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Cardiovascular Disease Risk Factors among Nigerian Pre-Adolescent, Adolescent and Adult Males and Females

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Abstract An increased in cardiovascular disease risk has been reported to be associated with body fat composition, blood pressure and lower aerobic fitness. This study was conducted to find out the difference between pre-adolescent, adolescent and adult males and females in selected disease risk factors. Topography of body fat composition, blood pressure and lower physical fitness were found to be risk factors of cardio vascular disease. A total of one hundred and eighty (180) subjects comprising preadolescents aged 7-11 years (60; M-30, F=30), adolescents aged 12-18 years (70; M=35, F=35) and adults aged 19-30 years (50; M=29, F=21) were selected at random from primary and post-primary schools in Zaria – 12 Minute Run Test was conducted in the evening after all measurements have been carried out. The results of this study revealed significant sex differences between preadolescents, adolescents and adults in blood pressure, body fat percent, BMI, GT, TC, VLDL-C, TC: HDL-C ratio and Vo_2 max as the values increased with advancing age from preadolescent through adolescent to adulthood. While height and weight significantly different, sex differences were mainly due to higher values in female subjects than in male subjects in all the listed variables except in VO_2 max where females recorded lower values than males. Results however, did not show any significant difference between the three groups in HDL-C, and TG suggesting that they had similar HDL-C, and TG levels, whereas insignificant sex differences are found in systolic blood pressure (SBP, TC, LDL-C, HDL-C, TC: HDL-C, ratio TG in the three different age groups indicating that they were very much similar in both male and female subjects. Based on the findings of this study, it was suggested that tracking of changes in blood pressure, fat content and lipoprotein profiles be started early in life, and physical education should form the basis of intervention against sedentary lifestyle.

Keywords Cardiovascular, Risk, Factors, Disease, Pressure

1. Introduction

Physical activity is essential for the health and well-being of all individuals irrespective of age and sex. However, modern scientific and technological developments have led to the production of energy saving machines such as automobiles, grinding amines, electronics (i.e. video and television and radio), milling machines, which have lessened the physical demand of everyday routine activities like going to work, milling stable foods, grinding grains and trekking short and long distances. Though what would have once required an hour or more can now be accomplished in a few minutes by pressing a button. This new trend has led to more leisure activities. This increased leisure is utilized in the pursuit of sedentary activities (Venkateswarlu, 1996; Heyward, 1998; Surgeon General's Report on Physical Activity and Health, 2003).

As a consequence of the high rates of physical inactivity, the number of individuals irrespective of age and sex suffer a host of health problems such as coronary heart disease, hypertension, hypercholesterolemia, obesity, diabetes, overweight, cancer and musculoskeletal disorders (Nieman, 2003; Heyward, 1998).

According to U.S Department of Health and Human Services (2000), reported that people who are physically inactive are at a greater risk of developing and increasing in the accidence of degenerative diseases commonly known as hypokinetic diseases. Current trends in the field of epidemiology, and exercise physiology have shown that disease risk factors tend to influence human health and performance. This led to much discussion among scientific circles regarding the magnitude and direction of the incidence of these disease risks among preadolescents, adolescents, and adults. Although cardiovascular disease risk factors form the broad theme of this paper. However, it was not clear how the different risk factors were modified during growth and development. Another interesting finding was that advancing in age have been found to be a factor for predisposing individuals to high blood pressure, elevated cholesterol and triglycerides, elevated glucose level, body fat percent, body mass index, and low aerobic fitness.

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2. Materials and Methods

An ex-post factor design was used in this research as all the variables measured in this study were already developed. A total of one hundred and eighty (180) subjects preadolescents aged 7-11 years (60) M=30, F=30), adolescents aged 12-18 years (70), M=35, F=35) and adults aged 19-30 years (50) M=29, F=21) whom were selected at random from primary and post-primary schools in Zaria. Series of testing protocols based on age and sex groups were conducted on the subjects. One short case study design was used because it involved a single measurement of performance status without treatment procedure. The three by two by seven (3 x 2 x 7) factorial) design was used for factor analysis and 12 minute run test was conducted in the evening after all measurements have been carried out on the subjects.

3. Measurement Tools

Subject age, sex, height and weight were measured in light clothing (without shoes) with a studio meter and calibrated physicals scale.

Anthropometric measurements were taken and these include height, weight, body mass index (BMI) determined by dividing weight and height indices (Wt) as suggested by Trowbridge 1983, Valerie et al. (1996). Body fat percent (BFP) by using skinfold measures of trunk and limbs (the trunk skinfolds include abdominal, surprailiac, and subscapular; while the limb skin folds include triceps, biceps, and medial calf) as suggested by Australian Health and Fitness survey (1985) and Heyward (1998).

1. Height and heights were measured by using a standardized anthropometric techniques and were recorded in centimeters using a stadiometer (Williams et al, 1986).
2. Weight: Subjects weights were measured by using a calibrated physician's scale (Shemond) while subjects dressed in light cloth without-shoes. All subjects were weighted three times and the average was used to determine the exact weight (Australian Health and Fitness Survey, 1985).

4. Body Fat Percent

A standardized calibrated skinfold calipers was used for the measurement of trunk (abdominal suprailiac, and subscapular), while limb skinfold (triceps, biceps, and medial calf). The calipers was used to measured folds of skin only, and no muscle tissue was included. The fold of the skin and subcutaneous fat was held firmly between thumb and index finger, pulling it away from the underlying muscular tissue and following the natural contour of the fat fold. The caliper was then placed on the skinfold as closely as possible (usually about ½ inch (0.5cm) and a constant with the skin (Heyward 1998, Venkateswarlu, 1992). Skinfold measurements were taken on the right side of the body as suggested by Heyward, 1998; Wilmore, et al, 1994). Three measurements for each side were made and the average was used to determine the fat fold score. Percent body fat was calculated based on age and sex using skinfold prediction equation formular (Slaughter et al, (1988), Jackson and Pallock, 1980).

5. Blood Pressure

Blood pressure was taken in sitting positon (Guyton, 1996) each subject was well-composed while seated on a chair and the calf of the sphygmomanometer was wrapped around his or her left upper arm and gently inflated to a pressure of between 140 to 160mmHg (Guyton, 1996). Heyward, 1998). Subjects were not allowed to see the inflated pressure as this is in order to avoid any anxiety, fear and psychological tremor/effect. Gradually culf was delated at the rate of 2 to 3mmHg per second by unscrewing the control valve of the inflator slowly but steadily while carefully watching the pressure gauge. Systolic blood pressure was recorded by hearing the first highly tapped sound regarded as the first arterial sound, while the arterial sound disappeared a Korotochoff was heard and recorded as diastolic blood pressure (Ganong, 1995). Three measurements were taken and the average found and recorded. Two minutes waited with the culf fully deflated before repeating in order to avoid artifacts caused by venous filling while culf is about venous pressure (Guyton, 1996).

6. Glucose Tolerance Test (GTT)

Sensitive and calorimetric methods for determining blood glucose intolerance was used (function of insulin resistance) among subjects (Juhan-Vague et al., 1993, Morja-Ritta, 1997). Non-fasting blood sample (3mml) were taken and was put into a heparinized tools for blood sugar analysis.

7. Testing Techniques

Blood sugar test was measured by glucose oxidase method using 4 – aminophenazone as oxygen acceptor (Garfield, 1971) and HBA, C was determined by colorimetric method (Parker et al., 1981) with results expressed as fructose equivalents (Heyward, 1998; Marga-Rita, 1997; Zavaroni, et al, 1993).

8. Blood Lipid Profiles (TC & TG) Techniques

Blood lipids obtained from subjects articulated vein without venstasis and collected into a hepanized tubers for blood lipids analysis. (Cooper, Myers, Smith & Sampson, 1988).

9. Statistical Analysis

1. Student's t-Test was used to detect any significance difference between male and female preadolescents, adolescents and adults of the same age group among independent variables.
2. One-way analysis of variance (ANOVA-1) was used to compare demographic and descriptive variables among different age and sex groups in blood pressure, percent body fat, body mass index, glucose tolerance, HDL-C, LDL-C, CLDL-C, and Triglycerides at significant level of 0.05.
3. Scheffes Post-Hoc Multiple Comparison test was used to locate significant difference among independent available (i.e. high blood pressure, percent body fat, body mass index, glucose tolerance, low density LDL-C, HDL-C, age, highest, sex, weight and VO_2 max.

10. Results

Analysis were conducted to identify the differences in cardiovascular diseases risk factors between preadolescents, adolescent and adult males and females in height, weight, blood pressure, bone fat percent, body mass index, glucose tolerance, total cholesterol, triglyceride, LDL-C, HDL-C, VLDL TC/HDL-C, and VO_2 Max and as inferred from the coopers 12 minute Run Test.

One way analysis of variance (ANOVA-1) was performed for differences between preadolescent, and adolescent and adult group in their Height (CM) and weight (Kg) as shown in table two (1) below:

Scheffe's post hoc test reveals significant difference between preadolescents Vs adolescents and adult between adolescents and adults for both height and weight.

Table 1 shows significant differences between different age groups both in height and weight. Scheffe's post hoc test showed that these significant differences were due to significant mean differences between pre-adolescents group and other two groups and between adolescents and adults in both height and weight.

Table 1. One way Analysis of Variance for Differences between Pre-Adolescent and Adolescent and Adult Groups in their Height (Cm) and Weight (Kg)

Variable	Source	df	SS	ms	f
Height (cm)	Between groups	2	45899.8343	22949.9171	233.0627
	Within groups	177	17429.3657	98.4710	
	Total	179	63329.2000		
Weight (Kg)	Between groups	2	32227.2313	16113.6167	285.7304
	Within groups	177	11023.4839	82.2796	
	Total	179	43290.7153		

t-test for Difference Between male and female groups for Height (CM) and weight (Kg) as shown below in table 3.

Observation of Table 2 shows insignificant differences between male and female subjects of the three age groups in height (cm) and weight (kg). This shows that the male and females of each group were similar in their height (cm) and weight (kg).

One-way analysis of variance (ANOVA-1) descriptive information on the different disease risk factors for different age groups as presented below in table 3.

Scheffe's post hoc comparison reveals significant difference between preadolescents versus adolescents and adults in systolic and diastolic blood pressures, body fatness percent, body mass glucose tolerance levels, total cholesterol (TC), HDL-C, LDL-C, VLDL-C, TC/HDL-triglyceride levels and aerobic fitness.

Table 2. t-test for Difference between Male and Female Groups for Height (Cm) and Weight (kg)

Variable	Age	Group	Number	Mean	SD	SE	t-Value
Height (cm)	Preadolescent (7-11 years)	Male	30	129.8333	10.819	1.975	-0.89
		Female					
	Adolescents (12-18 years)	Male	35	160.6857	12.046	2.036	0.37
		Female	35	159.7429	8.869	1.499	
	Adults (19-30 years)	Male	29	170.4828	7.029	1.305	1.22
		Female	21	167.9524	7.579	1.654	
Weight (Km)	Preadolescent (7-11 years)	Male	30	29.8000	4.875	0.890	-1.33
		Female	30	31.7500	6.393	1.169	
	Adolescents (12-18 years)	Male	35	53.2571	12.713	2.149	-0.96
		Female	35	55.6286	7.179	1.213	
	Adults (19-30 years)	Male	29	64.2069	6.858	1.273	1.27
		Female	21	62.0476	4.318	0.942	

Table 3. Mean Values of the Subjects for Blood pressure, Body Fat Percent, Body Mass Index, Serum Cholesterol, Lipoprotein and Triglyceride Levels, Glucose Tolerance, and Aerobic Fitness

Variable	Different Age Groups								
	Pre-Adolescent (7-11 years)			Adolescent (12-18 years)			Adults (19-30 years)		
Systolic Blood Pressure (mmHg)	109.60	8.3812	1.0820	115.46	8.4179	1.0061	120.30	6.3350	0.8959
Diastolic Blood pressure (mmHg)	72.7000	6.3280	0.8169	75.374	7.1752	0.8576	77.8400	6.9440	0.9820
Body Fat Percent	10.3632	1.9038	0.2458	12.7329	2.0550	0.2456	23.8400	1.5867	0.2244
Body Mass Index	17.8757	2.2911	0.2958	20.9704	2.3305	0.2785	22.0018	1.4943	0.2113
Total Cholesterol (mmol/l)	3.1812	9.5190	0.0676	3.5574	0.776	0.929	4.5538	0.9546	0.1350
HDL-C (mmol/l)	1.0250	0.2128	0.0275	1.1157	0.2743	0.328	1.1012	0.2875	0.0407
LDL-C (mmol/l)	2.2322	0.3826	0.0494	2.6146	0.6602	0.790	3.5076	0.9396	0.1329
VLDL-C (mmol/l)	2.7643	0.3773	0.0487	3.2071	0.7110	0.850	4.1064	1.0147	0.1435
TC/HDL-C (mmol/l)	3.1157	0.6354	0.820	3.4759	1.0332	0.1235	4.0936	1.1943	0.1689
TRIG (mmol/l)	1.2018	0.5722	0.739	1.1314	03901	0.0466	1.2550	0.4346	0.615
Glucose Intolerance	2.3405	0.6109	0.789	2.8473	0.9049	0.1082	3.9328	1.248	0.1591
Phsycial/Inactivity Level	18822.8333	552.6181	71.3427	171.5571	506.9440	60.5914	1542.7400	522.0118	73.8236
VO_2 Max (ml/kg/min)	33.6450	9.3239	1.203	32.1957	8.5882	1.0265	29.1560	8.7252	1.2339

Table 4. ANOVA-1 for Difference Between Age Groups in Systolic and Diastolic Blood Pressures, Body Fat Percent, Body Mass Index, Glucose Tolerance Level, Total Cholesterol, Lipoprotein and Triglyceride Levels and Aerobic Fitness

Variable	Source	DF	SS	MS	F
Systolic Blood Pressure (mmltg)	Between groups	2	316.6786	1582.3393	25.4606*
	Within groups	177	4000.2714	62.1484	
	Total	179	14164.9560	362.6686	7.7549*
Diastolic Blood Pressure (mmltg)	Between groups	2	725.3371	46.7665	
	Within groups	177	8277.6629		
	Total	179	9003.000		
Body Fat Percent	Between groups	2	5340.6353	2670.3177	751.9143*
	Within groups	177	628.5905	3.5514	
	Total	179	5969.2258		
Body Mass Index	Between groups	2	527.9094	263.9547	58.8515*
	Within groups	177	793.8619	4.4851	
	Total	179	1321.7713		
Glucose tolerance level (mmol/l)	Between groups	2	71.1619	35.5810	44.8181*
	Within groups	177	140.5199	.7939	
	Total	179	211.6818		
Total cholesterol (mmol/l)	Between groups	2	54.0090	27.0045	46.7372*
	Within groups	177	102.2595	.5778	
	Total	179	156.2785		
HDL-C (mmol/k)	Between groups	2	0.2929	0.1464	2.17552*
	Within groups	177	11.9159	0.0673	
	Total	179	12.2088		
LDL-C (mmol/l)	Between groups	2	46.0312	23.0156	49.6584*
	Within groups	177	82.0357	0.4635	
	Total	179	128.0669		
VLDL-C (mmol/l)	Between groups	2	50.3865	25.1591	47.5114*
	Within groups	177	93.7285	0.5295	
	Total	179	144.0468		
TC/HDL-C (mmol/l)	Between groups	2	26.3865	13.1933	13.9526*
	Within groups	177	167.3675	0.9456	
	Total	179	193.7541		
TC/HDL-C (mmol/l)	Between groups	2	633.3060	316.6530	4.0181
	Within groups	177	13948.6804	78.8061	
	Total	179	14581.9864		

Table 5. t-Test for Differences between Male and Female Groups in Systolic and Diastolic Blood Pressures, Body Fat Percent, Body Mass, Index Glucose Tolerance Level, Total Cholesterol, Lipoprotein and Triglyceride Levels and Aerobic Fitness

GROUPS													
Variable	**Sex**	**Preadolescents**				**Adolescents**				**Adults**			
		N	M	SD	t	N	M	SD	t	N	M	SD	t
Systolic Blood Pressure	Male	30	108.13	8.40	0.177	35	113.57	8.60	-	29	119.62	5.82	-.89 NS
	Female	30	111.10	8.30	NS	35	117.34	7.90	1.91 NS	21	121.23	7.01	
Diastolic blood pressure	Male	30	72.30	6.62	0.53	35	72.80	6.69	-	29	76.75	6.44	-.1.30 NS
	Female	30	73.13	6.10	NS	35	77.94	6.78	3.19*	21	79.33	7.48	
Body fat percent	Male	30	8.74	1.904	-12,82	35	11.21	1.48	-	29	22.96	1.47	-.3.58 NS
	Female	30	11.98	1.054	*	35	14.25	1.26	*	21	24.45	1.32	
Body mass index	Male	30	17.70	2.30	-.57	35	20.20	2.40	-.31	29	22.10	1.64	.44 NS
	Female	30	18.04	2.33	NS	35	21.74	2.02	NS	21	21.89	1.30	
Glucose tolerance level (mmol/l)	Male	30	2.50	.60	2.03	35	2.81	.93	-.74	29	3.87	1.10	-43 NS
	Female	30	2.30	.60	*	35	2.88	.88	NS	21	4.01	1.21	
TC (mmol/l)	Male	30	3.30	.54	1.06	35	3.50	.72	0.13	29	4.30	.79	-2.29*
	Female	30	3.11	.50	NS	35	3.62	.82	NS	21	4.90	1.10	
HDL-C (mmol/1)	Male	30	1.01	.022	-0.54	35	1.12	.30	-	29	1.10	.25	-1.36NS
	Female	30	1.04	.20	NS	35	1.11	.26	0.24 NS	21	1.20	.32	
LDL-C (mmol/l)	Male	30	2.30	.43	1.47	35	2.59	.61	0.04	29	3.42	.83	-.76NS
	Female	30	2.20	.31	NS	35	3.20	.74	NS	21	3.42	1.10	
VLDL-C (mmol/l)	Male	30	2.90	.41	2.10	35	3.2	.64	-	29	3.97	.80	-1.08NS
	Female	30	2.70	.31		35	3.20	.74	0.94 NS	21	4.30	1.24	
TC/HDL-C (mmol)	Male	30	3.24	.70	1.58	35	3.36	.86	1.50	29	4.13	1.10	.27 NS
	Female	30	2.98	.54	NS	35	3.59	1.80	NS	21	4.03	1.40	
TRIG (mmol/l)	Male	30	1.20	.60	-.04	35	1.20	.46	6.20	29	1.22	.40	-.65NS
	Female	30	1.20	.60	NS	35	1.06	.29	*	21	1.30	.50	
VO_2 max (mal/kg/min)	Male	30	40.11	8.50	*	35	37.32	7.84		29	33.46	8.64	5.02
	Female	30	27.80	5.13	6.81	35	27.07	5.84		21	23.20	4.21	

T(58) = 2.00P<0.05 *Significant NS= Not significant

t(68)=2.00 P<0.05 *Significant NS= Not significant

t(48)=2.021 P<0.05 *Significant NS= Not significant

Examination of Table 4 shows significant differences between preadolescents and adults in systolic and diastolic blood pressures, body fat percent, body mass index, glucose tolerance level, total cholesterol, LDL-C, VLDL-C, TC/HDL-C and $V0_2$ Max (ml/kg/min) that was inferred from 12 minutes run test. These significant differences were mainly due to Mean differences between preadolescents versus adolescent and adults. Further observation of Table 5 revealed insignificant difference in HDL-C and triglyceride levels between the three groups.

Examination of Table 5 shows a significant differences between male and female preadolescents, adolescents and adults in body fat percent and aerobic fitness which was determined by $V0_2$ max (ml/kg/min) that was inferred from 12 min run test. Further examination of table 6 revealed a significant difference between male and female preadolescent in glucose tolerance level and VLDL-C. While a significant difference was observed between male and female adolescents in diastolic blood pressure and body mass index. In addition a significant difference was observed between male and female adults in total cholesterol. However, examination of table 6 shows no significant difference between male and female preadolescents, adolescents and adults in HDL-C, LDL-C, TCFL-IDL-C and triglycents levels. Further observation shows no significant difference between male and female preadolescents and adolescents in total cholesterol (TC), adolescents and adult in glucose tolerance adolescents and adults in systolic blood pressure only. While critical observation shows no significant differences between male and female preadolescent and adults in diastolic blood pressure and body mass index. t-test for Difference between Male and Female Groups in Systolic and Diastolic Blood pressures, body fat percent, body mass index, Triglyceride levels and Aerobic fitness as shown in table 5.

The results of the study revealed significant differences between preadolescents. Adolescents and adults in blood pressure body fat percent, MBI, GT, TC VLDL-C, TC: HDL-C ratio and VO_2 max as the values increased with advancing age from preadolescent through adolescent to adulthood. However, all the values of different age's group were within normal range. Furthermore significant sex

differences were found in preadolescents in body fat percent GT level VLDL-C and VO_2 max, in adolescent in diastolic blood pressure (DBP), percent body fat BMI, VO_2 max, and in adults in TC and VO_2 max while height and weight significantly different, sex differences were mainly due to higher value in female subjects than in male subjects in all the listed variable except in VO_2 max where females recorded under value than male results, however, did not show any significant difference between the three groups in HDL-C and TG suggesting that they had similar HDL-C and TG levels, where as insignificant sex difference are found in systolic blood pressure CSBP, TC, LDL-C, HDL-C, TC: HDL-C ratio TG in the three difference age groups indicating that they were very much similar in both male and female subjects.

11. Discussion

On the basis of the findings of this study, the differences between preadolescents, adolescents and adults in disease risk factors which included blood pressure, body fat percent, body mass index, glucose tolerance, total cholesterol, HDL-C, LDL-C, triglycerides and aerobic fitness which was determined by VO_2 max, that was inferred from 12 minutes run test were identified. Research evidence revealed that pre-disposing disease risk factors tend to accelerate the rate of degenerative disorders, like coronary heart disease, atherosclerosis, myocardial infarction, hypercholesterolemia, musculoskeletal disorders and different types of cancer (Wilmore et al, 1994; Venkateswarly 1998; Heyward, 1998; and Maline, 2001).

Results of this study showed significant differences in systolic blood pressure between preadolescents, adolescents and adolescent and adults. One explanation for this difference was mainly because of a gradual increase form the systolic blood pressure level of 109.60 + 8.18mmHg in preadolescents through 115.46 + 8.12 mmHg in adults. This gradual increase in systolic blood pressure is attributed to the increase in height and weight from preadolescents to adolescent and growth associated hormonal modification in both males and females (Williamson, 1993; Fahey, et al 2003). Further explanation revealed that physical activity level during preadolescence and adolescence is much greater than during adulthood and that increased physical activity level decreases blood pressure (Warcham, Man-Yu, Susie, Joanne, Kirsten, Kennedy & Nicholas, 2000; Fahey, et al, 2003). In addition, it has been shown for example, one standard deviation increase in the physical activity level can be associated with a 5mmHg decease in systolic blood pressure in women and a 3mmHg decrease in men (Ebrahim and Smith, 1998). Similarly, growth in stature and the underlying mechanisms that control growth during puberty have independent effect on blood pressure of preadolescents and adolescent males and females (Kazue, et al, 1997). Thus, the underlying mechanisms for the control of lineer growth seen to involved a number of factors, especially genes) nutrition and thyroid hormones 9Kerrigen and Rogel, 1992; Glustin and Veldhuis, 1998). In this regard growth hormone (GH) and thyroid hormone (TH) are considered responsible for preadolescent growth, while gonadal steroids, especially, their interaction with growth harmone (GH) and (IGH) – 1 are of primary importance for the acceleration of growth rate at puberty (Prader, 1984).

Although systolic and diastolic blood pressures for preadolescents, adolescents and adults significantly differs, they were all within, the normal acceptable range for their respective age group-suggesting that they were all normal in their cardiovascular health. This implies that of the age of adolescent and adult groups of this age may not be pre-disposed to cardiovascular diseases due to raise in blood pressure. At the same time this appeared to be an indication of relatively strong hearts, indicating low risk levels for the onset of cardiovascular disease such as heart attack and strokes among these subjects (Hoeger & Hoeger, 2002).

The observations made in this study could be explained on the basis of the fact that the subjects used in this study had no history of insulin dependent diabetes mellitus, therefore glucose level may not change from the normal range (Betteridge, 1997). An alternative explanation is that the subject were non-obese and not overweight.

12. Conclusions

In view of the limitation of this study the following conclusions are drawn from this results.

i. Blood pressure, both systolic and diastolic increased during growth and development with the increased in height and weight.
ii. Body composition changes during growth and development with age, height and weight, as body fat percent, body mass index and TC increased. However, changes in TG during growth and development are insignificant.
iii. Lipoprotein like LDL-C, VLDL-C, and development with age. However, changes in HDL-C during growth and development are insignificant.
iv. Physical working capacity (PWC) as determined by VO_2 max increases from preadolescents through adolescents to adulthood.
v. Although, female have greater body fat percent and lesser physical working capacity (PWC) in different age groups, their TC and HDL-C levels are not significantly different from their male counterparts.

13. Recommendations

On the basis of the findings of the study, the following recommendations are made to improve the health of preadolescents, adolescents and adults. This study shows increase in blood pressure and fat composition of the body with increasing age. It is therefore suggested that tracking of

changes in blood pressure, fat content and lipoproteins should be started right from preadolescence period so as to take appropriate measures to control body composition and lipoprotein levels of preadolescents as they grow.

This study has shown increased physical working capacity (PWC) with increase in age. However, previous studies have shown that inactivity leads to the incidence of a variety of degenerative diseases. As pre-adolescents are fit enough to undergo exercise, suggesting that they should be encouraged to participate in moderate to vigorous physical activities through school physical education programme and community fitness programmes. Introduction of such programmes at an early age will help individuals maintain active lifestyle throughout their lives that would enhance their health and productivity.

This study has shown that fat composition and lipoproteins of the body dramatically increases right from preadolescent period, especially in females. It is therefore suggested that through medical examination should be conducted during adolescence in order to determine the direction of lipid and lipoprotein modifications so as to use appropriate interventions that can promote the health of the individuals. It is also therefore suggested that public, private and non-profit organizations should utilize different means to educate the general populace about the importance of leading an active lifestyle. This can easily be achieve through mass media and voluntary organizations.

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