Recommendations

IAP National Task Force for Childhood Prevention of Adult Diseases: The Effect of Childhood Physical Activity on Prevention of Adult Diseases

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Preamble

The adverse health consequences of the rapid nutrition transition in the Asian region are now beginning to get noticed. These include insulin resistance, type 2 diabetes, hypertension, coronary artery disease, hyperlipidemia, metabolic syndrome (Syndrome X), stroke and certain cancers. An epidemic related to this transition is already unfolding itself in India. Mortality from cardiovascular disease is expected to rise by about 60%, and overtake deaths from infectious diseases by 2015-2020. The prevalence of type 2 diabetes has increased by 40% in Chennai between 1988 and 1994. It is predicted that the prevalence of type 2 diabetes will rise by 30% worldwide, from 4% to 5.4% by 2025, and that the proportional rise will be greatest in developing countries (48%), especially China (68%) and India (59%). India will have more people with diabetes (~ 57 million), than any other country, with the greatest numbers in the 45-64 years age group. It is likely that type 2 diabetes will soon start to emerge in children. The economic and health consequences of this epidemic can spell disaster for the nation unless immediate remedial measures are instituted.

The pediatricians cannot now afford to ignore the rapidly accumulating evidence that these adult diseases are either programmed at the delicate fetal stage or have their origins in infancy or childhood. Realizing the crucial role of pediatricians in prevention of these adult diseases, the Indian Academy of Pediatrics constituted a “National Task Force for Childhood Prevention of Adult Diseases”. The initial and main envisaged objective of this Task Force is to frame evidence based guidelines to help those caring for children to institute preventive measures for developing adult diseases. The broader long-term objective is to liaise with other stakeholders to catalyze the initiation of relevant public health action.

The following is a pertinent review of evidence and the recommendations on one of these proposed preventive measures, namely, "The Effect of Childhood Physical Activity on Prevention of Adult Diseases". The document was drafted by the Writing Committee established for this purpose and circulated for comments to the entire “Task Force” (members listed in Annexure 1).

1.0 Summary

This document assesses the possibility of

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prevention of adult disease through physical activity in childhood. Generally, it would appear that children and adolescents in developed countries have little physical activity. This may well be similar in India. There are several ways in which physical activity can influence the incidence of adult chronic disease (*Table I*). Physical activity in childhood could prevent childhood obesity which in turn could prevent the occurrence of childhood morbidity. Childhood obesity or morbidity could track into adult obesity and morbidity, with the risk for developing chronic disease at that stage in life, and there is some evidence for these mechanisms at present. An interesting perspective on childhood physical activity is the possibility that this may either track by itself into adulthood, or have an exclusive role in preventing adult disease regardless of adult body weight and lifestyle. While there is insufficient data on the latter, the former situation is a possibility, although the type of physical activity is an important variable to consider. Conversely, it is possible for physical inactivity to track into adulthood.

The role of interventions to improve physical activity and prevent childhood obesity is less clear. However, even if interventions are undertaken, they should be holistic, incorporating changes in lifestyle, diet and physical activity. A combined approach should also be undertaken so that intervention strategies are implemented at the home and family level, at school and within the community. Curriculum time should be given for physical activity, and schools should embrace policies that encourage participation in physical activity. Interventions should also be designed to be inclusive of all children, and adequately trained, motivated personnel should be involved in these programs. It is better to implement primary prevention, rather than targeted or secondary prevention. Overall, a sustainable health promotion intervention program which is directed at physical activity should be able to achieve positive social, behavioral, cognitive and physical or biological outcomes.

Data from India is lacking, and there is a need for research in this area to define whether physical activity has a role in prevention of disease, to define whether there is a dose-response of benefit, and to identify who would be benefited most by intervention. Further, there is a need for operational research into the efficacy and benefit of interventions.

2. Definitions

2.1. *Physical activity and inactivity in children*

2.1.1. *Physical activity*

Physical activity is a global term referring to "any bodily movement produced by skeletal muscle that results in a substantial increase over the resting energy expenditure"(1).

2.1.2. *Physical inactivity* (*sedentary behavior*)

Physical inactivity or sedentary behavior can be defined as "a state when body movement is minimal and energy expenditure approximates resting metabolic rate (RMR)"(2). It includes participation in physically passive behaviors such as television viewing, reading working at the computer, talking with friends on the telephone, driving a car, meditating or eating.

2.2. *Classifications of activity*

2.2.1. *Classification of physical activity according to intensity of effort in children*(3)

Classifying the physical effort of activities according to children's heart rate (above 2 years of age)

Sedentary < 96

Light 96 - 120

Moderate 121 -145

Heavy > 145

2.2.2. *Classification of activity according to nature or purpose of the activity*(3)

Sleep: In bed at night; napping

School: Classroom work; recess; other school activities

Domestic chores: Child care; cleaning house; washing dishes; laundry; food preparation and cooking; miscellaneous house-hold crafts and tasks; fetching water; fuel collection.

Production: Agricultural activities; household manufacturing and crafts for sale; textile work; hunting fishing and gathering; trading and selling; wage work.

Non-work activities: Eating; personal care and hygiene; resting; walking and traveling; school homework; play and leisure; social and religious activities.

2.3. *Leisure time physical activity*

The non-work physical activity includes leisure time physical activity(1), which are activities undertaken in the individual's discretionary free time and is selected on the basis of personal needs and interests. It includes exercise and sport:

- *Exercise:* A planned and structured subset of leisure time physical activity that is usually undertaken for the purpose of improving or maintaining physical fitness.
- *Physical fitness:* Includes cardio-respiratory fitness, muscle strength, body composition, and flexibility, comprising a set of attributes that people have or achieve that relates to the ability to perform physical activity(4).
- *Sport:* Implies a form of physical activity that involves competition. It may also embrace general exercise and a specific occupation.

2.4. *Units of physical activity*

2.4.1. *Physical activity levels*(1)

Physical activity level (PAL) values express daily 24-hour energy expenditure as a multiple ofbasal metabolic rate (BMR), thereby allowing approximate adjustment for individuals of different sizes. PALs are a universally accepted way of expressing energy

TABLE I–*Summary of strength of evidence on childhood physical activity and risk of developing adult disease*

Evidence	Decreased risk	No relationship	Increased risk
Convincing	Adult chronic disease and adult physical activity Low bone mineral density with physical activity (exercise)		Television viewing and childhood obesity Childhood morbidity with childhood obesity
Probable	Direct effect of vigorous childhood activity		Sedentary behavior such as TV viewing and increased energy intake
Possible	Increased physical activity in childhood tracking to adulthood		
Insufficient	Interventions to increase physical activity in children		

expenditure and are a composite index of physical activity patterns.

In order to avoid obesity, populations should remain physically active throughout life, at a PAL value of 1.75 or more. Thus:

Lifestyle	*PAL*
Sedentary	1.4
Limited activity	1.55 - 1.60
Physically active	1.75

2.4.2. *Metabolic equivalents*

This is essentially a multiple of BMR for each type of activity. Total energy expenditure for a particular activity is computed as the product of BMR/min, the specific MET and the duration of activity in minutes (See MET *Table II* at end of this document). The 24 hour energy expenditure is computed by adding up all the MET values for the various activities in a day. The PAL is calculated as the ratio of the 24 hour energy expenditure to the BMR.

2.5. *Physical activity and energy expenditure/balance*

Energy balance is simply a balance between energy intake and expenditure. If the energy intake is greater than the energy expenditure, the person is said to be in "positive energy balance". The surplus energy is stored in the body, either as glycogen (these stores are small), or as energy dense fat, which can grow in size. The components of energy expenditure are the basal metabolic rate (BMR, about 60%), thermogenesis (about 10%) and physical activity (about 30%). The BMR varies by a small amount on a basis(5), and adaptations in thermogenesis are similarly small(6). However, big differences can occur in physical activity, since it is discretionary, and it therefore forms a large and modifiable component of energy expenditure.

3.0. Assessment of physical activity in children

3.1. *Primary or criterion standards:*

Doubly labeled water

The doubly labeled water (DLW) method, also thought to be the "gold standard" is a non-invasive means of assessing energy expenditure in free-living children. A dose of stable isotope ($^2H_2{}^{18}O$) is administered orally to the subject to enrich the pools of ^2H and ^{18}O in the body. Over the next 5 to 14 days, ^2H is eliminated as water, while ^{18}O will be eliminated as water and CO_2. The difference between the elimination rates is proportional to CO_2 production, which can be related to the oxygen consumption through the use of respiratory or food quotient and finally to the energy expenditure(7,8).

Direct observation

This is a practical and appropriate criterion measure of physical activity and patterns of activity for infants and young children. The technique is usually observation over a period of a few seconds to one minute time sampling in free living conditions(7).

Indirect calorimetry

Open circuit calorimetry estimates energy expenditure from O_2 consumption and CO_2 production. This technique requires a captive subject and is hence used to validate and measure only short-term energy expenditure(7).

3.2. *Secondary measures*

Heart rate monitoring

Minute-by-minute measurement of heart rate is used in estimating energy expenditure or physical activity, since heart rate and energy expenditure are linearly related. However the nature of the relationship varies between individuals, and hence has to be characterized

TABLE II–*General Physical Activities Defined by Level of Intensity*

The following is modified from the CDC and ACSM guidelines for all ages.

Light Activity+ Less than 3.0 METs* (less than 3.5 kcal/min)	Moderate Activity+ 3.0 to 6.0 METs* (3.5 to 7 kcal/min)	Vigorous Activity+ Greater than 6.0 METs* (more than 7 kcal/min)
Walking casually, less than 3 miles per hour (mph) Walking in the house or yard Window shopping, strolling and stopping frequently· Casual walking, sauntering, strolling, purposeless wandering	Walking at a moderate or brisk pace of 3 to 4.5 mph on a level surface inside or outside, such as • Walking to school, work, or to shop; • Walking for pleasure; • Walking the dog; or • Walking as a break from work. Walking downstairs Hiking Roller skating at a leisurely pace	Jogging or running Walking and climbing briskly up a hill or stairs Backpacking Mountain climbing, rock climbing and roller skating
Bicycling less than 5 mph - using very light effort	Bicycling 5 to 9 mph, level terrain, or with few hills	Bicycling more than 10 mph or bicycling on steep uphill terrain
Stretching exercises-slow warm-up	Yoga Gymnastics General home exercises, light or moderate effort, getting up and down from the floor	Calisthenics-push-ups, pull-ups, vigorous effort.Karate, judo, taekwondo, jujitsu, jumping rope
Table tennis for leisure	Table tennis-competitive Tennis-doubles	Tennis-singles
Playing catch-football or cricket Throwing a ball	Basketball -shooting baskets	Most competitive sports Football game Basketball game
Throwing a Frisbee Most competitive sports Bowling Darts, Billiards	Playing Frisbee Juggling Cricket-batting and bowling Badminton	Handball-general or team
Swimming-floating	Swimming-recreational Treading water-slowly, moderate effort Diving-springboard or platform	Swimming-steady paced laps Treading water-fast, vigorous effort
Putting groceries away-generally Stocking shelves with food	Putting groceries away-walking and carrying especially large or heavy items	Carrying several heavy bags of groceries at one time up a flight of stairs
Sitting and playing a board game or video game Sitting while reading, writing, coloring, painting, using a computer	Playing on school playground equipment, moving about, swinging, or climbing	Running Skipping Jumping rope

TABLE II (contd...)–*General Physical Activities Defined by Level of Intensity*

Light Activity+ Less than 3.0 METs* (less than 3.5 kcal/min)	Moderate Activity+ 3.0 to 6.0 METs* (3.5 to 7 kcal/min)	Vigorous Activity+ Greater than 6.0 METs* (more than 7 kcal/min)
Gardening and Yard work: pruning, weeding while sitting or kneeling, or slowly walking and seeding a lawn	Gardening and yard work: raking the lawn, bagging grass or leaves, digging, hoeing, light shoveling (less than 10 lbs per minute), or weeding while standing or bending Planting trees, trimming shrubs and trees, hauling branches, stacking wood	Gardening and yard work: heavy or rapid shoveling (more than 5 kg per minute), digging ditches, or carrying heavy loads
Light housework: dusting, vacuuming, sweeping floors, straightening, making beds, cooking or serving food, washing dishes, folding and putting away laundry, sewing, or carrying out light bags of trash Most other household tasks done while sitting or standing	Moderate housework: scrubbing the floor or bathtub while on hands and knees, hanging laundry on clothesline, sweeping an outdoor area, cleaning out the garage, washing windows, moving light furniture, packing or unpacking boxes, walking and putting household items away, carrying out heavy bags newspapers, and plastics, or carrying water or firewood General household tasks requiring considerable effort	Heavy housework: moving or pushing heavy furniture, carrying household items weighing 10kg or more up a flight or stairs, or shoveling coal into a stove. Standing, walking, or walking down a flight of stairs while carrying objects weighing 25 lbs or more

Source: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and prevention, National Centre for Chronic Disease Prevention and Health Promotion, Division of Nutrition and Physical Activity. Promoting physical activity: a guide for community action. Champaign, IL: Human Kinetics, 1999. (Table adapted from Ainsworth BE, Haskell WL, Leon AS, *et al.* Compendium of physical activities: classification of energy costs of human physical activities. Medicine and Science in Sports and Exercise 1993; 25(1): 71-80.

*The ratio of exercise metabolic rate. One MET is defined as the energy expenditure for sitting quietly, which, for the average adult, approximates 3.5 ml of oxygen uptake per kilogram of body weight per minute (1.2 kcal/min for a 70-kg individual). For example, a 2-MET activity requires two times the metabolic energy expenditure of sitting quietly.

+ For an average person, defined here as 70 kilograms or 154 pounds. The activity intensity levels portrayed in this chart are most applicable to men aged 30 to 50 years and women aged 20 to 40 years. For older individuals, the classification of activity intensity might be higher. For example, what is moderate intensity to a 40-year-old man might be vigorous for a man in his 70s. Intensity is a subjective classification.

Data for this chart were available only for adults. Threfore, when children's games are listed, the estimated intensity level is for adults participating in children's activities.

To compute the amount of time needed to accumulate 150 kcal, do the following calculation: 150 kcal divided by the MET level of the activity equals the minutes needed to expend 150 kcal. For example: 150/3 METS = 50 minutes of participation. Generally, activities in the moderate-intensity range require 25-50 minutes to expend a moderate amount of activity, and activities in the vigorous-intensity range would require less than 25 minutes to achieve a moderate amount of activity. Each activity listed is categorized as light, moderate, or vigorous on the basis of current knowledge of the overall level of intensity required for the average person to engage in it, taking into account brief period when the level of intensity required for the activity might increase or decrease considerably.

for each individual studied. This has been validated to assess physical activity in children aged between 7 to 15 years(7).

Motion sensors - Pedometers, accelerometers

Pedometers are simple electronic devices used to estimate mileage walked or the number of steps taken over a period of time. The technique has been validated in children between the ages of 4-11 years of age. However, it does not assess intensity or pattern of activity.

Accelerometers are electronic devices measuring accelerations produced by body movements. It has been validated in children between 2 to 16 years of age. However this too, does not detect daily or hourly patterns of activity(7, 9).

3.3. *Subjective measures*

Self-report questionnaires

This technique is useful in large-scale studies for previous day's recall of physical activity. Recall errors, deliberate misrepresentations, social desirability are some of the drawbacks of this method, especially in children.

Interviewer-administered questionnaires

This technique is used in large-scale studies. A trained administrator could improve a child's cognition and accuracy. Examples of such questionnaires can be found in Jacobs *et al.*(10), where a comparison of many questionnaires has been made. However, it is most important that questionnaires be designed and tested with reference to the scientific question being asked as well as the cultural, ethnic and linguistic context.

Activity diaries

While this may be the most accurate subjective technique in adults, its use is limited in pediatric populations. Adolescents may be able to complete this diary, although its accuracy should be viewed with caution.

3.4. *Problems associated with measurement of physical activity in children*

Physical activity in epidemiological terms is usually measured by a questionnaire. It is important to understand that this may be fraught with problems, in terms of reporting accuracy. There can be problems of under-reporting or large amounts of random error, increasing the dispersion or variability of the data, and reducing confidence in making associations. It is also important that questionnaires cover all domains of activity. Finally, the problem remains of measuring physical activity over relatively short periods of time, but extrapolating these findings to later life events.

4.0. Linkages between physical activity and adult disease

In recent years there is an escalation in the prevalence of overweight and obesity in different countries, both in adults and in children. In a study in India on 13 to 18 year old children, age adjusted prevalence of over nutrition was 17.8 % for boys and 15.8 % for girls. The prevalence increased with age and was higher in lower tertiles of physical activity and in the higher socio-economic group(11). This seems clearly to be due to changes in the lifestyle of children. Links between television viewing and obesity have been shown during the period of childhood and adolescence, with each hourly increment of TV viewing by adolescents being associated with a 2% increase in prevalence of obesity(12).

The key issue of this paper is to demonstrate the benefits of physical activity in childhood in terms of the prevention of adult disease. There is conflicting evidence in this regard, and *Figure 1* demonstrates a framework in which

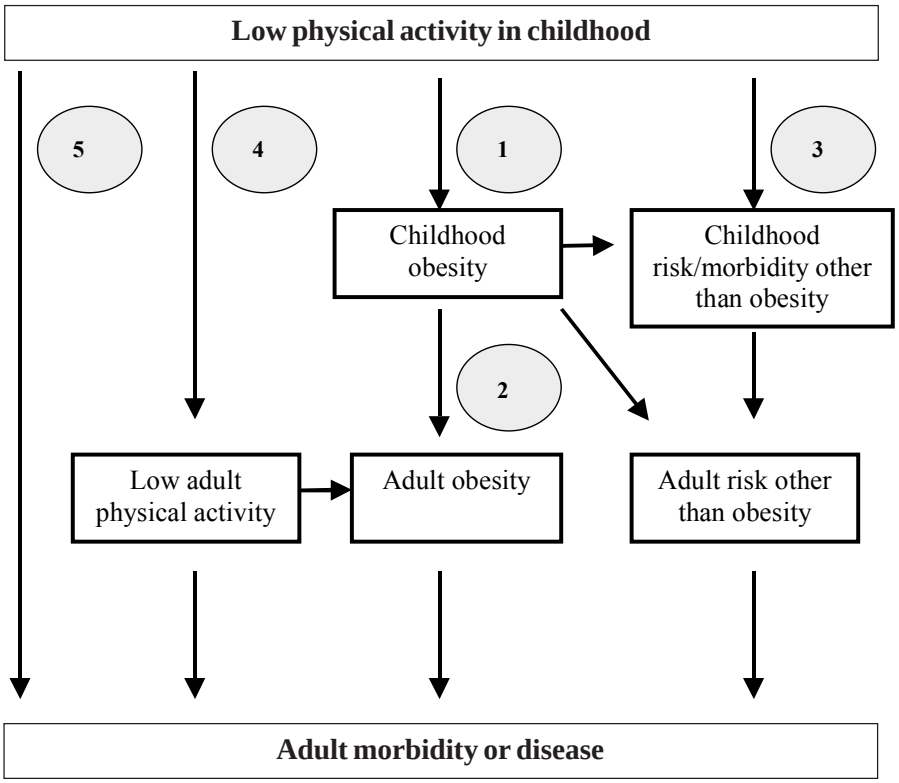

Fig. 1. Potential linkages between childhood physical activity and adult disease. Numbers 1, 2, 3, 4 and 5 refer to text.

this possibility may be analyzed, and following below is evidence whether each of the pathways between a lowered physical activity in childhood is linked to adult disease.

In the discussion below, each numbered point refers to evidence for or against each linkage between childhood physical activity and adult disease (*Fig. 1*).

4.1. *Linkage between physical activity and obesity in children (No. 1 in figure)*

Energy expenditure measurements are often used as a surrogate for physical activity, and this is usually measured by the DLW technique, or by calorimetry. These techniques give a total value for energy expended during the day, but do not specifically define the energy or time spent in physical activity. From the viewpoint of simple energetics, since obese children have a heavier weight, it seems likely that the cost of carrying this weight in weight-bearing tasks is likely to be high. Thus, total energy expenditure measured in obese children has been reported to be higher than that of normal weight children(13-15). This seemingly paradoxical fact is explained above, and importantly, is a clear indicator that the problem in childhood obesity is not simply a matter of low physical activity. Earlier studies on food intake of obese children suggested that they had a lower daily energy intake than normal weight children; this in turn suggested that their total energy expenditure was lower,

and besides constitutional decreases in energy expenditure components such as the BMR, their physical activity was singled out as a major determinant of childhood obesity. The higher TEE seen in obese children therefore suggests that there may be under-reporting of energy intake in these children.

However, does this mean that physical activity is not a determinant of the prevention of childhood obesity? Actual measurements of physical activity show that obese children spend less time in this domain of energy expenditure(16). It is possible that physical inactivity may be the important determinant of energy expenditure, and may indirectly determine the amount (or reduction) in time spent in physical activity. In Pima Indian children, in whom there were significantly greater amounts of time spent in sedentary activities such as television viewing, less time was spent in sports activities(17). The relationship between television viewing and obesity in children has been reviewed(18), and the mixed results found of either weak associations, or no associations at all, between the amount of television watched and obesity. Statistically significant associations have been observed between hours of TV watching per day and obesity(12). Another study has shown that there was a dose-response relationship between hours of television viewing and the incidence and prevalence of overweight over a 4 year period; as much as 60% of the prevalence in overweight could be attributed to excess television viewing(19). In another study, an increase in physical activity was associated with decreasing BMI in girls and in overweight boys, while conversely, an increase in inactivity was associated with increasing BMI in girls(20). These effects were generally stronger among overweight children.

A similar finding has been observed in a less developed country like Mexico, where the odds ratio for being overweight was significantly increased by 12% for every hour of television viewing and significantly reduced by 10% for every hour of physical activity after controlling for several variables including age and gender(21). To directly test the causal relationship between television viewing behaviors and body fatness (that is, the intervention only addressed TV viewing time, without specifically substituting more active behaviors), one study did show that television viewing is indeed a cause of increased body fatness(22).

Studies on obese and non-obese children have also shown that decreased physical activity could either be a cause or a consequence of obesity. A study by Yu *et al.*(23) on obese and non-obese children in Hong Kong, showed a significant difference between the two groups in the amount of time spent on sedentary activities, with the obese group spending 51 % more time than non-obese children.The ratio of active-to-sedentary waking time was 0.6 for obese children and 1.9 for non-obese children. If this trend of continued physical inactivity were to continue over a period of time, it could track towards adulthood, thereby being a major risk factor leading to non-communicable diseases like type 2 diabetes, cardiovascular disease and cancer.

Obesity in children is therefore related to physical activity; this may be more so in some groups. Importantly, obesity or weight gain is a matter of a positive energy balance, which is the difference between energy intake and expenditure. It seems reasonable to suggest that in obese children who stay obese despite having a relatively higher TEE than their lean counterparts, it is likely that the energy intake is even greater than the high energy expenditure. It becomes important to titrate energy expenditure against intake, in order to

prevent weight gain; this means that even though obese children have higher TEE, they still may have low levels of habitual physical activity; clearly, it is important to increase their physical activity(24).

4.2. *Linkage between childhood obesity and adult obesity (No. 2 in figure).*

Childhood BMI is related to the adult BMI and the pattern of BMI changes from 2 to 25 y has stronger effects on subsequent adult overweight than birth weight and adult lifestyle variables(25). The predictability of adult overweight from childhood BMI is best from the BMI at age 18 years and not good below 13 years(26). A recent study has indicated links between rapid infant weight gain and the obesity both in childhood and young adulthood. In a cohort of 300 African Americans was followed from birth till the age of 20 years, a trend toward rapid weight gain in early infancy was associated with young adult obesity(27). A follow-up study for a period of 22 years in Japan(28) showed that approximately 32% of obese boys and 41% of obese girls grew into obese adults. The problem of childhood obesity tracking into adult obesity is not the only problem; direct linkages can be traced to adult morbidity and mortality, sometimes independent of adult weight. A recent study in Glasgow on 8335 men and 2340 women, who as students came from relatively affluent backgrounds, showed a positive association between BMI in adolescence and mortality in later life(29). Each increment of BMI by 5 kg/m^2 in this cohort was associated with increased hazard for all cause mortality (adjusted for height, number of siblings, pulse rate, birth order and smoking and for age in menarche in females) of approximately 18% in men ($p = 0.015$) and 30% in women ($p = 0.096$). Indeed, there were trends of increased cancer related mortality as well in this cohort. Only a crude indicator of physical activity was available in terms of the pulse rate, but this showed a significant trend of declining as BMI increased, indicating that the high BMI students were relatively less active(29). This has also been observed in other studies relating pre-pubertal weight for males and females with adult mortality(30), as well as in the pre World War Boyd-Orr cohort, where those with childhood BMI above the 75th centile had an increased risk of all-cause and cardiovascular mortality(31). Similarly, in a locality with high adult mortality rates, adolescents were found to have a higher level of coronary risk factors such as overweight, smoking, physical inactivity and hypercholesterolemia, compared with children who came from a locality with average coronary heart disease related mortality(32). This is not necessarily dependent on adult weight, as adolescent obesity has been shown to be a risk factor for many adverse health effects(33). This implies that prevention of obesity from the period of childhood should be a major public health measure.

4.3. *Linkage between childhood physical activity and morbidity (other than obesity) (No. 3 in figure)*

In recent years, there is an increase in evidence that physical activity increases bone density and thereby prevents osteoporosis in later life. During childhood years, especially in the pre-pubertal phase, the maximum increase in bone density occurs. Under conditions of disuse and inactivity, both skeletal and muscle tissues atrophy, in children, who are in their growth periods(34). A cross-sectional study on bone mineral density (BMD) and physical activity on children showed that physical activity was strongly associated with bone mass in pre-pubertal children, with males showing greater associations. Those participating in sports showed a 4.2% higher BMD at the femoral neck and a 4.3% higher BMD at

the spine(35). This latter point is important, since only high intensity activity has beneficial effects on bone health(36).

It is important to look at cardiovascular risk factors as well, since there are important correlations of clinical risk factors in early life with anatomic changes in the aorta and coronary vessels with atherosclerosis along with cardiac and renal changes related to hypertension(37,38). Obese Indian children have been found to have a higher prevalence of essential hypertension(39). Physical activity levels (PAL) in a normal range have been found to correlate with flow mediated dilatation of the brachial artery in children(40). Physical fitness (but not physical activity) in adolescence is related to the presence of cardiovascular disease risk factors in young adulthood(41). These findings are repeated in the Amsterdam Growth and Health Longitudinal Study(42), in which body fatness in adulthood as well, was similarly related to physical fitness in adolescence. More active children had lower insulin secretion and greater insulin sensitivity that were independent of body fat or fat distribution(43). Further, in a Finnish study of 743 20-year old males both a childhood aptitude for endurance athletic events and a continuity of vigorous physical activity were found to be associated with protection against coronary heart disease(44). The probable link between physical activity and coronary heart disease is possibly mediated through the process of obesity tracking through childhood with cumulative lifetime effects leading to the development of adverse levels of total cholesterol, LDL-cholesterol, triglycerides and decreased HDL-cholesterol level.

These findings draw more attention to the maintenance of physical fitness, rather than physical activity level, in adolescence. It may be argued that physical activity and fitness go hand in hand; this is true as one study has shown that there were significant correlations between physical activity and health related physical fitness in Taiwanese adolescents(45). Physical activity also has an effect on the psychological variables of adolescents and may influence behaviors that increase the risk of obesity. For example, physical inactivity, through television viewing will increase behaviors that are pre-morbid in themselves: first is the possibility that increased dietary intake and the intake of high calorie foods will increase with television viewing(18), and more worrying is the relationship between television viewing and the initiation of smoking among youth(46). Several papers reviewed by Friedenreich(47) indicate that physical activity has a role in cancer prevention as there is convincing evidence linking physical activity to colon and breast cancer. However, no longitudinal study has been conducted from the period of childhood.

4.4 *Linkage between physical activity in childhood and physical activity in adulthood (No. 4 in figure)*

Chronic disease in adults is strongly linked to the daily amount of physical activity. Therefore, in assessing the protective effect of physical activity in childhood, it seems logical to look for the effect this has on physical activity in adulthood. Further, the question should also be whether physical inactivity also has similar effects on physical inactivity in adulthood. Adult physical activity has a low to moderate relation with activity measured after 13 years of age(48). The longitudinal development of the physical activity profile, in turn, had an influence on a better cardiovascular disease risk profile. An analysis from the Harvard Alumni study also showed that correlations between physical activity during college were not well correlated with physical activity during later life(49). This

may also be due to a methodological issue: physical activity assessed over a short time period in an individual may not be a valid proxy for activity over the long term, although, in the same study, the BMI measured at college did correlate better with BMI in later life. However, these findings do not allow a confident linkage to be made between activity levels in childhood and adulthood.

4.5. *Linkage between physical activity in childhood to adult morbidity or mortality (No. 5 in figure)*

Data that show clear trends in relating childhood activity to later life events and mortality are scanty; however, the Harvard Alumni Study does provide some insight into the effect of physical activity during late adolescence (or college) with the risk of death later in life. In this study, after adjustment for potential confounders, the relative risks of dying associated with increasing quintiles of total energy expenditure in college, showed a significant and decreasing trend(50). The relationship was more clear for vigorous than non-vigorous activity. However, the effect of childhood activity on later life mortality is clearly influenced by adjustments to lifestyle in later years. Changes in lifestyle, such as increasing physical activity, or quitting smoking, are important in preventing adult morbidity or mortality(51).

Overall, it appears that the evidence linking physical activity in childhood to adult disease, through a variety of pathways, is present, although not strong. The linkage of childhood events and lifestyle to adult disease is multi-factorial, and it is difficult to pinpoint physical activity as being the critical factor in this process.

5.0. Patterns of physical activity in children

In order to understand how physical activity can be successfully introduced, or increased in the lifestyle of a child, it is necessary to understand prevailing patterns and determinants of physical activity in children. The potential for positive physical activity behaviors learned during childhood to carry through to adulthood and positively affect health is definitely an incentive to promote physical activity from the period of childhood. Rapid psychosocial and biological development occurs during the period of infancy, childhood and adolescence which would also be reflected in their physical fitness and physical activity patterns. The importance of promoting physical activity in children becomes even greater, especially when it is evident that in the past leisure activities for children often meant active play, but leisure today may mean a quiet sedentary activity such as viewing television or playing a computer game(52).

Fox and Riddoch(53) summarized the pattern of activity of children and adolescents as being mainly incurred through:

- Transport, as in cycling or walking to school or shops
- Informal play, such as playground, street or park games during free time
- Formal play, as in physical education classes, organized sport or exercise sessions at school or elsewhere
- Work, such as in delivery rounds, jobs in sales or shelf stacking, or household tasks.

5.1. *Infancy*

In the case of infants, physical activity becomes difficult to define as energy cost of physical activity is not easy to assess, especially with growth costs to be accounted for. However, Wells and Davies(54) longitudinally estimated the physical activity

of 124 free living infants between 1.5 to 12 months of age. Total energy expenditure and body composition were estimated using doubly labeled water. Activity energy expenditure increased markedly over the first year of life, from 5% of energy intake at 6 weeks to 34% at 12 months. PAL was calculated using the ratio of activity energy expenditure (AEE) to the predicted sleeping metabolic rate (SMR), and it was found that this level increased from 0.1 to 0.58 from 6 weeks to 9 months and then got decreased to 0.53 at 12 months of age. This was attributed to environmental rather than to developmental factors.

5.2. ***School-going children and adolescents***

Tracking physical activity behaviors from childhood have given insights into the change in patterns in physical activity as children grow biologically and emotionally, and these could serve to identify periods during which intervention for promoting positive physical activity behaviors.

Decline in physical activity in children as they increase in age and differences with ethnicity has been recorded by many investigators(55,56). Strauss *et al.*(55) reported that there was a significant decline in physical activity levels (measured using the motion detector) between ages 10 and 16 years, in a cross-sectional study of 92 children. Moderate and vigorous activity levels decreased significantly between ages 10 and 16 years for both sexes(55,56). In a follow up study which prospectively followed up black and white girls enrolled in the National Heart, Lung and Blood Institute Growth and Health Study for 10 years(57), it was observed that physical activity levels declined with racial differences being evident. Physical activity assessed by a Habitual Activity Questionnaire to measure leisure time physical activity showed a decline by 83% from year 1 to year 10. By 16 or 17 years 56% of black and 31% white girls reported no habitual leisure time activity. Racial differences in physical activity were more notable at older ages. Aaron *et al.*(58) longitudinally studied a total of 782 adolescents, aged 12-15 years, for their physical activity using a questionnaire, for a period of 4 years. Physical activity declined by 26%, and this decrease seemed to be a function of the decrease in number of activities. They suggest that it could be critical to have pre-adolescent children maximize their exposure to various activities at a young age to enhance the likelihood that they will maintain participation in some of these activities in later years.

In school going children, physical activity is related to the school curriculum, especially during the ages of between 8 to 15 years. However in late adolescence, it becomes more a matter of choice(56, 59). In the study by Gordon-Larsen *et al.*(59), consisting of 17,766 US adolescents (11-21 years), enrolled in the National Longitudinal Study of Adolescent Health studying in the middle and high schools, important associations between modifiable environmental factors, such as participation in school physical education and community recreation programs occurred with the activity patterns of adolescents. Participation in daily school physical education program classes and use of community recreation center were associated with an increased likelihood of engaging in high level moderate to vigorous physical activity. However, despite marked and significant impact of physical activity in school programs, few adolescents participated in school physical education programs and this decreased with age. Gavarry *et al.*(60) showed that school days increased the habitual physical activity of children (assessed through heart rate monitoring over a seven day period and daily

activity dairy) compared to school-free days in their study of 182 children between the ages of 6-20 years. Further, compulsory activity at school made a difference to for all children compared to the school day without PE lessons(61). In contrast to the observations on school-going children and adolescents, in primary school children (aged 7.0 to 10.5 years) the total amount of physical activity did not depend on the duration of physical education timetabled at school, as these children compensated by being active out of school(62). This implies that although school physical education does make a difference to activity of children, age also contributes significantly to activity.

In children aged 10 - 16 years (n=92), it has been observed that those who spent the least time participating in sedentary behaviors were significantly more likely to have high levels of moderate activity compared with those who spent the most time in sedentary behaviors. Time spent on television and computer were inversely correlated with moderate activity (p=0.01) (55). However, there are no Indian data available on this issue.

5.3. *Gender based differences in physical activity*

Conflicting reports on differences in patterns of activity among male and female children occur in several studies, with some showing definite differences, while others showing none. In 3 to 4 year-olds (n = 104), total activity was found to be significantly different with total activity being higher in boys than in girls (63). Total physical activity declined by 69 % in male subjects, and by 36 % in female subjects during school days from childhood to adolescence (60). Dovey et al (56) reported that in girls, there was a decrease from 7.5 hours to 4.3 hours a week, while in boys it decreased from 11.7 hours per week to 7.8 hours per week. Differences in gender were also found to be related to age. Strauss et al (55) reported that before the age of 13 years, similar levels of physical activity were present in girls and boys, while after the age of 13 years, boys were significantly more active than girls.

By contrast, in 4-11 year-old children(64), no gender difference was observed in activity energy expenditure and total energy expenditure, and in PAL (although mean PAL of 1.4 ± 0.3 in boys and 1.2 ± 0.4 girls were observed). Similar trends were observed in a cross-sectional study in Oxford on physical activity levels of 10-13 year old children (n=38 children ,12 boys and 26 girls) on school days with and without physical education using activity diaries, the mean PAL value for all children was 1.52 ± 0.08, with 1.50 or boys and 1.53 for girls. For boys the lowest mean PAL value of 1.46 was observed during the weekend, while for girls the lowest mean value of 1.48 was on the school day without PE(61).

6.0. Determinants of physical activity in children

The determinants of physical activity in children are also important to know in order to understand how to create sustainable interventions that are successful in increasing their activity.

6.1. *Socio-demographic determinants*

Adolescents are more likely to be physically active if they had a circle of friends who are active. Peer influence also appears to be important with respect to participation in organized sports. Children whose parents are physically active have been reported to be nearly 6 times as likely to be active than children whose parents are both inactive(65).

Advanced maternal education and higher income were associated with lower levels of

physical inactivity(57,59). Pregnancy was associated with decline in physical activity only for black girls but not in white girls, while cigarette smoking was associated with decline in physical activity only in white girls(57).

6.2. *Environmental determinants*

Seasonal and geographic influences were found to play a large role in physical activity behaviors, with the activity highest in summer and lowest in winter(66). Lack of safe outdoor play areas in many portions of large cities limits children's ability to engage in active physical play or recreational sports(23,67).

Torun *et al.*(3) have reviewed several papers and indicated that compared with children (aged 5 to 19 years) in industrialized societies (PAL = 1.58-1.65), children in developing rural areas (mean PAL = 1.74 to 2.06) sleep less at night, participate longer in moderate and/or heavy physical activities, and have a greater energy expenditure in relation to their basal metabolic rate. Few studies have been conducted in children from cities in developing countries and their physical activity falls between those in industrialized countries and those in rural areas of developing countries (PAL = 1.56-1.62).

7.0. Perceived benefits and barriers to physical activity

Children should view physical activity as being interesting and fun to do. However, there can be important and significant barriers to engaging in physical activity. The barriers to engaging in physical activity are(55, 68):

(*a*) *Self-efficacy:* This refers to the confidence in ability to be physically active. Increased level of physical activity has been shown to be associated with increased self-efficacy.

(*b*) *Preference for indoor activities:* Children have reported a preference for television viewing and other small screen activities (like electronic games and computers).

(*c*) *Low energy level:* Feeling tired lazy and sluggish, along with the realization that 'junk food' slowed one down.

(*d*) *Motivation:* Low level of self-motivation and low levels of motivation from others (parents or teachers) have been perceived as barriers to physical activity.

(*e*) *Time constraints:* Lack of time due to homework or other plans and commitments have been perceived as barriers. In the Indian context, with increasing emphasis being given on tuitions and homework, there is a consequent forced decrease in physical activity of children.

(*f*) *Social factors:* Peer pressure with friends also involved in sedentary activities. Parental preferences and support, as well as motivation also have a role here. Teasing and bullying (between genders) was also reported.

(*g*) *Lack of access to facilities:* The extent to which the environment is conducive to physical activity (safe streets and playgrounds) is likely to have a strong impact on activity levels(69).

The perceived benefits of physical activity have been positively associated with physical activity in children and adolescents(70). These perceived benefits of activity have also been explored using semi-structured focus groups and specific prompts in a qualitative study(68) and are:

(*a*) *Social benefits:* Physical activity was fun. It allowed socializing with friends, and the possibility of understanding and enjoying teamwork. It also resulted in parent approval.

(*b*) *Psychological enhancement:* Physical

activity resulted in a sense of achievement, pride, self-esteem and confidence. It enhanced the mood, and inculcated a sense of discipline. A reduction in sense of guilt and a sense of balance in life was achieved.

(*c*) *Feeling good physically:* Children felt refreshed after physical activity, and there was a sense of 'creation of energy' along with reduction of fatigue. Sleep was also enhanced.

(*d*) *Sports performance:* There was an improved sports performance, along with skill development. Physical activity was also perceived to improve coordination, agility, flexibility and reflexes, along with fitness and strength.

(*e*) *Cognitive benefits:* Students reported that physical activity cleared the mind and thinking. It enhanced concentration and brain function.

(*f*) *Coping strategy:* Physical activity was perceived to provide stress relief, relaxation, and was a distraction from worries. It provided an outlet for aggression, frustration and anger.

7.1. *Probable risks*

Intensive training is not an essential feature of physical activity. Graded increase in fitness training is important while training physically. Musculoskeletal injuries, renal abnormalities, gastrointestinal disturbances, immune system suppression and menstrual irregularities may accompany high training loads. Although these conditions are mostly reversible with reduced training, they are undoubtedly troublesome and may partly offset any health benefits accruing from greater activity. They may also have an adverse effect on exercise adherence, reinforcing the likelihood of an optimal level of activity for health purposes(71). However physical fitness and experience may play a role in reducing the risk of injury.

8.0. Do interventional measures work?

As a first principle, it seems reasonable that physical activity interventions should be tailored to the physical and social capacity of the group of children, particularly for obese children in the group(72). In addition, it would also appear that schools would provide an excellent forum for prevention efforts, because of their potential to reach large numbers of children and to deliver structured risk-reduction programs. This is reinforced by the discussion (above) that physical activity tends to decline in adolescence. However, a note of caution should be sounded in school programs: they should not target obese children alone, since this can create stigma. It also loses focus on the target of primary prevention. It also seems reasonable to presume that intervention programs would be very effective if both school and family were involved, and the Pathways family intervention in American Indian children has shown that school based family involvement programs could be successfully initiated(73). Finally, since low physical activity and unhealthy eating tend to track together, it is also feasible to include nutrition education and behavioral management interventions along with physical activity interventions, so that a more holistic approach is undertaken.

Intervention studies in schools in developed countries have shown some good effects in increasing physical activity. In one such intervention at the school level (performed in multiple schools in the US, in a multiracial population trial called the Child and Adolescent Trial for Cardiovascular Health, CATCH), two primary end points that were undertaken were changes in the fat content of food service lunch offerings and the amount of moderate-to-vigorous (but not vigorous) physical activity in Physical Education programs, over a 3 year period of 6

semesters. The intervention resulted in significantly higher amounts of self-reported physical activity during school in the intervention group compared to controls, as well as in decline in fat intake(74). However, no significant difference between control and intervention groups was seen in the change in BMI or triceps skinfold at the end of 3 years. In another study performed in the UK (multiple schools, Activity Program Promoting Lifestyles in Schools, APPLES), a one year program designed to influence eating and physical activity in schools was instituted.This targeted the whole community, including parents, teachers and students, and could not find any change in physical activity levels in the intervention schools after one year(75). Indeed, there was a decline in the levels of physical activity in overweight children. However, the same authors noted that the implementation of the program was very successful(76). Here is a paradox: a successful program implementation, with an unsuccessful outcome.

This seems to be the problem in many intervention studies as reviewed recently, where it was found that there is little data available on the effectiveness of obesity prevention programs in children and that at present it is difficult to draw firm conclusions on this issue(77). It may be that many of these programs utilize techniques for endpoints, that are questionnaire based, which would increase the variability of responses; as stated above, physical activity is notoriously difficult to quantify accurately, and with a high variability and small degrees of expected change, it is quite likely that many of these studies would lack the statistical power to detect change.

Nevertheless, it has been reported that in Singapore, there has been a successful campaign to reduce obesity in school children (over an 8 year period, prevalence of obesity declined from 16.6 to 14.6%), through a program of nutrition education and targeting of overweight children(78). This was a government sponsored program, and given this success, and the less successful nature of the more universal program described above(75), it seems likely that the most cost-effective way forward is to target higher risk children and devote resources to more intensive treatment programs(79), as well as to have government involvement. However, this must be done with caution: it may well promote stigmatization and the emergence of eating disorders. It is also clear that different countries will have different success rates with such programs.

Targeted interventions, based on parents and care-givers have also proven effective in smaller groups. In the Girls health Enrichment Multi-site Studies (GEMS), culturally relevant family based intervention measures to prevent excess weight gain in African American girls aged 8-10 years, with a BMI above or equal to the 25th percentile of the CDC growth charts was implemented. The interventions were targeted to both the children and their parents or care-givers. Girls in both child targeted and parent targeted interventions increased their level of moderate-to-vigorous activity by 12%(80). In a small group of children, behavioral interventions along with counseling were useful in reducing television or small screen activities, as well as in increasing physical activity, suggesting that behavioral interventions may be useful(81), however, this still needs to be evaluated in terms of endpoints such as the prevention of obesity, as well as in large numbers over the long term. Interestingly, in one longitudinal study, multiple counseling sessions on physical activity from adolescence to adulthood did not result in a decrease in the rate of weight gain(48).

In a developing country situation, albeit with much younger children, one long-term study(82) evaluated just the effect of a physical activity intervention (15 minutes of walking plus 20 minutes of aerobic exercise) to Thai kindergarten children for 30 weeks. A reduction of the prevalence of obesity was found at the end of 4.5 months, in the intervention pre-school children (P = 0.057). Data at 6 months post-intervention showed that the overall prevalence of obesity rose again in both intervention and control groups, however this increase was less in the intervention group(77). It is not known (information not available) if the changes at 29.6 weeks plus 6 months are statistically significant, but such small differences between groups are unlikely to be clinically significant.

Overall, the data are conflicting, but the increase in physical activity of a child (in contrast to intensive physical training) is not associated with negative effects. It must be borne in mind that all these results are from short-term studies and hence positive outcomes may not be evident. Therefore, it is worthwhile implementing programs that target physical activity in addition to a healthy diet and lifestyle. Lessons from the previous studies should be heeded while implementing such programs. It is clear that the prevention of obesity in childhood, along with possible benefits on adult health, will require the cooperation of many agencies, including the school, community and government. It will require the development of novel interventions, with innovative educational and behavioral approaches, in order to work successfully in a sustainable manner. Finally, it should be sensitive to the needs of the children and the program: an insensitive approach may well cause more problems.

9.0. Recommendations for promotion of physical activity

On balance, it would appear that regardless of the effectiveness of interventions, modifying physical activity in children is an attractive and non-restrictive approach towards preventing obesity and the possibility of later life morbidity. There are several important questions to be answered when determining activity recommendations. Does activity have a beneficial effect? Is there a dose- response? Is there an inflection in the dose response that clearly defines a beneficial effect? Who is most benefited?

Answering these questions with regard to physical activity is difficult given the confusion in the data. In addition, it is difficult to define dose responses, as well as inflections in the curve of the dose response, when weak associations are present. Finally, with regard to India, there is dearth of evidence on the amount of, and benefit of, physical activity of children; regional, cultural, socio-economic and demographic differences could also lead to differences in physical activity patterns. However, with evidence pointing towards the increase in overweight and non-communicable diseases, probably tracking through to adulthood all over the world, promotion of physical activity during the childhood years should be a public health priority.

The WHO(83) recommendation for children reads as follows:

1. At least 30 minutes of cumulative moderate physical activity everyday (walking/ brisk walking as well as other appropriate, healthy and enjoyable physical activities and sport for all actions), with children of all ages requiring an additional 20 minutes of vigorous physical activity three times a week. (Listings of activities contributing to light, moderate and vigorous activities are given in *Table II*). Moderate intensity exercise of a non-structured nature facilitates most of

the disease prevention goals and health promoting benefits.

2. Restrict TV viewing, video games and use of computers to a total of ≤2 hours per day

Further recommendations to promote physical activity in children are:

1. *At the parent-child level*

- Encourage parents and physicians to promote physical activity from the period of infancy, by stimulating and encouraging the child to walk and play once he/she learns to do so. Discourage the use of prams once the child learns to walk.
- Encourage parents to support their children's participation in appropriate, enjoyable physical activities.
- Encourage familial participation in games and sports activities (for example, walking, swimming and other recreational activities).
- Encourage the participation of children in household chores.
- Teach families to consciously reduce television viewing, through education and behavioral techniques. Restrict viewing of TV to less than 2 hours per day.
- Encourage physical activity as a lifestyle:
  - » *Walk and talk:* Instead of sitting at the table while doing home-work, take a walk and practice spellings, multiplication tables and general knowledge.
  - » *Household jobs:* Encourage participation with responsibility in household chores, for example, walk the dog, dusting, cleaning cup-boards, vacuuming, watering plants and gardening, washing their playthings and bicycles and cars.
  - » Indoor games: Encourage and promote dancing, games with action, for example hop-scotch, blind man's buff.

2. *At the school-student level*

- Physical education must be compulsorily integrated into the school and college curriculum. Emphasis on competition should not be the sole objective. Emphasis should be placed on play and activities rather than "exercise". In sporting events, participation should be stressed and competition de-emphasized.
- Lack of space in the school for play activities should be compensated for by obtaining permission to use public playgrounds for the children so that all students in the school avail of the physical education classes.
- Educate teachers and parents about the benefits of physical activity. Show how this can be achieved.
- More emphasis should be on making physical activity seem an enjoyable experience so that all children could participate. Suitable games should be conceived for children with mild and major disabilities and this should be incorporated in the physical education program.
- Elementary school students should develop basic motor skills that allow participation in a variety of physical activities, and older students should become competent in a select number of lifetime physical activities they enjoy and succeed in.
- Discourage the use or withholding of physical activity as punishment.

3. *At a government-community level*

- Increase playground facilities and safe play areas for children. Each area, especially in big cities, should be developed with

adequate infrastructure for public playgrounds and parks for children to play and provided with safe play equipment.

- Encourage the use of community programs for promoting physical activity (for example, playing team games and cycling on safe roads with children in the neighborhood). Provide safe and level pedestrian paths for the public to walk.
- Promote physical activity within a cultural context that is appropriate for each child.
- Use media as an agent to promote physical activity. In children messages promoted through TV and newspapers and magazines are captured instantly and could prove to be a very effective way to disseminate knowledge on physical activity.

4. *At a targeted (secondary prevention) level*

- Targeted prevention should be a secondary option
- Secondary prevention should be done by experts, and with caution.

5. *At the doctor/pediatrician-patient level*

- Assess the degree of physical activity of the child. Assessment of activity should begin as early as 2 years and through adolescence.
- Determine the time spent on sedentary activities, especially to TV viewing, video games and computer usage and advise parents to establish time limits for the same ($\leq$ 2 hours/day).
- Encourage the participation of the child in unstructured and structured play based on the age of the child.
- Advise physical activity as a lifestyle (as mentioned in recommendations at parent-child level).
- Advise parents on the importance of being role models for active lifestyles and providing children with opportunities for increased physical activity. Familial attitudes toward exercise and sport participation should be explored
- Advise parents to include planned activities instead of food as part of the family's reward system for positive accomplishments.
- The child's access to regular convenient places of exercise and the ability of the family to encourage regular activity must be assessed.
- Emphasize the benefits of regular physical activity: an improved cardiovascular risk factor profile, increased energy expenditure, improved weight control, a general sense of physical well-being, improved interpersonal skills, and an outlet for psychological tension.
- Advise not to include or exclude children from activities because of physical or mental limitations. Suggestions for exercise should suit the child's physical ability.
- Encourage participation in noncompetitive activities, and organized sports. Emphasize on sports that can be enjoyed throughout life, participation in summer camps, and school physical education programs. The activities should be culturally suited. In Indian conditions, children could play games like hide-and-seek, kabaddi, hop-scotch, fly kites.

To aid in the process of rapidly assessing the physical activity of a child, the following key questions (and suitable recommendations in the case of low physical activity) could be asked (and advised):

Box 1: Screening children for their physical activity

» If a toddler: While the parent/care-taker walks, is the child carried, taken by pram, or does he/she walk?

Intervention: Child should be encouraged to walk till tired.

» How many hours a day does the child spend on television/computer /video games?

Intervention: More than 2 hours per day should be actively discouraged.

» How far is the school from home? How does the child commute?Intervention: If the distance is less than ½ km, walking should be encouraged.

» Totally how many hours are spent in active play both at home and school?Intervention: A minimum of 30 minutes of moderate activity (walking briskly, general play *etc.*), with a minimum of 20 minutes of vigorous activity thrice a week.

9.1 *Recommendations for children with disabilities*

It is mandatory that all individuals should be physical active to the extent of their capabilities. The WHO (84) has recommended that "persons with disability should be provided with enough opportunities and support to perform sport and physical activities adapted to their physical conditions".

Children and adolescents who are obese or who have physical or cognitive disabilities, chronic health conditions (*e.g.*, diabetes, heart disease, or asthma), or low levels of fitness need instruction and programs in which they can develop motor skills, improve fitness, and experience enjoyment and success. Young people who have these disabilities or health concerns are often overtly or unintentionally discouraged from engaging in regular physical activity even though they may be in particular need of it. Schools may allow students who have physical disabilities to be exempt from the physical education course; however they should be required to provide modified physical education and health education for these students. By modifying physical education, health education, extracurricular physical activities, and community sports and recreation programs, schools and communities can help these young people acquire the physical, mental, and social benefits of physical activity(85).

Box 2: Key messages to be conveyed

» Physical activity is beneficial for daily healthy living. However, it need not be strenuous to be beneficial.

» WHO (2003) recommends at least 30 minutes of cumulative moderate physical activity everyday (walking/ brisk walking as well as other appropriate, healthy and enjoyable physical activities and sport for all actions).

» Children of all ages require an additional 20 minutes of vigorous physical activity three times a week. (Listings of activities contributing to light, moderate and vigorous activities are given in *Table II*).

» Moderate intensity exercise of a non-structured nature facilitates most of the disease prevention goals and health promoting benefits.

» Promote activities that the child enjoys at home, school and community. Children who are forced to exercise are much less likely to be regularly active in adulthood.

» Time spent in sedentary activities and games, particularly TV viewing, video/computer games should be limited to ≤ 2 hours per day.

» Discourage the use or withholding of physical activity as punishment

9.2. *Making sports/play enjoyable*

In order make play or sports enjoyable CDC(85) has recommended that persons concerned with training of children in sports should ensure that:

- Exposure to the sun is minimized by use of protective hats, clothing, and sunscreen; avoidance of midday sun exposure; and use of shaded spaces or indoor facilities.

- Heat-related illnesses should be prevented by ensuring that children and adolescents frequently drink cool water, have adequate rest and shade, play during cool times of the day, and are supervised by people trained to recognize the early signs of heat exhaustion and heat stroke. Cold-related injuries can be avoided by ensuring that young people wear multilayered clothing for outside play and exercise, increasing the intensity of outdoor activities, using indoor facilities during extremely cold weather, ensuring proper water temperature for aquatic activities, and providing supervision by persons trained to recognize the early signs of frostbite and hypothermia.

- Measures should be taken to avoid health problems associated with poor air quality (*e.g.*, reduce the intensity of physical activity or hold physical education classes or programs indoors). Children and adolescents should be provided with, and required to use, protective clothing and equipment appropriate to the type of physical activity and the environment. Protective clothing and equipment includes footwear appropriate for the specific activity; helmets for bicycling; helmet, face masks, mouth guards, and protective pads for football. Protective gear and athletic equipment should be frequently inspected, and they should be replaced if worn, damaged, or outdated.

Due importance should be given to these factors as most schools and sports trainers tend to ignore these important aspects in India. On the whole, sports must be made an enjoyable experience, so that active living is sustained throughout the life span.

10.0. Future research needs

Effective research in this area is difficult to do. It has been suggested that in order to effectively answer questions linked to the influence of physical activity on childhood obesity, the ideal study would be a prospective randomized controlled trial, in which children would be assigned to an active and sedentary lifestyle; this is a study that will never take place(36). Nevertheless, epidemiological studies are still useful, given that the data on physical activity in childhood as prevention for adult disease is still sparse in India.

It is important to get estimates of the burden of childhood overweight in India. Further, research is required into the determinants of childhood obesity in India, with emphasis on dietary and lifestyle patterns. Structured physical activity questionnaires, which are validated, are also required to assess physical activity patterns in different domains of activity. It must be remembered that epidemiological associations that have been found are weak, and a lot of studies are cross-sectional. This is however an important research area, and requires studies of adequate power. The aim of such research should also be to answer specific questions, such as the putative protective effect of physical activity, the possibility of defining a dose response and so on. These questions are useful in translating epidemiological research into specific recommendations.

Physiological research looking at the effect of physical activity in determining body composition is also required. Further, the relationship between specific types of exercise and body weight and composition, and bone mass can also be explored, particularly in India. While epidemiological approaches can

define relationships, the etiological framework for these must necessarily be physiological.

Finally, research is required into the effectiveness of school and home based interventions, on a longitudinal basis, on reducing the burden of childhood obesity.

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