



Cardiovascular Original Article

Comparative Study of Physiological Indicators of Cardiovascular Fitness such as Heart Rate Variability, Harvard Step Test, Ankle-brachial Index, and Body mass Index in Rural and Urban Adolescent Girls

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ABSTRACT

Objectives: Health is defined as a state of complete physical, mental, and social well-being.

Materials and Methods: Humans have settled in both urban and rural areas, which might have influenced people and their physiology in different ways.

Results: Cardiovascular fitness as a marker of proper functioning of the whole body is associated with many health-related outcomes, with poor fitness leading to development of cardiovascular diseases (CVD).

Conclusion: This study aimed to perform a comparative study of the physiological parameters' indicative of cardiovascular fitness in urban and rural adolescent girls.

Keywords: Ankle-brachial index, Cardiovascular fitness, Heart rate variability, Heart rate variability, Rural, Urban

INTRODUCTION

The human populations have settled in various geographical locations from the beginning of time. There has been a broad division of these locales into urban and rural areas. Urban areas are identified with higher population per unit area, greater activity, and commerce. Rural areas are synonymous with a quieter life, agriculture, etc. Such differences have been proposed to have played a role in changing some of the physiological parameters too in the urban and rural populations. The present study intends to determine whether any significant difference exists between the values of these parameters among the two groups.

The World Health Organization defines health as a state of complete physical, mental, and social well-being.^[1] The harmonious balance of this state of the human individual integrated into his/her environment constitutes health. Health is a dynamic phenomenon that fluctuates frequently and subtly, ranging from optimum well-being to various levels of dysfunction, including death. The factors which influence health lie within the individual and the community they live in (socioeconomic factors), interaction of these factors may be health promoting or deleterious.

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Ability and capacity to perform daily routine activities and tasks enthusiastically and effectively are named as physical fitness of a person.^[2] Fitness is an important factor which improves the cardiovascular health. Cardiovascular fitness (CVF), as a marker of proper functioning of the whole body, is associated with many health-related outcomes.^[3] CVF is known to be associated with body fat,^[4,5] arterial compliance,^[4,6] and balance in autonomic functions, which when altered beyond physiological range(s) would eventually lead to development of cardiovascular diseases (CVD). Poor fitness is thus a risk factor for developing CVD which are usually manifested at an advanced stage of pathology. As cardiac diseases are the root cause of many deaths globally, early identification and intervention will prevent progression of diseases and development of complications. Cardiovascular system (CVS) complications are more common in females. At present, females of younger age group are also being affected due to sedentary lifestyle, low socioeconomic status, unawareness, etc. Adolescence is a critical time for the preservation or loss of cardiovascular health.^[7] Moreover, CVF seems to prevent premature mortality which supports the concept that CVF may exert a protective effect on the cardiovascular system from an early age.^[4,8] Usually, knowledge, attitude, and practices (KAP), which depend on various social, cultural, and economic factors, play a significant role in cardiovascular health. Hence, this study intended to know any the differences in the CVF tests in the rural and urban population, which if present can indicate presence of risk factors. In such a scenario, appropriate primordial prevention measures can be applied to preserve health.

REVIEW OF LITERATURE

Most studies focus on the adult health and diseases. Comparatively, fewer studies have been done on adolescents.

In a study done by Ghosh, it was seen that although prevalence of obesity may not be restricted to either urban or rural population/areas, but higher numbers were seen in urban areas/urban populations.^[9]

In a study done by Rose-Clarke *et al.* on adolescent girls in rural Eastern India, it was observed that thinness was prevalent in 14% of younger girls and 6% of older girls (2SD median BMI for age and sex). Girls were stunted in 45% of cases (2SD median height for age and sex).^[10]

According to the Contreras *et al.*,^[11] rural low-income preschoolers in the Midwest USA had higher BMI and engaged in more obesity-promoting eating habits, notably emotional overeating, as compared to urban preschoolers. They also did more physical activity than urban toddlers.

Choudhary *et al.* have observed in their study that the majority of the underweight girls in their study belonged to the rural region, although overall BMI was higher for the rural group compared to the urban group.^[12]

Maiti *et al.* made the same observation in their study with the lower BMI being observed for the rural population, compared to the urban population.^[13]

Tummala *et al.* have proposed that ankle brachial index (ABI) is one of the easier and better indicators to assess the presence of peripheral arterial disease, especially in the rural areas which may have lack of more sophisticated radiological equipment.^[14]

de Oliveira Alvim *et al.* in their study have found lower prevalence of peripheral arterial disease in the rural populations, although its incidence increases with age.^[15]

It has been recommended by some authors that post-exercise ABI is a better indicator of CVF, but Gouveri *et al.* disagree with this. According to them, post-exercise ABI does not increase sensitivity for the detection of PAD.^[16]

A study done on Chinese adolescents, aged 12–18 years, from 1991 to 2011 by Zhang, revealed that CVD risk biomarkers increased in Chinese adolescents. Urbanization was not so favorable for girls as for boys, especially for BMI.^[17]

According to a study done by McCarthy *et al.*, rural girls showed a higher BMI, than urban girls. The study concluded that rural living was linked to a higher incidence of CVD in Chinese children.^[18]

As per Zhao *et al.*, BMI is one of the indicators of obesity, which can predict cardiovascular risk in adolescents.^[19]

According to Gutin, physical activity does contribute to the future cardiovascular health and this could be through modulation of autonomic activity on the heart.^[10] This study also showed a favorable association between better heart rate variability (HRV) profiles and greater CVF in adolescents.^[20]

A study was done by Farah *et al.* indicate that the lower HRV shows association with clustering of cardiovascular risk factors in adolescent boys.^[21]

A study conducted by Tripathy *et al.* showed no significant urban/rural differences in dietary habits, physical activity, and obesity, although rural females were involved in strenuous activity than urban females.^[22]

Jacobs *et al.*^[23] report that rural dwellers have a greater frequency of significant health issues such as raised blood pressure and diabetes and are more likely to indulge in risky behaviors such as drug usage and drinking. According to their study, rural setting is not so conducive for adolescent health because of the lower income and education levels and increased frequency of chronic diseases observed in the rural population.

Aim of the study

The aim of the study was to perform a comparative study of the physiological parameters indicative of CVF in urban and rural adolescent girls

Objectives of the study

The objectives of the study are as follows:

1. To perform CVF indicator tests in the rural and urban adolescent girls.
2. To compare the results in the age matched rural and urban girls, both belonging to non-medical background.

MATERIALS AND METHODS

This study was approved by the Institutional Ethics Committee, ESIC Medical College, Sanathnagar, Hyderabad, Telangana. Before the start of the trial, all the details and procedure of the study were explained to all participants in their native language.

Adolescents between the age 12 and 19 years were invited to participate in the study. All participants gave their informed consent. Because we are primarily concerned with adolescent females, parental or guardian consent was also obtained. The consent forms were explained in their local language.

Rural areas were identified as per the standard norms of population density, facilities etc. around the city of Hyderabad. As part of health camps or routine visits by the Community Medicine department, rural areas were visited and adolescent girls were educated about the need of the study and eventually recruited in to the study using simple random sampling method. Healthy adolescent relatives of the patients who visit the hospital regularly and who stay in a rural area were also followed up and recruited in to the study as part of the rural group.

The urban group was selected from the areas of the city of Hyderabad from relatives of patients who visit ESIC Hospital or from acquaintances who are not relatives/friends of the investigators.

A questionnaire was designed to know the level of KAP of the subjects. Internal validation of the questionnaire was done with a Cronbach's alpha score of 0.7.

Questions were categorized as those which tested their knowledge about health and risk factors for development of disease, their attitude toward them and the day-to-day practices observed by the subjects. In the questionnaire, eight questions were related to knowledge, five on attitude, and 12 questions on practices followed by them. Additional questions were present to get more information about a particular practice, if it was done or practiced by the respondent. Scoring was done for the questions ranging from 5 to 1, with 5 being the best response and 1 being the least response.

For the sake of simplicity and ease of calculation, negative questions were not framed; rather the questions were framed in such a way that the better response was always 5, be it placed in any order in the multiple-choice options. We designed the

questions such that a higher total score indicated better KAP by the subject. This was helpful not only in our calculations, but also removed the predictability factor for respondents. They have to take their time in selecting their responses and not just select the first option that they come across.

Sample size

One hundred adolescent girls, 50 rural and 50 urban, were recruited in the study.

Study design

This was a cross-sectional analytical study.

Site of study

This study was conducted at ESIC Medical College, Sanathnagar, Hyderabad.

Duration

The duration of the study was 7 months. Our sample collection was slightly delayed due to the ongoing COVID-19 pandemic leading to hesitancy on part of the subjects/guardians.

Inclusion criteria

All apparently healthy adolescent girls aged 12–19 years were included in the study. The World Health Organization (WHO) defines “Adolescents” as individuals in the 10–19 years age group.^[24]

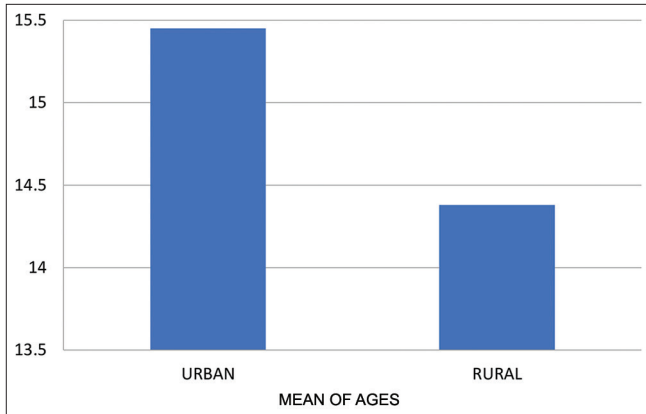
Exclusion criteria

Girls with known chronic disorders such as hypothyroidism, anemia, metabolic syndrome, with or without on treatment, and girls who are known cases of having cardiovascular disorders or respiratory ailments, endocrinopathies such as hypothyroidism or juvenile diabetes, and any other chronic diseases which may affect the exercise ability, cardiovascular performance, and parameters were excluded from the study. Treatment for any disorder/disease of any kind may affect the HRV parameters.

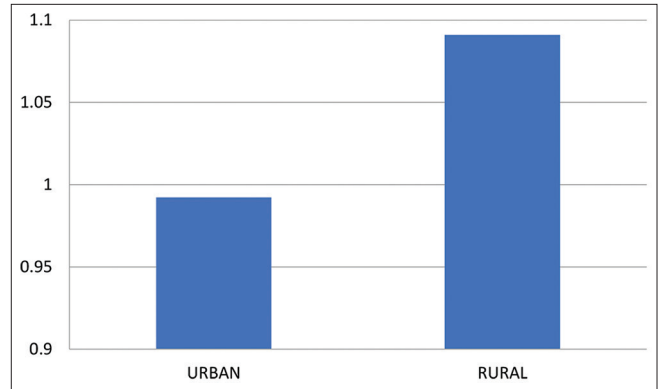
In addition, subjects associated with a medical background (preparing for/students of medical and paramedical courses and immediate family having a medical, paramedical background/profession etc.) were excluded as it might have influenced their responses in the KAP questionnaire.

METHODOLOGY

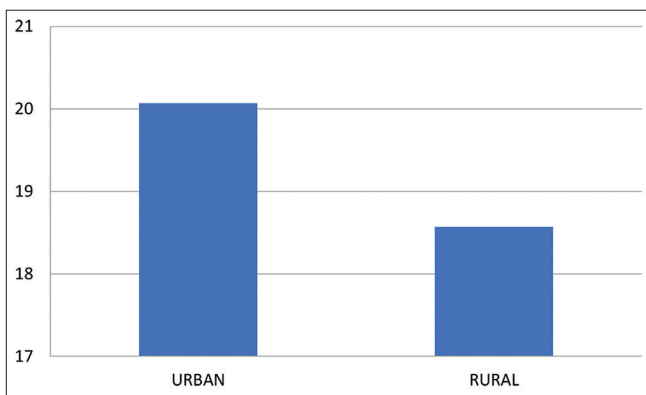
The procedures are conducted by following all the COVID-19 safety protocols. The room or the laboratory where the study was conducted and was adequately sanitized with sodium



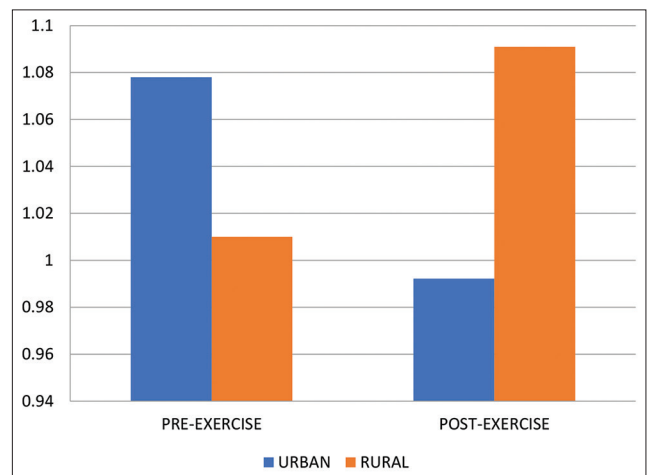
Graph 1: Means of age for urban and rural group.



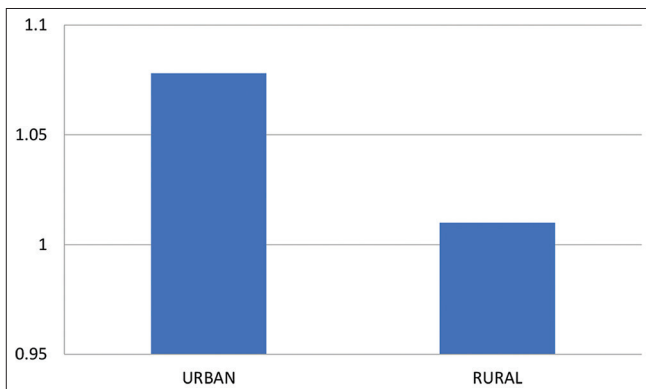
Graph 4: Means of ABI post-exercise for urban and rural group. ABI: Ankle Brachial Index.



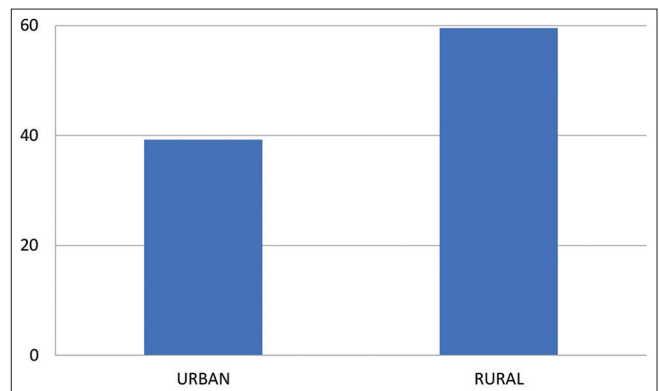
Graph 2: Means of BMI for urban and rural group. BMI: Body mass index.



Graph 5: Means of Ankle Brachial Index for urban and rural group pre- and post-exercise.



Graph 3: Means of ABI at rest for urban and rural group. ABI: Ankle Brachial Index.



Graph 6: Means of Harvard Step Test for urban and rural group.

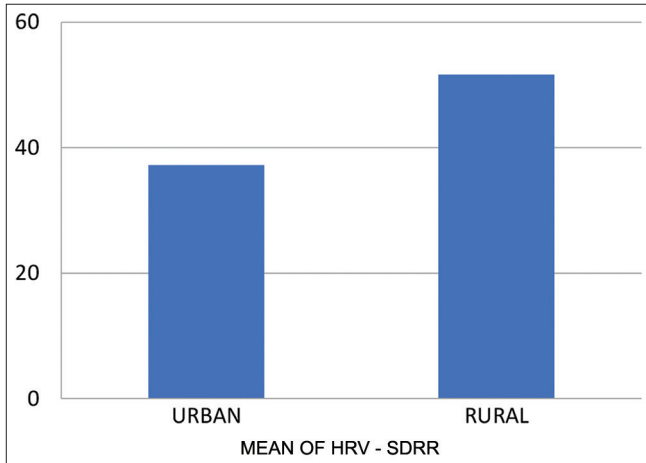
hypochlorite before and after the tests were done. The subjects were accompanied by their parents or guardians during the study.

KAP questionnaires were given to all the participants – a coinvestigator was present on hand to explain the components, clarify any doubts, and receive the responses. The responses were collected and the CVF tests were done.

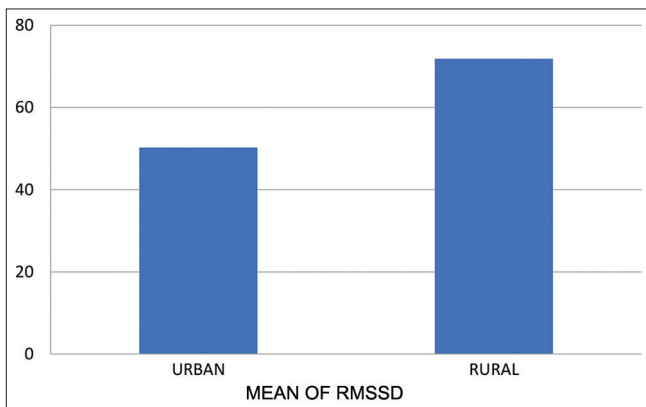
The following FITs (fitness indicator tests) were done:

Body mass index (BMI)

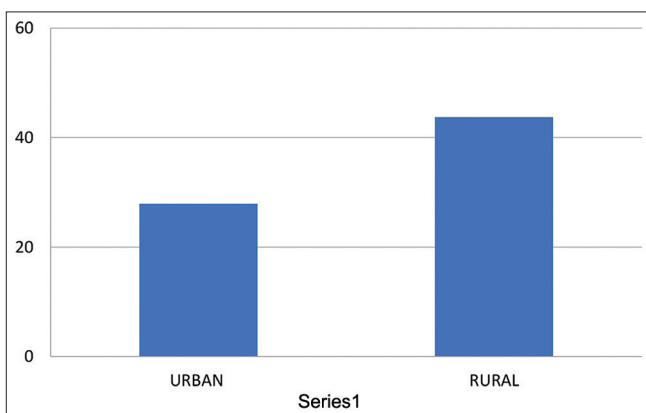
Each subject's height and weight were measured using stadiometer. BMI is calculated using the standard formula



Graph 7: Means of HRV – SDNN for urban and rural group. HRV: Heart rate variability, SDNN: Standard deviation of RR interval.

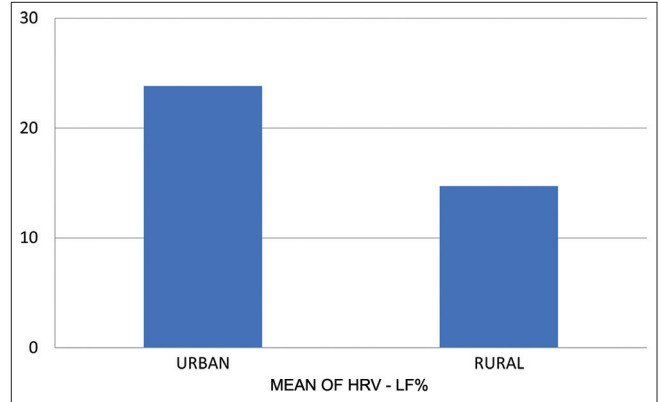


Graph 8: Means of HRV – RMSSD for urban and rural group. HRV: Heart rate variability, RMSSD: Root mean square of standard deviation.

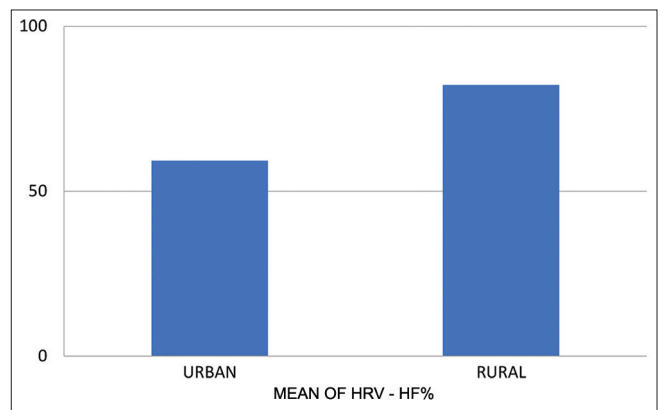


Graph 9: Means of HRV – pNN50 for urban and rural group. HRV: Heart rate variability, pNN50: The percentage of adjacent NN intervals that differ from each other by more than 50 ms.

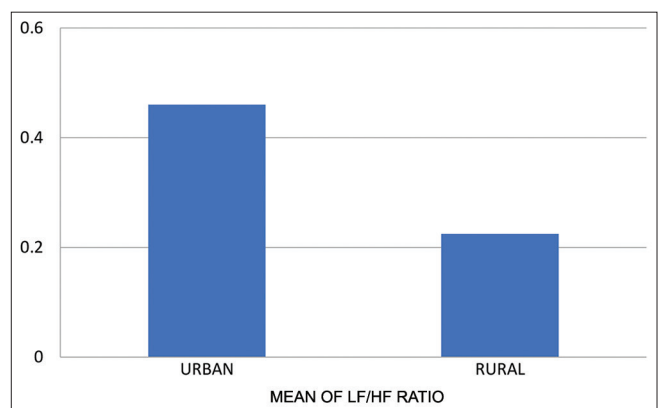
BMI = weight (kg)/height (sq.m). Based on the WHO criteria,^[25] subjects should be classified as underweight with a BMI < 18.5 kg/m², normal as having BMI between 18.5 and



Graph 10: Means of HRV – LF% for urban and rural group. HRV: Heart rate variability, LF: Low frequency.



Graph 11: Means of HRV – HF% for urban and rural group. HRV: Heart rate variability, HF: High frequency.

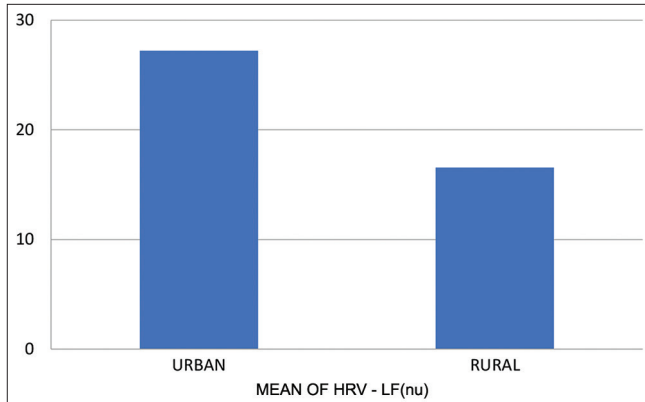


Graph 12: Means of LF/HF ratio for urban and rural group. LF: Low frequency, HF: High frequency.

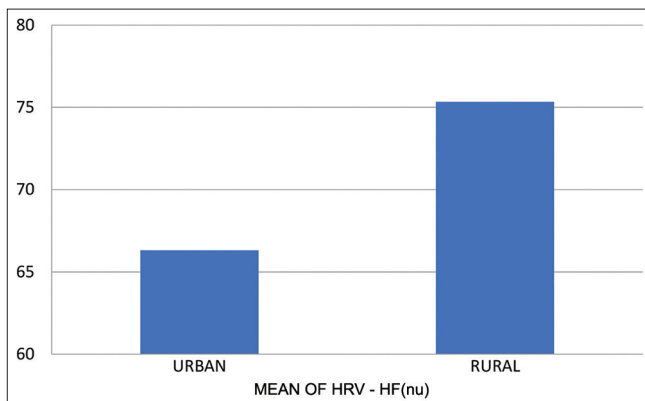
24.9 kg/m²; overweight as BMI 25.0–29.9 kg/m², and obese as BMI ≥30.0 kg/m².

ABI

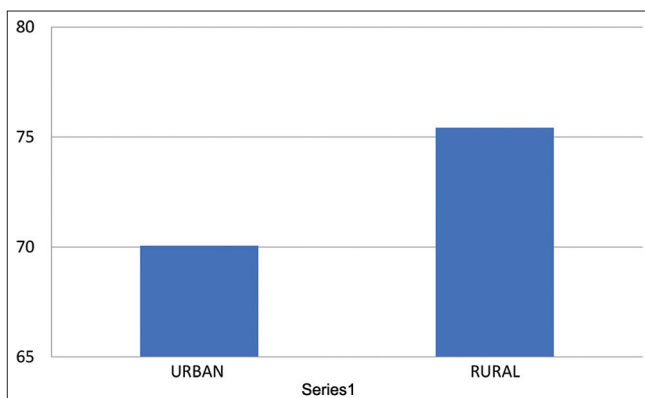
Using the department’s existing equipment, we customized the ABI apparatus. Before the process began, each



Graph 13: Means of LF (nu) for urban and rural group. LF: Low frequency.

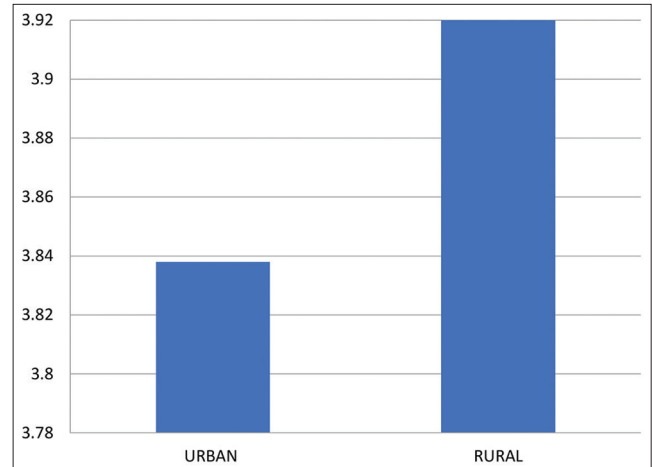


Graph 14: Means of HF (nu) for urban and rural group. HF: High frequency.



Graph 15: Means of VO₂ max for urban and rural group.

participant was requested to lay in a supine posture. Two sphygmomanometers were linked in series and connected to a common inflation slot. One cuff was connected to the arm and the other to the ankle, and the blood pressure was recorded simultaneously. Following the measurement of the blood pressure, the individual was instructed to conduct a moderate activity and the recordings were retaken.



Graph 16: Means of values from KAP questionnaire for urban and rural group. KAP: Knowledge, attitude, and practices.

As per the recommendations of the IEC, ESIC Medical College, Hyderabad, VO₂ Max was also added as a parameter to test CVF.

Harvard step test (HST)

A wooden block of height 16 inches was used for the exercise. Each participant was given few minutes to relax before being instructed in their native language to continuously step up and down a wooden block at a rate of 30 completed steps per minute (1 s up and 1 s down) for 5 min or until exhaustion. Exhaustion was regarded as a student's inability to maintain a 15-s stepping pace. The time of exhaustion was recorded.

Following the conclusion of the test, the subject was made to rest for a minute and the heartbeats were counted for 30 s intervals 3 times, that is, from 1 to 1.5, 2 to 2.5, and 3 to 3.5 min.

The heart beats were counted using stopwatch and the total number of heart beats were calculated using the formula $t_e \times 100/h_b \times 2$, where t_e represents the time of exhaustion; h_b represents total number of heart beats.^[26]

HRV

The room was maintained at normal temperature and illumination with a quiet environment. Subjects were asked to lie down on the couch for 5 min to acclimatize to the new environment, otherwise which might affect the ECG rhythm. We began our process once they were at ease.

The ECG from Lead II has been selected for recording. Lead II is preferred because it is parallel to the cardiac axis. The electrodes in Lead II are attached to the right arm and left foot, with the left leg electrode connected to the positive terminal and the right arm electrode connected to the negative electrode of the ECG machine. The MLA1090

electrode cream was applied to the right arm, left leg, and the right leg to which the ground electrode was connected. We used MLA2505 shielded lead wires with MLA700 Reusable ECG electrodes and MLA2540 5 Lead shielded bio amp cable with power lab 15T to connect to the subject.

Now, we requested the individuals to close their eyes and relax for 5 min without moving. Power lab 15T provided with the Lab Chart Pro version 8.1.19. was used to acquire the ECG data and for further analysis. The HRV software module in the system is a robust one which has the option for automatic deletion of ectopic beats. The collected data of all the subjects were saved as a file in the separate folder. The data obtained are assessed for the following ECG characteristics such as time domain and frequency domain.

Time domain parameters

1. Standard deviation of RR interval (SDNN): The standard deviation of all R-R intervals normalized is SDNN. The R-R intervals and beats are measured by SDNN, which has an impact on heart functioning.
2. Root mean square of standard deviation (RMSSD): The root mean square of the variations in normal heartbeats across time represents RMSSD. RMSSD is a measurement of the heart's vagus-mediated regulation. RMSSD is frequently used by professional athletes to track heart activity and HRV modification in response to physical exertion. Depending on age and health, the average RMSSD ranges from 20 to 80 ms.
3. pNN50: The percentage of adjacent NN intervals that differ from each other by more than 50 ms. The pNN50 is closely correlated with PNS activity.

Frequency domain parameters

The distribution of absolute or relative power is estimated in four frequency bands using frequency domain measurements. The signal energy found inside a frequency band is referred to as power. It comprises both relative and absolute power. Absolute power is computed by multiplying ms squared by the number of cycles per second. The absolute power for a single frequency band is divided by the summed absolute power of the low frequency (LF) and high frequency (HF) bands to calculate relative power, which is expressed as a percentage of total HRV power or in normal units (nu). Frequency domain includes parameters such as VLF, HF, LF, and LF/HF ratio.

VO₂ max

The highest amount of oxygen an individual can take in, transport, and utilize to produce ATP aerobically during heavy exercise. Rockport's Fitness Walking test was done. The formula used for calculating was:

VO max = 132.853 – (0.0769 × body weight) – (0.3877 × age in years) + (6.3150 × sex) – (3.2649 × walk time in minutes) – (0.1565 × heart rate in beats/min). Males were coded as “1” and females as “0” for substitution of gender in the formula.^[27]

Table 1: Means and SD of age for urban and rural group.

Population	Mean±SD	P-value
Urban	15.45±0.39	0.2376
Rural	14.38±2.87	

SD: Standard deviation

Table 2: Means and SD of body mass index for urban and rural group.

Population	Mean±SD	P-value
Urban	20.07±4.03	0.2422
Rural	18.57±2.709	

SD: Standard deviation

Table 3: Means and SD of Ankle Brachial Index at rest for urban and rural group.

Population	Mean±SD	P-value
Urban	1.078±0.064	0.0251
Rural	1.010±0.1366	

SD: Standard deviation

Table 4: Means and SD of Ankle Brachial Index postexercise for urban and rural group.

Population	Mean±SD	P-value
Urban	0.9922±0.107	0.0178
Rural	1.091±0.097	

SD: Standard deviation

Table 5: Means and SD of Ankle Brachial Index for urban and rural group pre- and post-exercise.

Population	Mean±SD		P-value
	Preexercise	Postexercise	
Urban	1.078±0.064	0.9922±0.107	<0.0001
Rural	1.010±0.1366	1.091±0.097	0.1196

SD: Standard deviation

Table 6: Means and SD of Harvard Step Test for urban and rural group.

Population	Mean±SD	P-value
Urban	39.26±3.21	0.0066
Rural	59.55±1.403	

SD: Standard deviation

KAP QUESTIONNAIRE

Personal information and other demographic data such as name, age, address, and occupation were collected separately.

Each subject was given a code which was mentioned at the top of the KAP questionnaire along with the group they belong to: "U" for Urban and "R" for Rural.

Group: U/R						
S. No.	Questions	OPTIONS				
1.	Regular physical activity can improve health and reduce disease risk	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
2.	Regular intake of Fresh fruits can improve health and reduce the disease risk	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
3.	Adding excess salt to food and fruits is harmful for health	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
4.	Frequent intake of outside food, especially deep fried items is bad for health	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
5.	Regular intake of fresh vegetables can improve health and reduce the disease risk	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
6.	Alcohol intake is not good for heart health	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
7.	Smoking is not good for heart health	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
8.	Sitting for longer times is good for health	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
9.	In your opinion, can people control their alcohol intake and not get addicted so easily?	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
10.	Teenage smoking is fine and people leave this habit when they grow up?	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
11.	It is alright to add more salt to fruits and other foods to make it tastier	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
12.	People make unnecessary issue of heart health and disease and that the actual issue is very small?	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
13.	All correct and verified information should be passed onto friends and family so that they can take better care of themselves?	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
14.	How many days per week do you eat fruit?	Daily	5-6	3-4	1-2	<1
15.	How many days per week do you a pure vegetarian diet?	Daily	5-6	3-4	1-2	<1
16.	How many times per week do you eat outside meals (meals not prepared at home/hostel)?	<1/month	<1/week	2-3	4-5	6-7
17.	Do you add excess salt to your food after its cooked?	No	Yes			
18.	Do you smoke? (includes cigarettes, cigars, handrolled cigarettes, etc.)	No. If no, go to Q20	Yes			
19.	If yes, specify the quantity smoked per day	1-2	2-5	5-10	10-20	>20
20.	Did you smoke in the past year?	No	Yes			
21.	Do you chew tobacco?	No. If no, go to Q23	Yes			
22.	If yes, please specify amount used					
23.	Do you drink alcohol? (local liquor like sendi, beer, wine, whiskey etc.)	No. If no, go to Q25	Yes			
24.	If yes, specify the frequency of intake per week	<1/month or on special occasions	<1/week	1-3	4-6	Daily
25.	Did you drink in the past 30 days?	No	Yes			
26.	How many of your waking hours per day are spent in sitting or lying down e.g., in talking to family and friends, watching TV, Phone, Tablets, Laptop, travelling etc. (Please exclude your sleep time)	<5	5-6	7-8	9-10	>10 h

(Contd...)

Group: U/R (Continued)						
S. No.	Questions	OPTIONS				
27.	Do you perform moderate intensity physical activity for at least 10 min continuously per week which cause slight shortness of breath and awareness of heart beat? (e.g., brisk walk/bicycle)	Yes	No. If no, go to Q29			
28.	If yes, specify the frequency (activity done on number of days/week)	Daily	5-6	4-5	2-3	<1
29.	Do you take part in sports regularly?	Yes	No			
30.	If yes, please specify the frequency (activity done on number of days/week)	Daily	5-6 h/day	4-5 h/day	2-3 h/day	<1 h/day
31.	How long does each sports session last?	>45 min	30-45 min	15-30 min	5-15 min	<5 min

Table 7: Means and SD of heart rate variability – standard deviation of all R-R intervals for urban and rural group.

Population	Mean±SD	P-value
Urban (ms)	37.24±16.88	0.051
Rural (ms)	51.64±29.32	

SD: Standard deviation

Table 12: Means and SD of heart rate variability – low frequency/high frequency ratio for urban and rural group.

Population	Mean±SD	P-value
Urban	0.46±0.343	0.048
Rural	0.2248±0.0082	

SD: Standard deviation

Table 8: Means and SD of heart rate variability – root mean square of standard deviation for urban and rural group.

Population	Mean±SD	P-value
Urban (ms)	50.22±28.007	0.08
Rural (ms)	71.88±48.49	

SD: Standard deviation

Table 13: Means and SD of heart rate variability – low frequency (nu) for urban and rural group.

Population	Mean±SD	P-value
Urban	27.21±11.04	0.0124
Rural	16.55±5.01	

SD: Standard deviation

Table 9: Means and SD of heart rate variability – pNN50 for urban and rural group.

Population	Mean±SD	P-value
Urban	27.93±2.35	0.1027
Rural	43.71±3.312	

SD: Standard deviation

Table 14: Means and SD of heart rate variability – high frequency (nu) for urban and rural group.

Population	Mean±SD	P-value
Urban	66.31±10.6	0.0243
Rural	75.34±7.15	

SD: Standard deviation

Table 10: Means and SD of heart rate variability – low frequency % for urban and rural group.

Population	Mean±SD	P-value
Urban	23.83±9.16	0.0082
Rural	14.71±4.4	

SD: Standard deviation

Table 15: Means and SD of VO₂ max for urban and rural group.

Population	Mean±SD	P-value
Urban	70.06±1.017	0.0003
Rural	75.42±2.942	

SD: Standard deviation

Table 11: Means and SD of heart rate variability – high frequency % for urban and rural group.

Population	Mean±SD	P-value
Urban	59.24±11.09	0.001
Rural	82.2±21.03	

SD: Standard deviation

Table 16: Means and SD of values from knowledge, attitude and practice questionnaire for urban and rural group.

Population	Mean±SD	P-value
Urban	3.838±0.28	0.8518
Rural	3.92±0.258	

SD: Standard deviation

OBSERVATIONS AND RESULTS

After completion of the tests, the data were collected and entered into an MS-Excel worksheet. Data were analyzed using GraphPad Prism Software (Version 9.2.0 [322]). Student's "t" test (unpaired, two-tailed) was done and "P" < 0.05 was considered to be significant. The following results were obtained.

Means and Standard Deviation of ABI before exercise was 1.078 ± 0.064 and 1.010 ± 0.1366 for urban and rural population, respectively, with "P" = 0.0251. This indicates that there is a significant difference between the values of ABI of both groups [Tables 1-5 and Graphs 1-5].

Means and Standard Deviation of ABI after exercise was 0.9922 ± 0.107 and 1.091 ± 0.097 for urban and rural population, respectively, with "P" = 0.0178. This indicates that there is a significant difference between the values of ABI of both groups [Table 4 and Graph 4].

Means and Standard Deviation of ABI in both groups before and after exercise is shown in the Table 6. There is a significant fall in ABI in the urban girls group with "P" < 0.0001. In contrast, though rural group shows a rise, it is not significant, with "P" = 0.1196 [Table 6 and Graph 6].

Means and Standard Deviation of SDNN was 37.24 ± 16.88 ms and 51.64 ± 29.32 ms in urban and rural population, respectively, with "P" = 0.051, which was not significant [Table 7 and Graph 7].

Similarly, Means and Standard Deviation for RMSSD for urban population was 50.22 ± 28.007 ms and it was 71.88 ± 48.49 ms for rural population, having "P" = 0.08, which was not significant [Table 8 and Graph 8].

Means and Standard Deviation for pNN50 for urban population was 27.93 ± 2.35 and it was 43.71 ± 3.312 for rural population, having "P" = 0.1027, which was not significant [Table 9 and Graph 9].

Means and Standard Deviation of low power expressed as a percentage (in LF%) was 23.83 ± 9.16 and $14.71 \pm 4.4\%$ in urban and rural population, respectively, which had "P" = 0.0082, which was significant [Table 10 and Graph 10].

Means and Standard Deviation of high power expressed as a percentage (in HF%) was 59.24 ± 11.09 and $82.2 \pm 21.03\%$ in urban and rural population, respectively, which had "P" = 0.001, which was significant [Table 11 and Graph 11].

Means and Standard Deviation of LF/HF ratio was 0.46 ± 0.343 and 0.2248 ± 0.0082 in urban and rural population, respectively, which had a "P" = 0.048, which was significant [Table 12 and Graph 12].

Similarly, power expressed in nu in both LF and HF bands was also analyzed. LF power band showed mean values and

Standard Deviation of 27.21 ± 11.04 and 16.55 ± 5.01 for urban and rural population, respectively, having "P" = 0.0124, which is significant. [Table 13 and Graph 13]

HF power band showed mean values and Standard Deviation of 66.31 ± 10.6 and 75.34 ± 7.15 for urban and rural population, respectively, having "P" = 0.0243, which is significant [Table 14 and Graph 14].

Regarding VO₂ max, the values of Mean and Standard Deviation are 70.06 ± 1.017 and 75.42 ± 2.942 for urban and rural population, respectively, having "P" = 0.0003, which is significant [Table 15 and Graph 15].

Regarding KAP questionnaire scores, the values of Mean and Standard Deviation are 3.838 ± 0.28 and 3.92 ± 0.258 for urban and rural population, respectively, having "P" = 0.8518, which is significant [Table 16 and Graph 16].

Classification of BMI.^[25]

BMI values	Category
<18.5	Underweight
18.5–24.9	Normal
25–29.9	Overweight
>30	Obese

BMI: Body mass index

Classification of Harvard Step Test.^[26]

HST values	Category
>96	Excellent
83–96	Good
68–82	Average
54–67	Low average
<54	Poor

HST: Harvard Step Test

DISCUSSION

The current study was conceptualized to see the difference between physiological parameters of rural and urban adolescent girls, which are indicative of cardiovascular health. With lifestyle contributing significantly to health as well as development of diseases, this study is an appropriate one to note the changes which occur due to two very different lifestyles – the urban and the rural. Primordial prevention refers to prevention of development of risk factors. If this is done correctly then the risk of development of diseases and their subsequent complications can be prevented.

The aim of the study was to see the differences between the following parameters between the urban and rural adolescent girls – BMI, ABI, HST, and HRV. They are considered to be indicators of CVD.^[3,4,28] Usually, KAP, which depend on various social, cultural, and economic factors also play a significant role in cardiovascular health, as has been observed

in many studies in various fields.^[29] Hence, they were also assessed in this study. The study began after getting approval from the Institutional Ethics Committee (IEC), ESIC Medical College, Sanathnagar, Hyderabad. The 100 apparently healthy adolescent girls between the ages 12 and 19 were chosen as subjects, although the actual age range of the subjects who agreed to participate in this study was between 13 and 17 years only. All the subjects were school going girls, although mode of teaching was varied and disrupted due to the ongoing COVID-19 pandemic. Subjects with known CVDs, obesity, and any other chronic diseases were excluded from the study. Subjects associated with a medical background (preparing for/students of medical and paramedical courses, immediate family having a medical, paramedical background/profession, etc.) were excluded as it might have influenced their responses in the KAP questionnaire. Of the 100 subjects, 50 belonged to an urban area (residents of Hyderabad city for at least 1 year) and 50 belonged to rural areas (residents of rural areas near Hyderabad for at least 1 year). Procedure and significance of the study were explained to all of them in their native language, following which they were invited to be part of the study. Informed consent was obtained from all the participants and their parents/guardians. A questionnaire was designed to know the level of KAP of the subjects. Internal validation of the questionnaire was done with a Cronbach's alpha score of 0.7.

Questions were categorized as those which tested their knowledge about health and risk factors for development of disease, their attitude toward them and the day-to-day practices observed by the subjects. In the questionnaire, eight questions were related to knowledge, five on attitude, and 12 questions on practices followed by them. Additional questions were present to get more information about a particular practice, if it was done or practiced by the respondent. Scoring was done for the questions ranging from 5 to 1. For the sake of simplicity and ease of calculation, the questions were framed in such a way that the better response was always 5, be it placed in any order in the multiple-choice options. This was helpful not only in our calculations, but also removed the predictability factor for respondents. The responses were collected and analyzed. Mean or average score of each subject was calculated and from this mean of each group was calculated with possible values of the average group score ranging between 1 and 5. CVF tests and measurements such as BMI, ABI, HST, HRV, and VO₂ max were performed and their results were analyzed.

The results of the above-mentioned tests as well as the KAP questionnaire were obtained and entered in MS-Excel Worksheet. Statistical analysis was done using GraphPad Prism Software (Version 9.2.0 [322]). Student's "t" test (unpaired, two-tailed) was done and "P" < 0.05 was considered to be significant.

The results indicated that the BMI was within normal range in both groups and was slightly higher in urban adolescent girls compared to rural girls, although the difference was not significant, with "P" = 0.22. Such a difference between the urban and rural groups was also seen in a study done by Goyal, which recorded higher mean BMI values in the urban group.^[30]

ABI was recorded at rest and after making the subjects walk on the treadmill at a speed of 2.4 kmph for 5 min or till subjects got exhausted.^[31] Subjects were familiarized with the functioning of the treadmill beforehand. It is recommended that any changes in the post-exercise ABI are better indicators of presence of peripheral arterial disease, which include a fall of ABI to <0.9 or a 20% fall in ABI values or a fall of ankle pressure by 30 mm post-exercise.^[31] In our study, ABI before exercise was higher for urban population compared to the rural population with "P" = 0.0251, which is significant. This result is in line with that observed in a study done on urban and rural population in Central African countries, where the rural group had better ABI.^[32]

Conversely after exercise, the ABI was higher for the rural population, respectively, with "P" = 0.0178, which is significant. This indicates that there is a significant difference between the values of ABI of both groups, although post-exercise changes seem to be a better indicator.

Comparison was also done before and after exercise in both groups. The urban girls group had a fall of ABI post-exercise by 8.6% with "P" < 0.0001, which is extremely significant. It is interesting to note here that even though the difference in means shows significance, the actual fall which can be taken as the cutoff to indicate the presence of peripheral artery disease (PAD) is <20%.^[31] Although a decrease in ABI is seen in urban girls post exercise, it is not indicating the presence of an actual PAD.

The rural girls group had a rise of ABI post exercise with "P" = 0.11, which is not statistically significant. Yet, some studies point out that a rise in ABI may also be an indicator of risk for the future cardiovascular events.^[33] However, most studies report that an increased ABI is an indicator of CVF.^[34]

ABI is an excellent indicator of presence of peripheral arterial disease be it recorded at rest or post-exercise. ABI values ≤0.9 are very good indicators for presence of lower extremity arterial stenosis.^[35] Kajikawa *et al.* have shown an increase in endothelial dysfunction in association with low and borderline ABI.^[36] Various studies done by multiple researchers have shown an association between low values of ABI with a higher risk of stroke, myocardial infarction, other cardiovascular morbidities, and mortalities.^[37-39] In light of such observations, it is a very valuable indicator for CVF for our study.

Rural girls performed better in HST than the urban girls with "P" = 0.0066, which is very significant. It is to be noted that even

though rural group performed better, their mean values still fall under the category of low-average as per HST rating whereas the means of urban group falls under poor category. In a study done by Mahmood *et al.* comparing urban and rural physiotherapy students, it was seen that the urban group performed better than the rural group.^[40] Our study does not support this. Conversely, in studies done by Gahlawat^[41] and by Biraadar,^[42] it was seen that cardiovascular efficiency as measured by HST was greater in rural high school girls compared to urban high school girls with rural population having a better score of HST compared to the urban group. This is similar to our study.

HRV has also been measured in all the subjects. The parameters of HRV analyzed include time domains such as SDNN, RMSSD, frequency domains such as LF, HF, and LF/HF Ratio.

Regarding HRV, the time domain parameters such as SDNN, RMSSD, and pNN50 were higher in rural girls, but this difference was not significant.

RMSSD indicates the beat-to-beat variance of the heart rate. It is considered to be the primary time-domain measure for estimating the vagally mediated changes as observed in HRV.^[43,44] It is correlated with HF power.^[43,45] Closely associated with HF power is the pNN50. In addition, it was observed that a correlation is also seen between pNN50 and RMSSD.^[43,46]

Therefore, RMSSD, SDNN, and pNN50 are measures of autonomic vagal influence on the heart, with lower values indicating shift in autonomic activity away from the vagus^[47] and toward greater sympathetic activity.^[43]

Our study shows greater time domain values for the rural group compared to the urban group, although the rise in not significantly higher. Greater time domain values have been associated with aerobic fitness and vice-versa.^[48]

LF was significantly higher in the urban girls group, compared to the rural group whereas HF and LF/HF ratio was significantly higher in the rural group. The environment can probably be playing a role as evidenced by a study done by Joung *et al.*, in which even a very short-term exposure to the countryside lead to increased HF and lowered LF values.^[49] Urban environment has higher degrees of noise and air pollution both of which are linked to decreased HF and increased LF, as well as decreased time domain parameters such as RMSSD and SDNN as evidenced by a study done by Rita Biel *et al.* These changes which were seen after a short-term exposure are likely to persist if the exposure continues.^[50]

Although it is seen that LF shows influences of both SNS and PNS, it is traditionally considered to reflect activity of SNS primarily. On the other hand, the HF band is related to parasympathetic activity and HF power indicates degree of vagal modulation of the heart and heart rate.^[43]

Decrease in HF power indicates lesser vagal tone and has been associated with stress, anxiety, etc. Modulating the vagal tone helps in maintaining the CVS health with decreased tone leading to increased morbidity.^[43,51]

As mentioned above, traditionally, LF is associated with SNS and HF associated with PNS. Hence, when we consider the LF/HF ratio, a lower ratio indicates parasympathetic dominance and vice-versa.^[43]

ANS dysfunction is associated with many disorders, including CVD and its associated morbidities and mortalities.^[48] HRV is an important tool to assess autonomic cardiac dysregulation, which plays a role in development of pathological processes leading to a decline in health.^[43]

VO₂ max was a parameter added as per the recommendations of the IEC, ESIC Medical College, Sanathnagar, Hyderabad to assess CVF. It is considered to be an indicator of cardiorespiratory fitness.^[27] Significantly higher values for VO₂ max were obtained for the rural group compared to the urban group. In a study done by Suleiman *et al.*, it was observed that there is no significant difference between the VO₂ max values of urban and rural study subjects.^[52]

However, the results of our study were similar to an Indian study done which compared the difference in VO₂ max values in urban and rural girls and showed a significant increase in the values of VO₂ max of the rural girls.^[53]

KAP questionnaire questions were remodeled for the sake of clarity. Internal validation was done and a Cronbach's alpha score of 0.7 was obtained. Questions were asked to know their level of knowledge, their attitude toward health and disease and the daily practices done which may contribute toward CVS health. The results were analyzed. Mean scoring of all the questions answered by a subject was done and means of the both the groups were assessed from this. The possible values were expected to range between 1 and 5. Surprisingly, the mean values of both groups were very similar with little difference between them and an insignificant "P" value. We believe that with the advent of better schooling opportunities and accessibility of smartphones and internet, both urban and rural girls had similar level of knowledge and attitudes along with a similar impact on practices followed by them in their daily life.

Our study shows slightly better results of the physiological parameters in the rural population.

CONCLUSION

The distinction and final labeling of whether urban or rural lifestyle is not an easy one, with our own study not clearly showing absolute results favoring one over the other. Parameters such as BMI were non-indicative with no significant difference between the values of both groups.

ABI showed varied results, with urban girls scoring more than rural girls at rest and rural girls scoring more post-exercise compared to the urban population. When the mean of each group is compared at rest and post-exercise, urban girls showed a significant decrease of score after exercise compared to their pre-exercise values; though this drop is not enough to be indicative of peripheral vascular disease. On the other hand, the ABI values of rural girls increased after exercise compared to that at rest, yet this rise was not significant. The values of HST are better in the rural population. Similarly, even HRV shows better results in the rural population with the frequency domain parameters being significantly better in the rural girls. Although time domain values are also greater in rural girls compared to the urban girls, this rise is not significant. KAP questionnaire values showed surprising similarities in both the groups. This can be attributed to better opportunities to schooling, greater exposure to internet which may have contributed to better awareness about health. It appears that with similar KAP, it is the environmental influences such as air and noise and nutritional influences as seen by BMI, which may account for some of the changes in the above tested physiological parameters. Adolescence is the period of change, growth, and development. This is also the period of vulnerability with risk factors marking their presence and increasing the likelihood of a person developing a disease in later life. Hence, primordial prevention when applied at this younger age can be beneficial, as it prevents the development of risk factors.

Summary

This study was conceptualized to determine any difference in the physiological parameters determining cardiovascular health in adolescent girls of the urban and rural areas. Clearance for this study was given by the Institutional Ethics Committee, ESIC Medical College, Sanathnagar, Hyderabad. The aim of the study was to see the differences between the following parameters between the urban and rural adolescent girls – BMI, ABI, HST, and HRV. They are considered to be indicators of CVF.^[3,4,28] A questionnaire was designed to know the level of KAP of the subjects. Internal validation of the questionnaire was done with a Cronbach's alpha score of 0.7.

The 100 apparently healthy adolescent girls between the ages 13–17 agreed to participate in this study, of which 50 belonged to an urban area and 50 belonged to rural areas. Subjects with known CVDs, obesity, and any other chronic diseases or a medical background were excluded from the study. Procedure was explained and informed consent was obtained from all the participants and their parents/guardians. The results were variable, with BMI having non-significant higher values in urban girls, ABI showing better

post-exercise values in rural girls, HST and HRV showing better responses in rural girls. KAP questionnaire showed very similar responses, which can be attributed to improved schooling opportunities and better access to internet and smartphones which can increase awareness. Hence, the likely reason for better performance of rural girls could be the environment around them with cleaner and fresher air, lesser noise, and lesser weight compared to the urban girls, although the weight is in normal range for both. All these factors might have contributed to better CVF in the rural population.

Limitations of the study

1. KAP questionnaire is subjective to the actual veracity of the responses given by the subjects.
2. The reasons behind the differences in the physiological parameters in urban and rural group need to be tested at a molecular level, which is beyond the scope of this study. Based on similar studies, it can be deduced that environmental influences play a huge role in determining the CVF.

Declaration of patient consent

Patient's consent not required as there are no patients in this study.

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Conflicts of interest

There are no conflicts of interest.

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