, with gender-based differences aligning with established physiological norms.

One of the most significant findings in this study was the higher-than-predicted FEV_1/FVC ratio, which suggests efficient airway function in these endurance-trained athletes. Similar results were observed in a study on Ethiopian distance runners, where FEV1/FVC values exceeded 95% due to the effects of endurance training.[15] Research suggests that sustained aerobic training improves airway patency and reduces airway resistance, resulting in enhanced air exchange efficiency.[2]

Furthermore, the FEV_1/FVC ratio of Manipuri runners (95.8%) aligns with values reported in North Indian (94.9%)[11] and South Indian athletes (96.7%).[12] These results suggest that elite Manipuri distance runners exhibit lung function characteristics similar to those of other trained endurance athletes, with sex-based differences aligning with established physiological norms.

The relatively small variation indicates that regional differences do not significantly impact airway efficiency in trained endurance runners. This reinforces the hypothesis that endurance training leads to adaptive changes in respiratory mechanics, including enhanced expiratory muscle function and increased elastic recoil of the lungs.[6]

It is also important to consider altitude and ethnic differences when interpreting spirometric values. Studies on Caucasian and Ethiopian athletes[15] have shown that altitude-adapted populations tend to have higher FVC and PEFR values, which supports the hypothesis that high-altitude exposure stimulates greater lung development.[8] Similarly, a very old study[17] reported that Caucasian endurance athletes exhibited FVC values above 4.4 L, significantly higher than those observed in Manipuri athletes. The relatively lower

Table 2: Resting pulmonary function of the runners.

Spirometry parameters	*Male Participants (n = 6)*		*Female Participants (n = 6)*	
	Mean ± SD	*95% CI*	*Mean ± SD*	*95% CI*
FVC (L)	3.3 ± 0.5	2.78 – 3.82	2.4 ± 0.3*	2.09 – 2.71
FEV_1 (L)	3.1 ± 0.3	2.79 – 3.41	2.3 ± 0.3*	1.99 – 2.61
FEV_1/FVC (%)	94.9 ± 5.7	88.92 – 100.88	96.7 ± 2.8	93.76 – 99.64
PEFR (L/s)	8.5 ± 0.9	7.56 – 9.44	5.2 ± 0.5*	4.68 – 5.72
PIFR (L/s)	6.2 ± 1.1	5.05 – 7.35	3.7 ± 1.1*	2.55 – 4.85

FVC =Forced vital capacity, FEV_1 =Forced expiratory volume in first second, PEFR = Peak expiratory flow, PIFR =Peak Inspiratory flow, FEV_1/FVC =Forced expiratory volume in the first second as a portion of forced vital capacity, *$p < 0.05$

Table 3: Comparison of the predicted means and actual means of spirometry parameters

Spirometry variables	*PredictedMean*	*ActualMean*	*Difference$*	*SD*	*t*	*df*	*p*
FVC	2.88	2.85	0.03	0.4	0.2	11	0.825
FEV_1	2.46	2.72	-0.3	0.4	-2.1	11	0.057
FEV_1/FVC	85.26	95.82	-10.6	5.9	-6.3	11	0.000*
PEFR	7.24	6.87	0.4	1.3	1.0	11	0.344

$ Indicates predicted means – actual means. N = 12. * = Statistically significant.

Table 4: Cumulative statement of available spirometry parameters of male and female participants.

	Male participants			*Female participants*	
	FVC (L)	*FEV_1 (L)*	*PEFR (L/sec)*	*FVC (L)*	*FEV_1 (L)*
Turkish Athletes[13]	5.53	4.55	8.42		
Ethiopian Runners[15]	3.80	3.30	-		
Caucasian Distance Runners[15]	5.10	4.30	-		
Kashmiri Healthy Adults[9]	4.42	4.00	-	3.12	2.76
Himalayan Region Sherpas[10]	4.70	3.88	-		
North Indian Healthy Adults[16]	-	-	8.95		
Elite South Asian Athletes[14]	-	-	9.80		
North India Healthy Adluts[4]	3.95	-	-	2.78	-
West India Healthy Adults[6]	3.54	2.80	-	2.61	2.02
South India Healthy Adults[12]	3.34	2.84	-	2.34	1.89
South India Children (7-19 yrs)[11]	3.37	2.92	-	2.54	2.13
Caucasian High Altitude region[8]	4.44	3.67	-		
Caucasian Endurance Runners[17]	4.29	-	-	3.16	-
Manipuri Elite Runners	2.85	2.72	8.5	2.4	2.3

FVC values in this study may reflect genetic predisposition or differences in training environment rather than a lack of pulmonary efficiency.

The obtained values of spirometry parameters of elite Manipuri distance runners align with predicted norms, except for an elevated FEV_1/FVC ratio, which suggests superior airway efficiency. Their high FEV_1/FVC ratio and PEFR values indicate well-adapted respiratory function, which is critical for oxygen exchange and prolonged aerobic activity. However, the lower FVC values suggest that additional training strategies, such as inspiratory muscle training or altitude exposure, could further enhance lung capacity in these athletes. Future studies with larger sample sizes and high-altitude exposure are recommended to further explore the physiological adaptations in this athletic population.

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PEER-REVIEWED CERTIFICATION

During the review of this manuscript, a double-blind peer-review policy has been followed. The author(s) of this manuscript received review comments from a minimum of two peer-reviewers. Author(s) submitted revised manuscript as per the comments of the assigned reviewers. On the basis of revision(s) done by the author(s) and compliance to the Reviewers' comments on the manuscript, Editor(s) has approved the revised manuscript for final publication.