Chapter – II

REVIEW OF RELATED LITERATURE

The investigator has made sincere efforts to locate both critical and allied literature pertaining to the present study. All the available resources are explored to identify the related literature and the same has been reviewed and presented in this chapter.

Pahkala, et. al.\(^1\) had conducted a study on obesity, sedentary lifestyle and poor cardio respiratory fitness in childhood may increase the risk of health problems later in life. The authors studied the association of early childhood weight status with cardio respiratory fitness and leisure-time physical activity (LTPA) in adolescence. The stability and associations of LTPA and fitness from childhood through adolescence were also studied. Body mass index (BMI) was assessed annually since birth in a prospective, longitudinal study. The mean BMI between ages 2 and 7 years indicated weight status at preschool age. Fitness was

studied with a shuttle run test at age 9 and with a maximal cycle ergometer test at age 17. The same questionnaire was used to assess LTPA at age 9, 13 and 17. Complete data on preschool BMI, LTPA at ages 13 and 17 and fitness at age 17 years was provided by 351 children, while fitness and LTPA data were available for 74 children at ages 9 and 17. Preschool BMI was inversely associated with fitness in adolescence independently of adolescent LTPA (p=0.0001). Children who had a high preschool BMI but whose weight status was reduced in adolescence had similar fitness in adolescence as the children with a persistently low BMI. Regardless of the fitness level in childhood, the children whose LTPA increased between age 9 and 17 had a similar adolescent fitness level as persistently active subjects. It is important to maintain a healthy body weight and a physically active lifestyle from very childhood through adolescence to improve fitness during adolescence.
Suarez, et. al.\textsuperscript{2} the objective of this study was to examine the association of preadolescent obesity using body mass index (BMI) and waist circumference (WC) with health-related physical fitness components. Grades 4 to 6 students in 2 private schools in Manila were included in this study. Height, weight, WC, and BMI were obtained. Physical fitness field tests were sit-and-reach test, 1-minute sit-ups, standing broad jump, 40-m sprint, and 20-m shuttle run. Obese subjects had poorer scores in the field tests except in the sit-and-reach test. BMI and WC were significantly negatively associated with all the physical fitness parameters, except for the 40-m sprint where positive correlation was observed, and in the sit-and-reach test where no correlation was seen. In the management of preadolescent overweight and obesity, exercise programs should therefore be designed toward enhancing these fitness parameters, while not sacrificing enjoyment and creativity.

Singh, et. al.\textsuperscript{3} there is increasing evidence that the development of underweight and obesity in children has deleterious social and health consequences. This study was conducted to determine the prevalence of underweight and obesity in urban and rural areas of NCR Region. Total of 100 students ages 8–12 were selected from different schools of urban and rural areas. The results found were alarming. The prevalence of underweight was 88\% in rural areas and 68\% in urban areas irrespective of age and gender. Given the high prevalence of underweight that we found in the NCR Region, primary and secondary prevention measures are needed in order to reduce the proportion of non-transmissable diseases among NCR Region in the coming decades. There are differences linked to different factors like dietary intake, physical activity, and family history of underweight and social class that must be further investigated.

Niemi, et. al.\textsuperscript{4} investigated the independent associations and the possible interaction of body mass index (BMI), leisure time physical activity (LTPA) and perceived physical fitness and functional capability with the risk of mortality. Prospective 16y follow-up study. A regionally representative cohort of 35-63-y-old Finnish men (n= 1,090) and women (n= 1,122). All-cause, cardiovascular disease (CVD) and coronary heart disease (CHD) mortality were derived from the national census data until the end of September 1996 while the initial levels of BMI, LTPA, physical fitness and function were determined from self-administered questionnaires. After adjustment for age, marital and employment status, perceived health status, smoking and alcohol consumption, the Cox proportional hazards model showed that BMI was not associated with the risk of death among the men or the women. Compared with the most active subjects the men and women with

no weekly vigorous activity had relative risks of 1.61 (95% confidence interval, CI, 0.98-2.64) and 4.68 (95% CI, 1.41-15.57), respectively, for CVD mortality, and for the men there was a relative risk of 1.66 (95% CI, 0.92-2.99) for CHD mortality. When compared with the men who perceived their fitness as better than their age-mates, the men with the 'worse' assessment had a relative risk of 3.29 (95% CI, 1.80-6.02) for all-cause mortality and 4.37 (95% CI, 1.80-10.6) for CVD mortality. In addition, in the comparison with subjects with no functional difficulties, the men and women who had some difficulty climbing several flights of stairs had relative risks of 1.47 (95% CI, 0.97-2.23) and 2.39 (95% CI, 1.25-4.60) for all-cause mortality, respectively. For CVD mortality the relative risks were 1.85 (95% CI, 1.04-3.30) and 3.38 (1.22-9.41), respectively. Although BMI did not prove to be an independent risk factor for mortality from CVD, CHD or from all causes combined, perceived physical fitness and functional capability did. An increase in LTPA seems to have a similar
beneficial effect on the mortality risk of obese and non obese men and women, and the effect also seems to be similar for fit and unfit subjects.

Ortlepp, et. al., Obesity is a well-accepted cardiovascular risk factor associated with hypertension and hyperlipidaemia. A body mass index (BMI) within the range of 18.5–25 kg/m² is considered normal. To prevent cardiovascular diseases regular physical activity and abstinence from smoking are strongly recommended. Since it is not evident that a lower optimal threshold exists concerning cardiovascular risk factors if other lifestyle conditions are apparently optimized, we studied the relation between BMI and vascular risk factors in 3127 hyper healthy Caucasian males. They were aged between 18 and 23 y, were nonsmokers, without regular alcohol intake, and had at least 3 h of sports activity per week. Their BMI was below 25 kg/m². Low BMI

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revealed to be significantly associated with high physical fitness, low blood pressure, and low serum lipids. The lower the BMI was, the more favorable these parameters were. Thus, the threshold for an optimal BMI concerning cardiovascular risk factors might be far below 25 kg/m$^2$ even if other lifestyle conditions are apparently optimal.

Cruz, et. al.$^6$ the aim of this study was to examine the relationship between physical fitness (PF), physical activity (PA), and body mass index (BMI) among adolescents who attended secondary school. A total of 131 healthy students (49 boys, 82 girls) age 14 to 18 years (M=16±1) participated in the study. PA was assessed by a questionnaire based on the practice of organized and non-organized PA on a regular basis. PF level was determined by the Pacer test and allowed to label the individuals as ‘not fit' or ‘fit' according to the Fitness gram. The individuals were also profiled according to their fat levels as ‘not fat' or ‘fat' also based

on the Fitness gram. Qui-square and t-test were performed to analyze the relationship between PF, PA, and BMI. Boys and girls were analyzed separately. 66% of the boys and 38% of the girls were considered fit based on PF test. Still the majority of students did not meet the recommended 1 h/day of MVPA. The average time spent doing PA was 2.9±2.2 h/day for the boys and 1.8±1.5 h/day for the girls.

The difference in PA participation levels was significant between boys and girls (p=0.005). Almost all students were considered fit based on BMI (84% boys, 79% girls) and no differences were found between genders (p=0.531). Although the most active boys and girls performed better on PF test, a relationship between PF and PA was not found (boys p=0.069, girls p=0.079). For both genders, students with lower BMI had better results on the PF test, however only for the boys the results were significant (p=0.009).

Additionally, there was no relationship between the practice of PA and BMI for boys (p=0.883) and girls (p=149). There are no
relationships between PF, PA and BMI. The only exception was observed for the boys; those with lower BMI had better results on the PF test.

Nikolaidis and Ingebrigtsen⁷ the main objective of this study is to examine the relationship between elevated Body Mass Index (BMI) and selected physical fitness variables in male handball players. In addition, we investigated whether this relationship is age-dependent, i.e., whether a higher BMI has the same implications for physical fitness in adolescents as in adult players. Therefore, adolescent (n = 57, aged 14.9±1.4 yr) and adult (n = 39, 26.6±5.7 yr) participants performed a series of anthropometric and physical fitness measures. In adolescent players, BMI was inversely related with countermovement jump (r = -0.26, P<0.05), mean power during a 30-s Bosco test (r = -0.30, P<0.001) and handgrip muscle strength (r = -0.52, P<0.001). Further, BMI was in direct

relationship with fatigue index of the Wingate anaerobic test \( (r = 0.29, \ P<0.05) \). Correspondingly lower and non-significant correlations were found in adult players. Also, in the latter players, there was an inverse association between BMI and maximal anaerobic power during the force-velocity test \( (r = -0.34, \ P<0.05) \).

The present findings indicate that elevated BMI is more strongly inversely related to physical fitness in adolescent compared to adult team handball players.

Chakraborty, et. al.,\textsuperscript{8} the relationship between body mass index (BMI) and percent body fat (PBF) with central adiposity measures varies between ethnic groups and it has not been much studied in low socio-economic groups in India. Therefore, this study was undertaken to test the relative efficacy of waist circumference (WC), hip circumference (HC), waist hip ratio (WHR) and conicity index (CI) to predict BMI and PBF among Bengalee Hindu male slum dwellers. A total of 465 adult (aged 18-

72 years) male slum dwellers of Bengalee Hindu ethnicity were included. Standard anthropometric techniques and formulae were used. WC showed the strongest significant ($p < 0.001$) partial correlation with BMI and PBF (0.82 and 0.77, respectively).

Stepwise multiple linear regression analyses of BMI and PBF with the central adiposity measures revealed that WC had the strongest impact on BMI and PBF.

On the other hand WHR, HC and CI had weaker effect. Moreover, WC alone accounted for about 67 and 60 per cent of the variations, respectively, of BMI and PBF. The models involving only WC and CI, explained almost similar proportions of variations ($adjR^2 = 94.1$, and 69.4, respectively). Furthermore, the WC was found to best predict BMI ($R^2$ Change = 0.666; $F$ Change = 921.32, $p < 0.001$) and PBF ($R^2$ Change = 0.597; $F$ Change = 686.66, $p < 0.001$). Even after controlling for each other, i.e., BMI and PBF (results not shown) WC had the strongest significant impact on these two measures. Therefore, in this population, WC may be
preferred over other measures of central adiposity in studies dealing with obesity and cardio vascular disease risk factors.

Bose, et. al., there exists no ethnic-specific reference percentile values of body mass index (BMI) for pre-school children of Bengalee ethnicity. The research attempted to develop age and gender–specific reference values of BMI for pre-school children of Bengalee ethnicity. This cross-sectional study was undertaken on 2016 Bengalee children (930 boys and 1086 girls) from Chapra Block of Nadia District, West Bengal, India. Weight and height were measured and BMI was computed. The BMI values were smoothed and developed using the LMS method.

For boys and girls, the median BMI at age three years were 14.94 kg/m2 and 14.59 kg/m2, respectively. These values decreased with advancement of age in both sexes. The L, M, S values, and age and sex specific percentile values were developed. Results showed that median BMI at all ages were lower than WHO reference medians.

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The proposed values may be useful in evaluating growth and nutritional status of rural Bengalee preschool children. They may also be used for comparisons with other ethnic groups.

Nanaware, et. al.,\textsuperscript{10} the present study was conducted to study correlation of Body Mass Index (BMI) with blood pressure in school going children and adolescents. Study population consisted of 400 male students between the age group of 8-16 years which were grouped as Group I: 8-12 yrs and Group II: 13-16 yrs with 200 students in each. Height and weight recorded to calculate Body Mass Index (BMI). Blood pressure was recorded as recommended by the fourth report on diagnosis, evaluation and treatment of high blood pressure in children and adolescents. The statistical analysis was done using correlation t-test. There was significant positive correlation between BMI with both systolic as well as diastolic blood pressure in both groups. The mechanism by which excess fat

deposition (obesity) influences BP in children and adolescents appears to be through increased sympathetic activity, renin-angiotensin-aldosterone system activation, and compression of kidneys. Changes in insulin sensitivity and its compensatory hyperinsulinaemia lead to sodium and water retention and stimulation of sympathetic activity, which may in turn lead to hypertension. The recognition of obesity (as assessed by BMI) in the present study as important factors associated with increased risk of developing elevated BP among children and adolescents may help target prevention towards high-risk individuals in this age group. This is especially important because of evidence linking adolescent obesity with metabolic abnormalities and risk of cardiovascular diseases in adulthood.

Khadilkar, et al.,11 the assessment of growth is crucial in child care and reference data are central to growth monitoring. As the pattern of growth of a population changes with time it is

recommended that references be updated regularly. To produce contemporary growth curves for Indian children from 5-18 years for height, weight and BMI.

Multicentre, School based. Participants: 19834 children were measured from 10 affluent schools from five major geographical regions of India. Data were analyzed on 18666 children (10496 boys and 8170 girls) using the LMS method and smoothed percentiles 2007 were produced. Compared to the 1989 data, median height at 18 years was 0.6 cm greater for boys but unchanged for girls, while the 97th height percentile had increased by 1.7 cm for boys and 2 cm for girls. Boys and girls were heavier and taller at almost all ages. The study also showed that boys and girls were taller at a younger age. Contemporary cross sectional reference percentile curves for height, weight and body mass index for the assessment of physical growth of present day
Zhao, et. al.,\textsuperscript{12} the study sample included 8941 students aged 7 to 18 years in Anhui who attended the Physical Fitness and Health Surveillance program of Chinese School Students, in 2010. Within each sex- and age-specific group, students were classified into five BMI categories which were: very low, BMI < 5th percentile; low, BMI ≥ 5th but < 15th percentiles; normal, BMI ≥ 15th but < 85th percentiles; high, BMI ≥ 85th but < 95th percentiles; and very high, BMI ≥ 95th percentiles. Z-scores based on urban-rural, sex- and age-specific means and standard deviations were calculated, and the sum of Z-scores for the fitness tests was used as a PFI. Differences in PFI between BMI categories were compared with ANOVA. Sex- and grade-specific regressions of PFI on BMI were done by using a linear model.

For 8941 students, the PFIs on very low, low, normal, high and very high group were -1.77, -0.91, 0.32, -0.17 and -0.54,

respectively, and showed an inverted U shape. The normal BMI group students presented the highest PFI. Data from Linear regression analysis revealed that PFI was significantly positively correlated with BMI, while negatively associated with BMI square, which indicated that PFI was the quadratic function of BMI. When BMI was increasing, PFI showed a parabolic curvilinear. Relationships between BMI and PFI were parabolic curvilinear among the children and adolescents aged 7 to 18 in Anhui province.

Eliakim, et. al.,\textsuperscript{13} effect of a weight assessed the management programme on body weight, body mass index (BMI), and fitness in obese children and adolescents. The study was designed as a longitudinal, non-randomised, clinical experience of a 3 and 6 month combined dietary-behavioural-exercise intervention. A total of 177 obese children (age 6-16 years) participated in the 3 month programme, of whom 65 completed the 6 month intervention. A

group of 25 age- and maturity-matched obese children who did not participate in the structured programme served as controls. Body weight, BMI, and fitness were evaluated at baseline, and after the 3 and 6 months intervention. Body weight and BMI were significantly reduced (P<0.05), and endurance time significantly increased (P<0.0005) following the 3 months intervention. Obese children who continued the programme for 6 months maintained the decrease in BMI and further improved endurance time. In contrast, obese children who did not participate in the structured programme gained weight, increased their BMI, and improved fitness less significantly. Gender, pubertal status, and the degree of obesity had no influence on BMI changes. A combined, structured multidisciplinary intervention for childhood obesity results in decreased body weight, decreased body mass index and improved fitness.
Sola, et. al.,\textsuperscript{14} to investigate the feasibility and impact on BMI and physical fitness of an intervention for obese and inactive children, based on physical activity and carried out in primary health care. A prospective, longitudinal one-year follow-up study. The community of Kristiansand, Norway (80 000 inhabitants). A 40-week structured intervention based on physical training with some lifestyle advice for the obese child and one parent. A total of 62 physically inactive children aged 6-14 years with iso-BMI $\geq 30$ kg/m$^2$. Body mass index (BMI), maximum oxygen uptake, and physical fitness in tests of running, jumping, throwing, and climbing assessed at baseline and after six and 12 months as well as number of dropouts and predicting factors. A total of 49 out of 62 children completed the first six months and 37 children completed 12 months. Dropout rate was higher when parents reported being physically inactive at baseline or avoided physical participation in

the intervention. The children's maximum oxygen uptake increased significantly after 12 months from 27.0 to 32.0 ml/kg/min (means), as did physical fitness (endurance, speed, agility, coordination, balance, strength) and BMI was significantly reduced. This one-year activity-based intervention for obese and inactive children performed in primary health care succeeded by increasing cardiovascular capacity and physical fitness combined with reduced BMI in those who completed. Dropout was substantial and depended on the attendance and compliance with physical activity by the parents.

Chen, et. al.,\textsuperscript{15} current body mass index (BMI) norms for children and adolescents are developed from a reference population that includes obese and slim subjects. The validity of these norms is influenced by the observed secular increase in body weight and BMI. We hypothesized that the performance of children in health-

related physical fitness tests would be negatively related to increase BMIs, and therefore fitness tests might be used as criteria for developing a more appropriate set of BMI norms. We evaluated the existing data from a nation-wide fitness survey for students in Taiwan (444,652 boys and 433,555 girls) to examine the relationship between BMI and fitness tests. The fitness tests used included: an 800/1600-m run/walk; a standing long jump; bent-leg curl-ups; and a sit-and-reach test. The BMI percentiles developed from the subgroup whose test scores were better than the ‘poor’ quartile in all four tests were compared with those of the whole population and linked to the adult criteria for overweight and obesity. The BMIs were significantly related to the results of fitness testing. A total of 43% of students had scores better than the poorest quartile in all of their tests. The upper BMI percentile curves of this fitter subgroup were lower than those of the total population. The 85th and 95th BMI percentile values of the fitter 18-Year-old-students (23.7 and 25.5 kg m\(^{-2}\) for boys; 22.6 and 24.6
kg m\(^{-2}\) for girls) linked well with the adult cut-off points of 23 and 25 kg m\(^{-2}\), which have been recommended as the Asian criteria for adult overweight and obesity. Hence, the BMI norms for children and adolescents could be created from selected subgroups that have better physical fitness. We expect that the new norms based on this approach will be used not only to assess the current status of obesity or overweight, but also to encourage activity and exercise.

Mak, et. al.,\(^{16}\) this study was designed to investigate the relation between health-related physical fitness and weight status in Hong Kong adolescents. 3,204 students aged 12-18 years participated in the Hong Kong Student Obesity Surveillance (HKSOS) project in 2006-2007. Anthropometric measures (height, weight) and health-related fitness (push-up, sit-up, sit-and-reach, 9-minute run) were assessed. Body mass index (BMI) was computed to classify participants into normal weight, underweight (Grade I,\(^{16}\)Kwok-Kei Mak, Sai-Yin Ho, Wing-Sze Lo, G. Neil Thomas, Alison M. McManus, Jeffrey R. Day and Tai-Hing Lam, “Health-Related Physical Fitness and Weight Status in Hong Kong Adolescents”, **BMC Public Health**, (2010) Vol. 10: 88.)
II/III), overweight, and obese groups. The associations of health-related physical fitness with BMI and weight status were examined by partial correlation coefficients and analysis of covariance, respectively. More boys than girls were overweight or obese (18.0% vs 8.7%), but more girls than boys were underweight (22.3% vs 16.7%). Boys performed significantly (P < 0.001) better in sit-up (38.8 vs 31.6 times/min) and 9-minute run (1632.1 vs 1353.2 m), but poorer in sit-and-reach (27.4 vs 32.2 cm) than girls. All four physical fitness tests were significantly positively correlated with each other in both sexes, and BMI was only weakly correlated with sit up and sit-and-reach tests in boys. Decreasing performance (P for trend < 0.05) was observed from normal weight to overweight and obese for push-up, sit-up, and 9-minute run in both sexes. From normal weight to Grade I and Grade II/III underweight, decreasing performance (P for trend < 0.05) for sit-up and sit-and-reach in both sexes and for push-up in boys was observed.
The relations between BMI and health-related physical fitness in adolescents were non-linear. Overweight/obese and underweight adolescents had poorer performance in push-up and sit-up tests than normal weight adolescents. Different aspects of health-related physical fitness may serve as immediate indicators of potential health risks for underweight and overweight adolescents.

Stea, et. al.,\(^{17}\) few studies have focused on the potential relationship between parental educational level and cardiovascular risk factors among young male adults. The aim of this study was to investigate cardiovascular disease risk factors among young men and whether body mass index (BMI), serum lipids, physical fitness and smoking habits were related to paternal and maternal education. In this cross-sectional study 750 18- to 26-year-old male recruits participated. Linear regression analyses showed that the paternal education was inversely associated with BMI \( (P = 0.035) \)

and the concentration of total cholesterol ($P = 0.003$) and low-density lipoprotein (LDL) ($P = 0.014$). Running performance was inversely related to cigarette smoking ($P = 0.022$) and the concentration of triacylglycerol ($P = 0.001$). BMI was positively related to the concentration of LDL ($P = 0.002$), total cholesterol/high-density lipoprotein (HDL) ratio ($P < 0.001$) and inversely related to the concentration of HDL ($P < 0.001$), running performance ($P < 0.001$) and muscular strength ($P = 0.011$). Recruits with low BMI, both high and low fitness, had a significantly better lipid profile than recruits with high BMI and low fitness ($P \leq 0.016$). A lower concentration of triacylglycerol ($P \leq 0.001$) and a higher concentration of HDL ($P = 0.034$) were further shown among recruits with high BMI/high fit compared to recruits with high BMI/low fit. High paternal educational level was associated with a lower BMI and a better lipid profile among young adult men. Furthermore, men with low BMI, both high and low fat had a better lipid profile than those with high BMI/low fit. Men
with high BMI/high fit had a better lipid profile that those with high BMI/low fit.

Huang, et. al., the purpose of the study was to evaluate the cross-sectional relationship between BMI and a physical fitness index (PFI) based on four indicators of fitness in a national sample of Taiwanese youth. Height, weight, and four measures of physical fitness (sit-ups completed in 60 s, standing long jump, sit and reach, and 800- or 1600-m run/walk) were measured in a national sample of 102,765 Taiwanese youth 9-18 yr of age: 50,940 girls and 51,825 boys. BMI was calculated for each subject. Within each sex-specific half-year age group, students were classified into five BMI categories based on national percentiles: very low, BMI or = 5th but or = 15th but or = 85th but or = 95th percentiles. Z-scores based on sex-and age-specific means and standard deviations were calculated, and the sum of z-scores for the four fitness tests was used as a PFI. Differences in PFI between BMI categories within

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each sex-specific half-year age group were compared with ANOVA with Bonferroni adjustments. Sex-specific regressions of PFI on BMI, using a nonlinear quadratic model, were done in four broader age categories. Relationships between BMI and PFI are nonlinear and vary with age from late childhood through adolescence. With increasing age during adolescence, the relationship becomes parabolic, and the peaks of the parabola are sharper in adolescent boys than girls. PFI declines in a curvilinear manner with increasing BMI among youth 9-18 yr of age, but the slope of the relationship varies with age.

Ramachandran, et. al.,\textsuperscript{19} the present study on body mass index and health related physical fitness of school children was undertaken with the view of portraying the health related fitness profile of school children in Kannur district of Kerala. Data on body mass index and health related fitness according to

ICHPER.SD Asia Youth Health Related Fitness test was collected from 1000 school children from different schools of Kannur district, Kerala. The study had sub samples of 250 boys and 250 girls from schools belonging to urban areas; and 250 boys and 250 girls belonging to rural areas. The data on BMI and health related fitness variables of the study were comparable to the data of Indian counterparts shown in previous studies. The analysis of data revealed that girls had significantly greater BMI as compared to boys. However, boys scored significantly better than girls on one mile run, sit ups and modified pull ups. Girls were significantly better than boys in case of flexibility performance in the sit and reach test. In case of sum of skin folds, girls had significantly greater skin fold measurements as compared to boys. Rural sample of school children scored significantly better than urban school children unmodified pull ups. In case of sum of skin folds, urban school children had greater skin fold measurements as compared to their rural counterparts. The study warrants the need for further
investigations covering a wider segment of population and taking other vital parameters such as nutritional status, physical activity patterns, and socio-economic conditions so as to obtain meaningful relationships.

Monyeki, et. al., the purpose of this study was to determine the relationships between the body composition characteristics, body mass index (BMI), sum of skin folds (SSF), % body fat (%BF), fat-free mass (FFM) and waist-to-hip ratio (WHR), and nine physical fitness items in undernourished rural primary school children in Ellisras, South Africa. The study consisted of 462 boys and 393 girls who were aged 7–14 y. Five body composition measures were assessed: BMI, SSF, %BF, FFM and WHR. Nine physical fitness test items were assessed: standing long jump, bent arm hang, sit-ups, 10 5 m shuttle run, 50 m sprint, 1600 m run, flamingo balance, sit and reach, plate tapping. BMI was highly

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correlated with FFM (r=0.7, P<0.001). In line with findings from Western countries, regression coefficients (B) showed that children with higher BMI or SSF performed worse in bent arm hang (girls, B=-0.84, P<0.001, and B=-0.06, P=0.02, respectively) and in 1600 m run (B=6.68, P<0.001). BMI was significantly associated with flamingo balance (B=0.26, P=0.04). WHR was positively associated with bent arm hang (B=9.37, P=0.03), and inversely with sit and reach (B=-7.48, P=0.01). In contrast, significant relationships were found between BMI and standing long jump (B=0.74, P=0.04), sit and reach (B=0.51, P<0.001), flamingo balance (B=0.26, P=0.04) and plate tapping (B=-19, P=0.01). SSF was significantly associated with sit and reach (B=0.04, P=0.03). Significant inverse associations were found between FFM and bent arm hang (girls, B=-0.06, P=0.05), 1600 m run (girls, B=-2.33, P=0.003) and 50 m run (boys, B=-0.11, P=0.006). FFM was significantly associated with standing long jump (boys, B=0.99, P<0.001; girls, B=0.73, P<0.001), flamingo balance (B=0.17, P<0.001), and
with sit and reach (boys, B=0.59, P=0.03).

In the present study in undernourished children, body composition was significantly related to physical fitness, but not always in the expected direction. It is therefore important to note that in this population, BMI should not be interpreted as a measure of fatness/overweight, but rather as an indicator of muscle mass.

Ostojic, et. al.,\textsuperscript{21} lack of physical activity and/or physical fitness are some reasons epidemiologists suggest for increase in childhood obesity in the last 20 years, with clear correlation between body composition and physical activity and/or physical fitness yet to be determined. The objectives of the study were to (a) investigate the prevalence of overweight and obesity among Serbian school children and (b) determine the relationship between indicators of physical activity and body fatness in Serbian school children aged 6-14 years. The study subjects included a

representative sample of Serbian elementary school children (n=1,121-754 boys and 367 girls - aged 6.2-14.1 years), all of whom were recruited in the OLIMP (Obesity and Physical Activity among Serbian School Children) study. Anthropometric and physical fitness values, including body mass index (BMI), waist-circumference, body-fat, and aerobic capacity, were measured in all the children. Significant differences were found between male and female children regarding the prevalence of obesity (6.8% vs 8.2%, p<0.05, boys and girls respectively). Boys had significantly lower body mass, BMI, waist-circumference, sum of six skin folds, and body-fat compared to their female counterparts (p<0.05). The highest level of weight, BMI, body-fat, and waist-circumference observed in a 14-year old girl (96.3 kg, 40.5 kg/m², 54.5%, 91.4 cm respectively) implies the existence of extreme obesity in Serbian school children. The negative relationship between body-fat and maximal oxygen (VO₂max) uptake was moderately high (r=-0.76; p<0.05). The study has shown a high prevalence of adiposity
among Serbian school children, with a strong negative relationship between aerobic fitness and body fatness. Data of the study emphasize the necessity to identify children with weight problems and to develop early interventions to improve physical activity in children and prevent the increase of childhood obesity.

Orjan, et. al. Physical fitness and overweight are both important health-related parameters. Reference data from a population are important for comparisons with children with impairments, different diseases, in habilitation or rehabilitation after injuries. The aim of the survey was to obtain reference data on physical performance in Swedish children and adolescents aged 10, 13 and 16 years. In addition, height and body mass were assessed and body mass index (BMI) was calculated. In total, 2118 children and adolescents in 48 randomly selected schools in Sweden were invited and 1737 subjects participated. Testing procedures were similar to the Euro fit tests, but with some modifications. Results

show generally better performance in boys than in girls and increasing performance with age. BMI increased with age with only small differences between genders. Large variations were found within age and gender groups. The present study provides reference data on physical performance and body size in Swedish children and adolescents. The results from the present study may be used to compare performance and anthropometric data over time or between countries, to evaluate performance in different patient groups or to set goals for athletes.

Wingfield, et. al., the purpose of this study was to investigate relationships between body mass index (BMI), physical fitness, and academic performance in elementary school students. Specifically, BMI and scores on the President’s Challenge Physical Activity and Fitness Awards Program, a physical fitness test, were compared to reading and mathematics scores on the Florida

Comprehensive Assessment Test (FCAT), a standardized norm-referenced academic achievement measure. Participants included 132 4th and 5th grade students from a k-12 school located in North Central Florida. Results revealed that BMI and physical fitness were correlated with academic performance for 5th grade females. In addition, there was a significant and negative association found between BMI and physical fitness across grade level and sex.

Rauner, et. al., Not only in adults but also in children and adolescents, obesity increases the risk for several health disorders. In turn, many factors including genetic variations and environmental influences (e.g. physical activity) increase the risk of obesity. For instance, 25 to 40 percent of people inherit a predisposition for a high body mass index (BMI). The purpose of this systematic review was to summarize current cross-sectional and longitudinal studies on physical activity, fitness and overweight

in adolescents and to identify mediator and moderator effects by evaluating the interaction between these three parameters.

The electronic academic databases Pub Med, Sport Discus, Web of Knowledge and Ovid were searched for studies on physical activity, fitness and overweight in adolescents aged 11 to 19 years (cross-sectional studies) and in adolescents up to 23 years old (longitudinal studies) published in English in or after 2000.

Twelve cross-sectional and two longitudinal studies were included. Only four studies analyzed the interaction among physical activity, fitness and overweight in adolescents and reported inconsistent results. All other studies analyzed the relationship between both physical activity and overweight, or between fitness and overweight. Overweight here including obesity was inversely related to physical activity. Similarly, all studies reported inverse relations between physical fitness and overweight. Mediator and moderator effects were detected in the interrelationship of BMI, fitness and physical activity. Overall, a distinction of excessive
body weight as cause or effect of low levels of physical activity and fitness is lacking.

The small number of studies on the interrelationship of BMI, fitness and physical activity emphasizes the need for longitudinal studies that would reveal 1) the causality between physical activity and overweight / fitness and overweight and 2) the causal interrelationships among overweight, physical activity and fitness. These results must be carefully interpreted given the lack of distinction between self-reported and objective physical activity and that studies analyzing the metabolic syndrome or cardiovascular disease were not considered. The importance of physical activity or fitness in predicting overweight remains unknown.

Douglas and Shingairai\textsuperscript{25} the purpose of this study was to determine if a relationship exists between physical activity or Body

Mass Index (BMI) and academic performance in college-age students. Both physical activity and BMI have shown to impact academic performance in younger students, but data for college-age students is limited. Between October and December 2006, data were collected from 98 biochemistry students at the University of Nebraska-Lincoln. Analysis was performed on 77 students who had complete outcome data. Physical activity measures were categorized to reflect those who met and those who did not meet the Centers for Disease Control and Prevention (CDC) and American College of Sports Medicine (ACSM) recommendations for physical activity [1]. BMI was calculated from each student’s height and weight recordings. Academic performance was determined by each student’s cumulative college Grade Point Average (GPA) and score on the ACT examination. The means were compared using test for two groups and general linear models. Where statistically significant results existed, groups were compared using the Tukey multi-test procedure. A one-sample
comparison of means was conducted for fitness between our sample and the age-matched American population as stated by the Healthy People 2010 Report [1]. Results: Students in the normal BMI category had significantly higher GPA and ACT scores than students in the overweight category. Juniors had significantly higher GPA and ACT scores than seniors. Our findings did not differ between our sample and the American population with regards to recommendations for fitness by the CDC and ACSM.

Conclusions This study demonstrated that normal weight individuals, had higher GPA and ACT scores than their overweight counterparts, underscoring the need to intensify interventions focused on reducing and preventing obesity among school-age populace.

Ray\textsuperscript{26}, compared the physical fitness of urban and tribal students of Agartala. Sixty male students from each age group ranged from 16 to 20 Years were randomly selected as subjects.

Data was obtained by administering the AAHPER Youth Fitness Test and was statistically analyzed by using percentile scale. It was concluded that the performance of urban students in Pull-ups and Softball throw for distance was significantly greater than the tribal subjects and also there was no significant difference between the urban and tribal students in Standing broad jump, Shuttle-run, 600 meter run/walk, 50 meter dash and Sit-ups. Results also showed that there was no significant difference in physical fitness level between urban and tribal college students of Agrartala.

Singh$^{27}$ constructed physical fitness norms for male Teenagers of Jammu and Kashmir State. He used AAHPER Physical Fitness Test items to measure physical fitness, which included Pull-ups, Bent-knee sit-ups, Standing broad jump, Shuttle-run, 50 meter dash, 600 meters run/walk. The study concluded that the subjects belonging to age group 16 to 19 years showed better performance in all the test items, over the other age group 13-15

years. On the average physical fitness improved linearly according to age. The scales, percentile scale, Hull scale and T-scale were also prepared for each age group separately.