School based Exercise and Life Style Motivation Intervention (SEAL - MI) on Adolescent's Cardio Vascular risk factors and academic Performance: Catch them Young

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Abstract

There are evidences of shared biological mechanisms between obesity and hypertension during childhood in the adulthood, and loads of research literatures have proven that, it will cost the economies and health of nations profoundly if neglected. The Prevention and early diagnosis of cardiovascular risk factors such as overweight and hypertension is an essential strategy for

control, effective treatment and prevention of its' complications. The aim of the study is to assess the effect of school based Exercise and Life style Motivation Intervention (SEAL-MI) on adolescent's cardiovascular risk factors and academic performance. An experimental study was conducted among 1005 adolescents - 520 and 485 adolescents were randomly selected for control and study group, respectively. Demographic details and the data related to dietary habits, physical activity and sleep quality were collected by a structured interview questionnaire. The study group adolescents were given the SEAL-MI for six months which includes a school based rope exercise for 45 minutes per day for 5 days a week and a motivation intervention related to dietary habits, physical activity and sleep. Post-test 1 and 2 were done after 3 and 6 months of intervention. The prevalence of overweight among adolescents was 28.73% and prehypertension was 9.26%. Among overweight adolescents, the prevalence of prehypertension was found to be very high (32.25%). In post intervention, there was a significant reduction in weight, BP (p=0.000) and improvement in dietary habits, physical activity, sleep (p=0.000) and academic performance. A significant positive correlation was found between BMI and SBP (p=0.000) and BMI and academic performance (p=0.003). The linear regression analyses revealed that the gender (ß: 0.47, 95% CI: 0.39, 0.81), age (ß: 0.39, 95% CI: 0.17, 0.46), family income (ß: 0.2, 95% CI: 0.41, 0.5), residence (ß: 0.19, 95% CI: 0.01, 0.27) and type of family (ß: 0.25, 95% CI: 0.39, 0.02) had the strongest correlate with the BMI of the adolescents. Also, Mother's education Mother's education (ß: 0.35, 95% CI: 0.18, 0.59) had the strongest correlate with the SBP of the adolescents. In contrast, the DBP was negatively persuaded by age (ß: -0.36, 95% CI: 1.54, 0.29) and gender (ß: -0.26, 95% CI: 1.34, 0.12) of the adolescents. Regular practice of rope exercise and lifestyle modification such as diet, physical activity and sleep quality among adolescents prevent and control childhood CVD risk factors like overweight, hypertension. The SEAL-MI may lead to age appropriate development of adolescents and improves their academic performance and quality of life. Giving importance to the adolescents from urban habitat, from affluent nuclear family and catching them young will bring significant change in the disease burden.

1. Introduction

The world of tomorrow will inherit the adolescents of today. Developing the full potential of adolescents and helping them to survive with good health is essential. Nevertheless, due to the constant development of economic level and corresponding lifestyle changes, we are facing

gradually increasing weight with the younger-age trend. In the United States, according to the Centre for Disease Control and Prevention (CDC), approximately 17% (i.e. 12.5 million) of adolescents and adolescents aged 2–19 years are obese, with the obesity prevalence in these groups having almost tripled since 1980(1).

Obesity causes various disorders and it is of great public health concern across the world. According to the World Health Organization, childhood obesity has been strongly associated with a higher chance of premature death and disability in adulthood (2,3). Central adiposity, defined as fat mass accumulation around the abdomen, has been shown to be highly correlated with cardiovascular risks such as hypertension, elevated plasma lipid concentrations, lipoprotein concentrations, C-reactive protein (CRP) levels, insulin resistance (IR) (3), and changes within the vasculature such as increased arterial stiffness (4) and blood pressure (BP) (5) in children and adolescents (6).

The behavioural risk factors such as an unhealthy diet are estimated to be related to about half of hypertension (about 30% related to increased salt consumption, and about 20% related to low dietary potassium, low fruit and vegetables). Insufficient physical activity is the fourth leading risk factor for mortality. Physical inactivity is related to about 20% of hypertension and obesity is also related to about 30%. More than two-thirds of the adolescents are physically inactive in India, as per WHO standards. Any preventive and promotive health interventions targeted in this age will be relatively cost effective, yet yield a lifetime gain, not only for individuals, for societies and economies. Also, school -based childhood interventions are among the most cost-effective in saving the Disability Adjusted Life Years (DALYs) in their later life.

Captivatingly, adolescents who have a low level of physical activity are more prone to be obese, depressed and more likely to have a lower grade point average (GPA)(7). Academic performance, in general, is considered to be associated with cognitive and memory functions (8). Known the negative relationship of obesity with cognitive and memory functions, being overweight or obese might negatively impact adolescents' academic achievement (9). Indeed, a high body mass index (BMI) has been linked with negative alterations in brain structure and an increased risk of Alzheimer's disease (10).

Further, depressed adolescents are more likely to develop and sustain obesity during their adolescence. Understanding the shared biological and social variables that link depressed mood and obesity could help with both prevention and therapy of both disorders. Depression in

adolescents has also been linked to a higher body mass index in adulthood, though it is uncertain whether depression promotes obesity or obesity causes depression (11).

For these reasons, school-based healthy lifestyle curriculum development is the need of the hour for adolescents as there is relative evidence that physical activity elevates adolescents' mood, improves memory, cognitive function, and prevents CVD risk factors.

Also, school is an easily accessible and affordable ambience to adolescents, and teachers play a crucial role in children's physical, psychological, social, and emotional development. Therefore, the main objectives of this study were to estimate the prevalence of overweight and hypertension among adolescents and to assess the effect of school-based Exercise and Lifestyle Motivation Intervention (SEAL-MI) on adolescents' cardiovascular risk factors and Academic performance.

2. Methods

2.1. Design:

This experimental study was conducted in the randomly selected high schools of Tiruvallur district, Tamilnadu, India

2.2. Population and Setting:

The adolescents with overweight and increased blood pressure were the population of the study. The data collection took place in the chosen high schools of the Tiruvallur district, Tamilnadu, India.

2.3. Sample Size and Sampling process:

The Sample size was calculated based on the power analysis taking 95% confidence level and 80% power of the study with $\alpha = 5\%$, $\beta = 20\%$. The sample size was estimated with the improvement of 20% gain from baseline 50% with 80% power of the study, 5% allowable error and 10% dropout rate. The estimated sample size was rounded as 500 in each control and intervention group. An updated list of all public schools was used as the sampling frame, and a stratified sampling method was used. The schools were stratified proportionately according to urban/rural distribution; after ensuring matching, eight rural zones and eight urban wards were selected, and they were randomly allotted into intervention and control groups using the lottery method. In the same way, two schools (for intervention and control group) from rural and urban wards were selected in the second stage. From the 16 selected schools from each urban and rural

area, all the adolescents aged 13- 14 years, who were willing to participate in the study, were screened for hypertension and overweight as a first phase.

After obtaining approval from the Institutional Ethical Committee, the baseline information was assessed by the modified "WHO STEPS" instrument for the surveillance of chronic disease risk factors (12). The adolescents who fell in $\geq 85^{th}$ percentile according to the WHO chart on BMI for age (Boys & Girls) and have$\geq 90^{th}$ Systolic/Diastolic Percentile - NHBPEP Working Group on Adolescents and Adolescents of NHLBI were included for the study.

The adolescents diagnosed with pathological causes of hypertension such as renal diseases, cardiac conditions with any other co-morbidities and who were already on medication for overweight and hypertension, were excluded. The adolescents who had significant complications associated with medical conditions, learning disabilities, breathing, hormonal and musculoskeletal limitations, on an exercise program, and unable to perform moderate to vigorous-intensity exercises were excluded.

Initially, 12,895 adolescents from 16 rural and 16 urban schools were screened for obesity and hypertension in the first phase. Among them, 3,705 were overweight, and 1,195 were identified with both overweight and prehypertensive. Based on the inclusive and exclusive criteria, 1005 adolescents with overweight and prehypertensive were randomised and allotted by lottery method in the study(500) and control(485) group.

2.4. Intervention:

The school-based Exercise and Life Style Motivation Intervention (SEAL - MI) incorporated planned teaching on knowledge regarding prevention and control of blood pressure, overweight, dietary modifications, the rope exercise program and activities to enhance sleep quality. The intervention, designed to change adolescents' BMI and blood pressure, was administered by the investigators for six months. The teaching was given at the beginning of the intervention, and the rope exercise program was carried out for six months with a frequency of 5 times a week in the school after the school hours under the supervision of physical education teachers. Before implementing the rope exercise program, a no harm certificate was received from a Paediatrician, a Physical therapist and a Clinical Nutritionist for ethical reasons.

During the rope exercise program, participants warmed up for 5 minutes and did eight cycles of rope jumping exercise. Each cycle consisted of rope jumping for 2 minutes followed by 2 minutes rest which lasted for around 30 minutes followed by relaxation exercise for 5 minutes.

To maintain the exercise intensity, changes in heart rate was observed. In the current study, the participant's mean age was 13 years 2 months and the estimated maximum heart rate (MHR) employed was 210 bpm. Therefore, the MHR giving rise to a change in heart rate (as defined by aerobic work) is $210 \times 60\%$ MHR = 126bpm. The heart rate of every child was recorded daily at the end of each 2-minute cycle of rope jumping, before and after warm-up to keep up the required advantage of the exercise and a diary was maintained for each child by the physical education teachers who have been trained for the same.   The compliance was ensured through phone calls and weekly direct visits to the intervention group adolescents by one investigator on rotation. A 6 months physical activity, diet and sleep record was maintained by the investigators, with the help of physical education teachers for rope exercise and parents for diet and sleep pattern to monitor the progress and compliance. After 3 and 6 months, post-interventional data was collected.

2.5. Data Collection tools/instruments:

The primary dependent variables were the students' bio-physiological variables, including height, weight, Body Mass Index (BMI) and blood pressure. Adopting the BMI Percentile Chart for boys and girls (12, 13), if a child has a percentile ranking of 85th or greater was considered overweight. Age and height adjusted systolic blood pressure (SBP) and diastolic blood pressure (DBP) was estimated for each participant (14,15). Blood Pressure is defined and classified based on 3 readings as normal blood pressure - both SBP and DBP < 90th percentile for the particular age group, Pre-hypertension- an average SBP or DBP between the 90th and 95th percentiles, or if BP 120/80 mm Hg even if below 90th percentile up to < 95th percentile, Stage 1 - SBP or DBP $\geq$ 95th percentile for age, sex, and height and $\leq 99^{th}$ percentile plus 5 mm Hg and Stage 2 - SBP or DBP $\geq 99^{th}$ percentile plus 5 mm Hg. The height percentile was determined using the newly revised WHO Growth Charts to use the tables in a clinical setting. The adolescent's measured SBP and DBP were compared with the numbers provided in the table (boys or girls) according to the child's age and height percentile. The child was normotensive if the BP was below the 90th percentile. If the BP was equal to or above the 90th percentile, the BP measurement was repeated three times with adequate rest to verify and confirm an elevated BP. The tool's reliability was assessed using Cronbach Alpha method and Test-retest methods(r=0.92).

To assess the academic performance of adolescents, their self-reported academic performance was calculated by a question: "In the past 12 months, how has your average academic performance been?". The answers were verified with their previous year school academic records, and the available responses were scored with a 5 - point rating scale including 5

score for very good (average score above 80%) and 1 score for very poor (average score below 35%) respectively.

2.6. Ethical consideration:

Written consent was obtained from the Director, Directorate of Education, Tiruvallur District and Head of the Institution of all the schools selected for the study. Also, written consent from the parents and assent from the adolescents was obtained. The Institutional Ethical Committee approval was obtained from Meenakshi Academy of Higher Education and Research, Chennai.
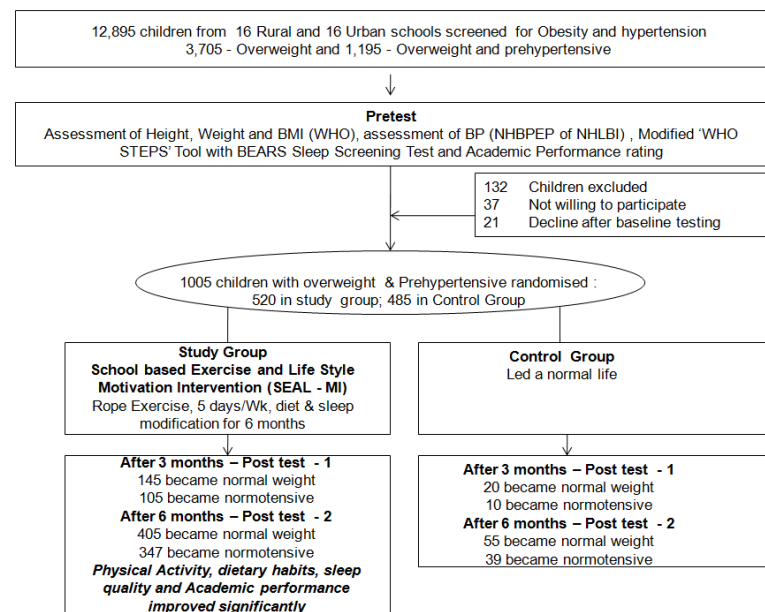
Fig. 1: CONSORT flow diagram of the study

2.7. Statistical Analysis

Bivariate Analysis, Correlation Coefficient, Chi-square test, paired, unpaired 't' test, repeated measures ANOVA, multiple regression analysis was performed to compare scores over a period of time, within and between groups to determine the effect, correlate and associate the variables. All results from this study were presented as mean ± standard deviation. Statistical significance was set at $p<0.05$, and the data were entered into Excel sheet and analyzed through Statistical Package for Social Science/PC$^+$ Ver.17.

Results

In the present study, a total of 12,895 adolescents aged between 13 – 14 years were screened by our team of investigators for overweight and hypertension. Among these adolescents,

3,705 adolescents (28.73%) were found to be overweight, and 1,195 adolescents (32.25%) were found to be overweight and prehypertensive.

Among the 1,195 with overweight and prehypertension, 1005 adolescents and their parents who were willing to participate in the study were selected randomly for the intervention and control group. Among them, 520 and 485 adolescents were allotted by lottery method for intervention and control group respectively. At the end of the first and second post-test, only 500 and 485 adolescents were in the intervention and reference group, respectively, and the attrition rate was 3.85%. It was due to various reasons such as changing school or residence, dropping out from school, etc.

In the first post-test, 145(29%) adolescents from the study group became normal weight which was statistically significant (p = 0.000). After six months of intervention, 405(81%) study group adolescents became normal weight, none of them was obese and only 95 (19%) adolescents were overweight, which was statistically significant (p = 0.000). The comparison of blood pressure status for study and control group adolescents showed that adolescents become normotensive in the posttest-1, 105 (20.2%) study group. In the second post-test, 347 (69.4%) study group adolescents became normal, which were statistically significant (p = 0.000) whereas only 39 (8.3%) of control group became normotensive after six months.

Table 1: Comparison of BMI Status among Study and Control Group

Study Time	Study Group		Control Group		t value
	Mean	S.D.	Mean	S.D.	p value
Pretest	20.3	0.58	20.2	0.51	t = 0.416; p=0.675(N.S)
Posttest-1	20.1	0.63	20.1	0.55	t = 0.474,p=0.635 (N.S)
Posttest-2	20.1	0.64	20.1	0.57	t = 0.257, p=0.797 (N.S)
Repeated ANOVA	F= 3.619, p = 0.036*		F= 1.679, p =0.188(NS)		

The comparison of BMI status among the study and control groups showed a significant difference in the study group between different study periods at p=0.036 level as per repeated ANOVA. In contrast, the control group did not show any statistical difference in the BMI between the study periods (Table 1). Effective score for BMI between study and control group compared by independent "t" test, showed that though it was not significant, the difference found during

both study periods, confirms that the SEAL-MI was highly effective in reducing the BMI among study group as well as it demands the long-term intervention with appropriate reinforcement. Also, the significance level after three months and six months indicates that it was easy to reduce BMI initially and sustain the reduction was the more significant challenge.

Table 2: Comparison of Effective score for BP

Effect Period	Systolic Blood Pressure					Diastolic Blood Pressure				
	Study Group		Control Group		p value	Study Group		Control Group		p value
	Mean (S.D)	p value	Mean (S.D)	p value		Mean (SD)	p value	Mean (S.D)	p value	
Pre to Post test -1	0.27 (0.96)	0.006 *	0.08 (0.57)	0.16	0.10	0.09 (0.34)	0.03 *	0.03 (0.2)	0.32	0.10
Pre to Post test -2	1.57 (1.53)	0.000 *	0.31 (1.01)	0.03 *	0.000 *	0.69 (1.26)	0.000 *	0.12 (0.75)	0.11	0.000 *

Table 2 depicted that in the intervention group, the mean differed SBP is 0.27 with SD of 0.96 in pretest to post test- 1 and 1.57 with SD of 1.53 in Pretest to post-test -2 i.e. after six months of intervention which were significant (p = 0.000). In contrast, the control group did not show any significant difference after three months but showed a significant difference after six months (p = 0.03) due to the time effect. Similarly, the mean differed DBP is 0.09 with SD of 0.34 in pretest to post-test -1 and 0.69 with SD of 1.26 in pretest to post-test - 2, which confirms that the intervention should be long term to bring desired change in DBP. Additionally, this confirms that the SEAL-MI was highly effective in reducing the BP among study group adolescents.
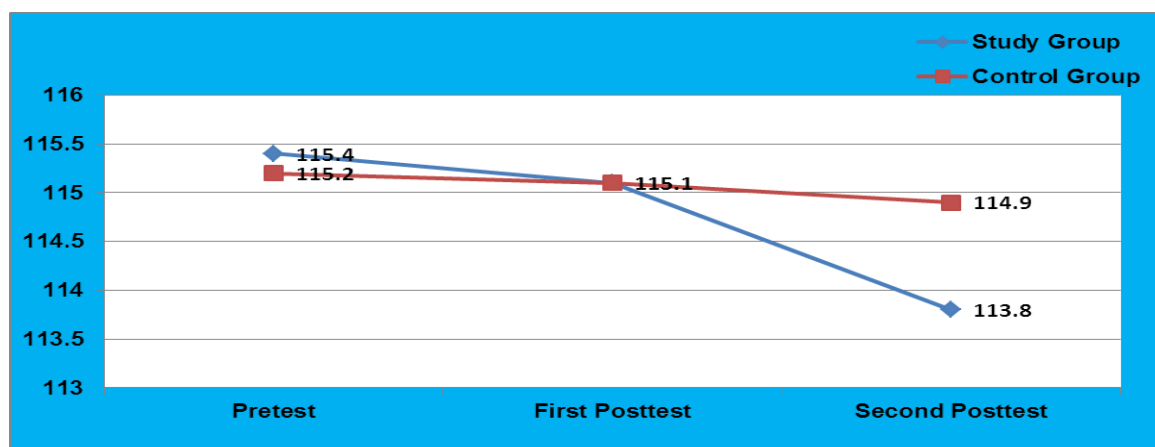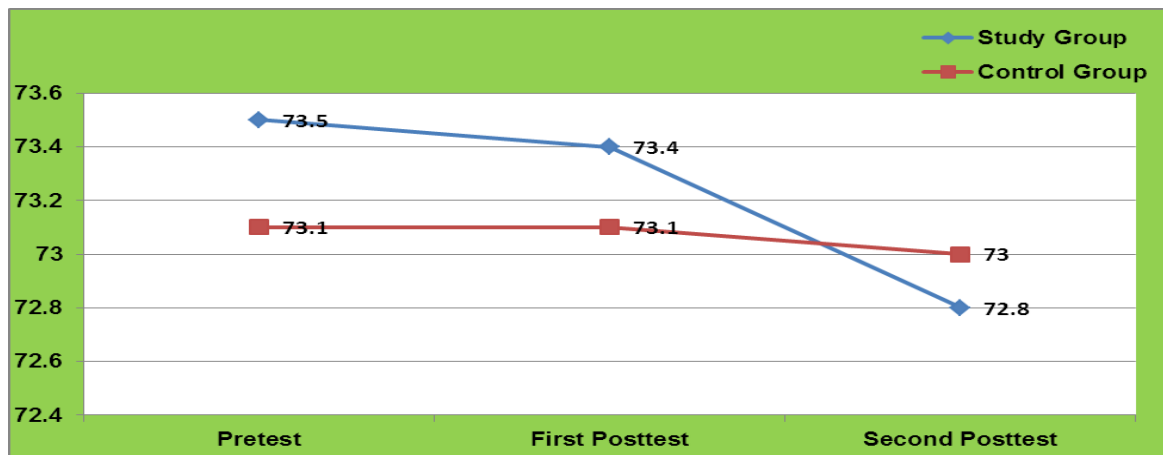
Fig. 2: Comparison of SBP among Study and Control Group

Fig. 3: Comparison of DBP among Study and Control Group

Table 3: Comparison of Effective score for Dietary Habits, Physical Activity and Sleep

Effective Period	Study Group			Control Group			p value
	n	Mean (S.D.)	p value	n	Mean (S.D.)	p value	
Dietary Habits							
Pre to Post Test-1	500	0.46(2.7)	0.91	485	2.55 (5.5)	0.91	0.000 *
Pre to Post test-2	485	6.48 (6.3)	0.000 *	484	1.95 (5.3)	0.11	0.000 *
Physical Activity							
Pre to Post test-1	500	18(9.3)	0.000 *	485	1.89 (5.3)	0.16	0.000 *
Pre to Post test-2	485	49.8(19.5)	0.000 *	484	2.23 (5.7)	0.21	0.000 *
BEARS Sleep Score							
Pre to Post test-1	500	3 (7.6)	0.000 *	485	0.26 (1.8)	0.158	0.000 *
Pre to Post test -2	485	10.31 -14.5	0.000 *	484	0 (2.6)	1.0	0.000 *

Regarding the dietary habits, physical activity and sleep quality based on BEARS Sleep Scale (B = bedtime problems, E = excessive daytime sleepiness, A = awakenings during the night, R = regularity and duration of sleep, and S = snoring), there was a significant difference within the study group at p = 0.000 level after 6 months of intervention (Table 3).

Table 4: Association between BMI and Systolic BP with Demographic Variables of study group adolescents

S.No.	Demographic Variables	BMI			ANOVA F & p - value	Systolic BP			ANOVA F & p − value
		No.	Mean	S.D.		No.	Mean	S.D.	
1	**Gender**								
	Male	226	20.1	0.57	t= 2.918	168	118.4	2.08	F=10.91

	Female	274	20.4	0.55	p=0.004*	332	117.8	2.01	p=0.000*

		PRETEST				POST TEST- 1			POST TEST - 2
2	**Education**								
	7th Std.	274	20.4	0.6	F= 42.293 p=0.000*	244	115	2.1	F=11.94 p=0.000*
	8th Std.	226	20.6	0.58		256	116	1.4	
3	**Number of Family Members**								
	≤ 3	53	20.3	0.42	F= 4.430 p=0.006*	54	116	1.2	F=4.354 p=0.003 *
	4	221	20.4	0.57		233	116	2.2	
	5	125	19.9	0.62		66	115	2.4	
	≥ 6	101	20.3	0.49		147	115	0.9	
5	**Type of family**								
	Nuclear	178	20.4	0.56	F= 3.481 p=0.035*	186	116	2.1	F=6.72 p=0.002*
	Joint	103	20.1	0.64		113	114	1.8	
	Extended	219	20.1	0.55		201	115	1.6	
6	**Family History of Obesity and Chronic Illness**								
	Nil	268	20.4	0.47	F= 2.952 p=0.036*	327	115	2	F=3.083 p=0.031 *
	DM	127	20	0.75		83	117	2	
	HT	72	20.3	0.65		51	116	0	
	Cancer	33	20	0.28		39	118	0	

Regarding association between BMI and systolic BP and demographic characteristics of study group, the ANOVA test findings in table 4 revealed that there was statistically significant association found between the demographic variables such as gender (p = 0.004) (p =0.000), education (p = 0.000) (P=0.000), number of family members (p = 0.006) (p =0.003), type of family (p = 0.035) (p =0.002), family history of obesity and chronic illness (p = 0.036) (p =0.031) respectively with BMI and systolic BP of the adolescents in study group (Table 4).

Table 5: Regression Model describing the Effect of BMI on Demographic Variables of Study group

	Beta coefficient	't'	'p'	95% CI Lower	95% CI Upper	Beta coefficient	't'	'p'	95% CI Lower	95% CI Upper	Beta coefficient	't'	'p'	95% CI Lower	95% CI Upper
Gender	0.29	3.98	0.000***	0.17	0.51	0.34	4.5	0.000***	0.24	0.61	0.47	5.71	0.000***	0.39	0.81
Religion	0.28	4.21	0.000***	0.12	0.32	0.26	3.6	0.001***	0.09	0.32	0.05	0.67	0.505	-0.08	0.18
Age	0.67	8.42	0.000***	0.37	0.6	0.49	5.88	0.000***	0.26	0.52	0.39	4.27	0.000***	0.17	0.46
Birth order	-0.12	1.43	0.157	-0.29	0.05	-0.18	2.06	0.042*	-0.39	-0.01	-0.17	1.79	0.078	-0.41	0.02
Number of Siblings	0.19	1.88	0.063	-0.01	0.41	0.26	2.06	0.024*	0.04	0.53	0.23	1.95	0.054	-0.01	0.54
Family Income(Rs.)	-0.03	0.35	0.728	-0.18	0.12	-0.12	1.46	0.147	-0.34	-0.06	-0.2	2.69	0.009**	-0.41	0.05
Residence	0.14	1.83	0.071	-0.01	0.19	0.1	1.27	0.207	-0.04	0.19	0.19	2.18	0.032*	0.01	0.27
Type of Family	-0.1	0.98	0.328	-0.22	0.08	-0.16	1.47	0.145	-0.29	0.04	-0.25	2.16	0.03*	-0.39	-0.02
R squared value = 60.6%						R squared value = 53.5%									

The linear regression analyses (Table 5) revealed that the gender (ß: 0.47, 95% CI: 0.39, 0.81), age (ß: 0.39, 95% CI: 0.17, 0.46), family income (ß: 0.2, 95% CI: 0.41, 0.5), residence (ß: 0.19, 95% CI: 0.01, 0.27) and type of family (ß: 0.25, 95% CI: 0.39, 0.02) had the strongest correlate with the BMI of the adolescents. This suggests that gender, age, family income, residence and type of family strongly influence the BMI status of adolescents in the descending order.

Table 6: Regression Analysis of SBP with Demographic Variables among Study Group

Demographic Variables	PRETEST Beta coefficient	't'	'p'	95% CI Lower	95% CI Upper	POST TEST- 1 Beta coefficient	't'	'p'	95% CI Lower	95% CI Upper	POST TEST- 2 Beta coefficient	't'	'p'	95% CI Lower	95% CI Upper
Age	0.52	5.624	0.000***	0.88	1.84	0.47	4.77	0.000***	0.71	1.73	0.59	5.82	0.000***	0.7	1.42
Mother's Education	0.26	3.05	0.003**	0.14	0.68	0.23	2.57	0.012*	0.08	0.65	0.35	3.77	0.000***	0.18	0.59
Residence	0.32	3.546	0.001***	0.33	1.17	0.25	2.58	0.012*	0.13	1.01	0.26	2.71	0.008**	0.11	0.73
R squared value = 48.4%						R squared value = 44.4%						R squared value = 44.0%				

The linear regression analyses (Table 6) revealed that the age (ß: 0.59, 95% CI: 0.7, 1.42), Mother's education (ß: 0.35, 95% CI: 0.18, 0.59) and residence (ß: 0.26, 95% CI: 0.11, 0.73) had the strongest correlate with the SBP of the adolescents. This suggests that age, Mother's education status and place of residence strongly influence the SBP status of adolescents in the descending order. In contrast, the DBP was negatively persuaded by age (ß: -0.36, 95% CI: 1.54, 0.29) and gender (ß: -0.26, 95% CI: 1.34, 0.12) of the adolescents (Table 7).

Table 7: Regression Analysis of DBP with Demographic Variables among Study Group

Demographic variables	PRETEST			95% CI		POST TEST - 1			95% CI		POST TEST – 2			95% CI	
	Beta coefficient	't'	'p'	Lower	Upper	Beta coefficient	't'	'p'	Lower	Upper	Beta coefficient	't'	'p'	Lower	Upper
Gender	-0.23	2.13	0.036*	-1.86	-0.06	-0.24	2.21	0.029*	-1.91	-0.1	-0.26	2.38	0.020*	-1.34	-0.12
Age	-0.36	2.87	0.005**	-2.19	-0.4	-0.31	2.46	0.016*	-2.03	-0.21	-0.36	2.91	0.005**	-1.54	-0.29
R squared value = 15.1% ;						R squared value = 20.2%;									

Table 8 : Relationship among BMI, SBP and DBP of study and control group

Study Periods	Correlation variables	Study Group		Control group	
		r - value	p-value	r - value	p-value
Pretest	BMI and SBP	0.412	0.000*	0.169	0.099
	BMI and DBP	0.01	0.918	0.004	0.973
	BMI and Academic Performance	-0.006	0.953	-0.102	0.318
Post Test -1	BMI and SBP	0.355	0.000*	0.0222	0.29 *
	BMI and DBP	0.052	0.607	0.005	0.959
	BMI and Academic Performance	-0.087	0.391	-0.17	0.095
Post Test-2	BMI and SBP	0.421	0.000*	0.0339	0.30*
	BMI and DBP	0.134	0.191	0.002	0.982
	BMI and Academic Performance	-0.301	0.003*	-0.193	0.058

Regarding the relationship among BMI, SBP and DBP of the study group in different study periods, BMI and SBP show a significant positive correlation at p = 0.000 level, proving that BMI was strongly correlated with blood pressure and if the BMI, BP also increases. Hence, there is the greatest need for early diagnosis and treatment of overweight to significantly reduce hypertension status and prevent CVD risk factors at the earliest. Related to academic performance, in the post test -2, there was a significant association of academic Performance with BMI at p=0.003 among the study group adolescents (Table 8).
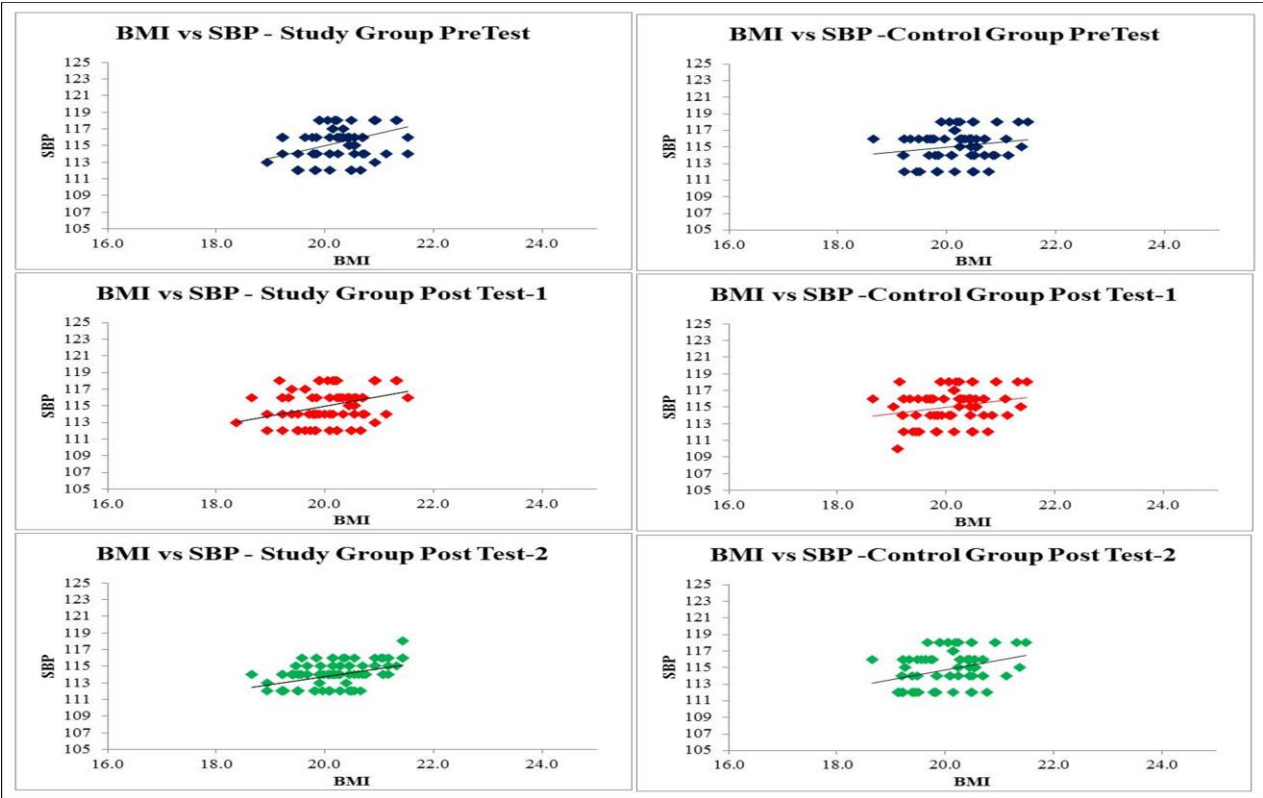
Fig.4: Relationship between BMI and SBP of Study and Control group

Discussion

The present study was carried out to encourage a healthy lifestyle by implementing school-based intervention program (SEAL-MI) among adolescents with overweight and prehypertension. The study's secondary objectives were to find the correlation between BMI and Blood pressure and BMI with academic performance.

In the present study, the intervention group had 520 adolescents and control group had 485 adolescents initially with the dropout rate of 3.85% in the intervention group at the end of the study. Among the 12,895 adolescents screened, 28.73% were found to be overweight, and 9.26% were prehypertensive. Among the overweight adolescents, the prevalence of prehypertension was 32.25%, which was relatively very high. Many studies emphasised the same trend of overweight and hypertension among adolescents (16-20). This finding is consistent with the ORANGE project by Kumaravel V et al., 2014 at Chennai, which concluded that the prevalence of overweight/obesity was 26.4% among children aged 6-11 years at Chennai (21). Regarding the prevalence of hypertension, many studies conducted by various researchers (17-20, 22) including the present study found that the prevalence of hypertension was significantly high among overweight and obese adolescents.

In this study, the reduction in the BMI and BP of the intervention group adolescents was statistically significant at three months and after six months of intervention. The comparison of effective score for BMI and BP in the study group, done by independent "t" test showed that though it was not significant, the difference found during the study periods, indicated that the SEAL-MI was highly effective in reducing the BMI and BP among study group. It also emphasises that long-term intervention with appropriate reinforcement is needed to meet the desired change. It also indicates that it is easy to reduce BMI and BP initially, and sustaining the reduction is the more significant challenge.

A study by Lone DK et al.,*2014* to find the effect of a dietary intervention or dietary intervention plus exercise for 20 weeks, concluded that the exercise and diet group showed a significant decline in SBP than the diet-only group. The study suggested that a chronic aerobic exercise intervention lasting 4 - 8 months, effectively reduces blood pressure in overweight adolescents at high to moderate intensities (24). Ghosh S et al., (2010) also, conducted a study to associate the anthropometric, body compositional and physiological characteristics with physical activities among 469 adolescents concluded that a significant inverse correlation was observed in mean arterial pressure with the duration of walking, cycling and gym (25). These findings were consistent with other studies, suggesting that we need to provide more opportunities for overweight and obese adolescents to be active throughout the week, emphasising physical activity during school hours (23). Additionally, Sung K D et al., (2019) studied the effects of a rope exercise program on abdominal adiposity in adolescent girls with prehypertension. They reported that rope exercise might be an effective intervention to improve these CVD risk factors in prehypertensive adolescent girls. Jumping rope is an easily accessible exercise modality that may have significant health implications for CVD prevention in younger populations (26). These results highlight the importance of multidisciplinary programs including physical exercise and diet education to prevent and treat childhood hypertension, overweight/obesity such as SEAL-MI and emphasise their encouraging long-term positive effects on CVD risk factors.

Regarding dietary habits, physical activity and sleep quality based on BEARS sleep scale, there was a significant difference within the study group at $p = 0.000$ level after 6 months of intervention. According to Kim J et al., (2020), there were significant improvements following the 12-week exercise program for body fat percent, waist circumference (WC), systolic blood pressure (SBP), blood glucose and insulin levels. This study evidenced that rope exercise intervention can be a beneficial therapeutic intervention to improve CVD risk factors in obese adolescent girls with prehypertension (27).

An interesting fact emerged from the study that there was a negative association between the BMI and academic performance of the adolescents during both the study periods. It shows that when BMI increases the academic performance of the adolescents' declines. A similar finding was reported in few other studies as well (28, 29). Obesity increases the risk of developing early puberty in adolescents (30), menstrual irregularities in adolescent girls (31), and sleep disorders such as obstructive sleep apnea (OSA) (32,33). The Excess adiposity may also persuade various aspects of pubertal development, such as pubertal initiation and hormonal parameters during puberty. These alterations may not be harmless. For example, earlier puberty in girls appears to be associated with a higher risk of psychological problems, risk-taking behavior, and even future breast cancer. Obesity during childhood may lead to early signs of puberty (thelarche) in girls and pubertal delay in boys. Girls with obesity are at risk for hyperandrogenemia due to increased total testosterone production and reduced sex hormone-binding globulin (SHBG). Hyperandrogenemia in adolescence may portend adult PCOS and its potential metabolic and cardiovascular complications (34). Though this aspect is not the scope of this study, obesity in the pubertal stage hampers adolescents' sexuality and reproductive health. Hence, screening adolescents for obesity and early intervention to prevent these physical and psychosocial problems in pubertal adolescents is mandatory.

In this study, there was a statistically significant association between the demographic variables such as gender, level of education, number of family members, type of family, family history of obesity and chronic illness with BMI and systolic BP of the adolescents. The present study results were consistent with other studies (35,36). The literature survey on the demographic variables associated with BMI has found moderate to high significance with age (37).

The linear regression analyses revealed that the gender (ß: 0.47, 95% CI: 0.39, 0.81), age (ß: 0.39, 95% CI: 0.17, 0.46), family income (ß: 0.2, 95% CI: 0.41, 0.5), residence (ß: 0.19, 95% CI: 0.01, 0.27) and type of family (ß: 0.25, 95% CI: 0.39, 0.02) had the strongest correlate with the BMI of the adolescents. This suggests that gender, age, family income, residence and type of family strongly influence the BMI status of adolescents and giving importance to the adolescents from urban habitat, from affluent nuclear family and the most crucial point of catching them young will bring significant change in the disease burden. Also, Mother's education Mother's education (ß: 0.35, 95% CI: 0.18, 0.59) had the strongest correlate with the SBP of the adolescents. In contrast, the DBP was negatively persuaded by age (ß: -0.36, 95% CI: 1.54, 0.29) and gender (ß: -0.26, 95% CI: 1.34, 0.12) of the adolescents.

BMI and SBP showed a significant positive correlation in all the three study periods, proving that BMI is strongly correlated with blood pressure and the greatest need for early

diagnosis. The treatment of overweight will have a significant reduction in hypertension status. Numerous studies have been performed across the globe on whether or not physical exercise has a significant positive correlation with weight and cardiovascular risk factors (38- 42). These studies have reasonably concluded that there is indeed a positive correlation, although the correlation coefficient varies from study to study between BMI and BP. The current evidence suggests that exercise intervention with consistent motivation among adolescents improves body composition, mainly by lowering body fat. The limited accessible support further indicates that exercise intervention may improve cardiometabolic risk factors and prevent CVD risk during adulthood.

5. Conclusion

The earlier is the best for any preventive strategies. Lifestyle and behavioural modifications such as physical activity, an adaptation of a balanced diet, and improving sleep quality are the need among adolescents. Regular physical activities and a balanced diet help maintain body weight, blood pressure as well as prevention of cardiovascular diseases in future. In addition, it also promotes the academic performance and reproductive health of the pubertal adolescents. Regular physical activity along with diet modification should be included and implemented strictly in the school curriculum. Nutrition education should start from the home and there should be a continued nutritional education and emphasis of compulsory physical activity, in the school curriculum.

6. Implications

Medical experts can feel confidence in advising parents to address their at-risk children's food choices and exercise patterns instantly at the earliest rather than waiting for overweight and the patterns that promote it to resolve on their own. Identifying adolescent obesity allows healthcare professionals to intervene sooner, to slow the trajectory of aberrant weight gain that leads to the development of obesity-related illness and CVD risk factors. Preventing these will provide a more significant opportunity for the adolescents to grow to their fullest potential physically, psychologically, socially, and emotionally.

Institutional Review Board Statement

Institution Ethical Committee gave an ethical clearance with IEC/LCN/2021-11.

Informed Consent Statement

Written informed consent was obtained from the participants of the study to publish this paper.

Data Availability Statement

The data presented in this study is available on request from the corresponding author.

Declaration of Conflicting Interests

The authors declare no conflict of interest.

Author Contributions

All authors have read and agreed to the published version of the manuscript.

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