

Increasing In-Home Physical Activity of Obese Children in Urban Area using Kinect

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Abstract—The benefits of physical exercise extend far beyond weight management. Research shows that regular physical activity can help reduce the risk for several diseases and health conditions and improve the overall quality of life. Research has also demonstrated that virtually all individuals can benefit from regular physical activity. Even among frail and very old adults, mobility and functioning can be improved through physical activity [2]. This paper proposes a framework for in-home physical exercise monitoring based on a Kinect platform. The effectiveness of regular physical exercising has been evidenced in general for preventing the deterioration of chronic diseases and premature death [1]. The analysis goes beyond the state-of-the-art solutions by monitoring more joints and offering more advanced reporting capabilities on the movement such as: the position and trajectory of each joint, the working envelope of each body member, the average velocity, and a measure of the user's fatigue after an exercise sequence. This data can be visualized and compared to a standard (e.g. a healthy user, for rehabilitation purposes) or an ideal performance (e.g. a perfect sport pose for exercising) in order to give the user a measure on his/her own performance and incite his/her motivation to continue the training program. This research is mainly targeted for children in metropolitan area to continue their daily physical activity but such information can be used as well by a therapist or professional sports trainer to evaluate the progress of a patient or of a trainee.

Keywords—movement quantification; skeleton tracking; physical exercising; rehabilitation; Kinect.

I. INTRODUCTION

Physical fitness is defined as the ability of body to function efficiently and effectively, to enjoy leisure, to be healthy, to resist disease, and to cope with emergency situations. Health-related components of physical fitness included body-composition, cardiovascular fitness, flexibility, muscular endurance, and strength. Skill-related components included agility, balance, coordination, power, reaction time, and speed. Physical fitness is used in two close meanings: health-related which state the health and well-being and skill-related which more task-oriented based on the ability to perform specific aspects of sports or occupations. Physical activity is an important part of both a healthy lifestyle and a child's daily routine [3]. Development of good health and fitness habits in childhood is associated with physical fitness as an adult [4]. Participation in physical activity is an important part of a child's normal psychosocial development and self-image. Children should not be excluded from physical activity without a compelling medical contraindication.

II. Statement of problem

Along with the modernization of the world, most of the technologies nowadays have make people less active. They do less work but achieve more output as this is what we call efficiency, to do something with little input but bring out more input. As the technologies becoming more advanced, people are less making work and this resulting in the decrement of fitness. Many

factors can be related to level of physical activity among children. Loucaides et. al. (2004) stated five factors that would contributed to level of physical activity among children in their study “Differences in Physical Activity Levels between Urban and Rural School Children in Cyprus”. They stated that the factors that contribute are seasonal factors, space and safety, exercise equipment availability, transportation to and daily activity. Other factors that would related to children's physical activity are, participation in organized sport, physical education classes in schools, transport patterns, electronic and screen based entertainment, and socio cultural changes (Dollman, 2005). These factors, some lead to the result of the urban children to have higher level of physical activity such as the equipment availability and transportation while some factors lead to the result that rural children have better level of physical activity (Loucaides et. al., 2004) [5]. Children nowadays also less active especially in urban areas. Dollman et. al. (2005) stated that children nowadays are more 'preferred' to be inactive when choosing activities such as eating and sleeping as their top 10 activities [6]. Furthermore, television watching also get higher rates if years by years especially girls. In Iowa, A study examining differences in physical activity, physical fitness, and overweight among rural and urban children shows that children from rural areas and small cities were more active than urban children (Joens-Matre et. al. 2008) [7].

However, despite higher activity levels, the prevalence of overweight was higher among rural children (25%) than children from urban areas (19%) and small cities (17%). Joens-Matre et.al. believed that diet impacted the weight status of the subjects in their study. Moreover, some researches resulting the vice versa. This may caused by the physical activity done by these children. Maybe the urban children do more physical activity than children who live in rural areas? Do urban children of Malaysia have lower physical fitness level compared to their friends who lived in rural areas?

III. Objective of study

- 1) Compare health-related fitness level between school children who lives in rural and urban areas.
- 2) To find out the various kinds of diseases for the lack of physical activity.
- 3) To find out the physical activity to prevent various diseases.
- 4) Present an in-home system for increasing the physical activity of urban children using Kinect.

IV. Significance of the study

The significance of this study is to compare whether the Malaysian children who lives in the urban areas has lower physical fitness level than children who lives in the rural areas as happened in most country of the world. The findings of the study could provide a better understanding on the level of fitness of children in urban and rural areas in Malaysia. The findings of the study could provide the information about the physical fitness level of the urban children and it also providing information to policy-makers of the Ministry of Education to create and develop strategies that preventing the decreasing level of physical fitness among urban school children.

V. Childhood Obesity in Bangladesh

Despite a major reduction in child being under-nutrition and undersize over the last three years, there has been a considerable increase in obesity among children in Bangladesh, say studies. A health study, published on 24 April shows the number of undersized children decreased from 41% to 36% and the percentage of underweight malnourished children came down to 14% from 16% in last three years. However, a survey conducted by the Centre for Control of Chronic Diseases of the ICDDR,B with support from the National Nutrition Services of Institute of Public Health Nutrition says ten out of every 100 children, aged 5-18 living in Bangladesh's urban areas, are overweight while 4% are obese. Around 4,100 children living in 30 wards of each of the seven city corporations were brought under the study. Another survey conducted separately by ICDDR,B shows the same result. The study was carried out using 19 years of demographic surveillance data to identify the changing risk factors behind childhood malnutrition.

In our part of the world, where chubby children are considered cute and healthy, parents often fret over the physical appearances of their children. There are parents who routinely feed their children burgers, fries, pizzas, pastries, etc. from the belief that these will make their children appear healthy. Unfortunately, the term healthy is often associated with fat or overweight; chubby children are not necessarily healthy children. In a country, where malnutrition has always been a problem, the high economic growth of recent decades has introduced a new but starkly different kind of health concern -- childhood overweight and obesity. In the preliminary results of a nationwide study recently conducted by ICDDR,B on obesity prevalence and physical activity among children and adolescents in urban areas of Bangladesh, it was seen that of children aged 5-18 years, 10 per cent are overweight while 4 per cent are obese. The figures are alarming, considering the size of our young population. The research identified availability of high-calorie fast/processed food, sedentary lifestyle, better transportation facilities, less outdoor recreational space and intake of more food and beverages as result of attractive media campaigns as some of the important factors contributing to childhood overweight and obesity among school-going children of Bangladesh. According to Obesity Prevention Source of Harvard School of Public Health, South Asian countries like Bangladesh, India and Pakistan have low child obesity rates compared to other countries. But the large populations of these countries add up to large numbers of children who are overweight or obese. I am used to seeing overweight and obese children here in the United States, where 18 per cent of children aged 6-11 years and a similar percentage of adolescents aged 12-19 years are obese or have excess body fat. In Bangladesh, childhood overweight and obesity is a new concern, but a grave concern nonetheless. During my last Dhaka trip, I saw children as young as two years old munching potato chips and watching TV. Children aged 6-10 years are eating chocolate-covered cereals for breakfast, doughnuts for lunch at school and fast food like burgers, or deep-fried drumsticks as afternoon snacks. We are happily feeding our children and grandchildren foods that are doing them more harm than good. On weekends, these children are eating out with their families and having high-fat, high-calorie restaurant food.

The emerging epidemic of childhood obesity is mainly attributed to dietary and lifestyle modifications, especially in urban areas. Fast-foods and high caloric beverages, reduced physical activities due to lack of playgrounds in schools and housing societies, widespread use of electronic gadgets by this tech-savvy generation are contributing to this modern epidemic. As childhood overweight and obesity tend to follow through adulthood, in longer terms, there is increased risk of developing chronic illnesses, said children's nutrition specialists.

Tahmeed Ahmed, director of Centre for Nutrition and Food Security at ICDDR,B told Prothom Alo, "When a country develops financially, the number of its undersized children decreases and obese kids increases. Same is in the case of Bangladesh." "While childhood under-nutrition is still highly prevalent in the country, there has been a steep rise in childhood obesity and overweight in the last two decades leading to double burden of malnutrition. So we should be cautious of the situation before it is too late," said Tahmeed Ahmed.

Reasons for worries: The study conducted by ICDDR,B shows about 56% of children had a normal weight while 30% weighed less than the normal weight (malnutrition). About 14% children had a weight above the normal ranges while 4% were obese. The assessment of their diets reveals that 98% children consumed rice or bread at least four times a week. Consumption of other types of food was less than three times in a week. These were meat (24%), egg (60%), legume (71%), vegetables (61%), milk (56%) and fruits (22%). The study says more than half of the children had frequently taken local fried snacks such as singara, samosa, chop, beguni, peaju while about 20% children ate calorie-rich fast food -- pizza, burger, and fried chicken and so on. Rising trend of overweight and obesity is emerging as a serious health concern in Bangladesh, creating higher risks of diabetes among urban children.

Fouzia Hossain, head of Pediatric Endocrinology, Birdem General Hospital who gives treatment to diabetes-affected children, told Prothom Alo, "Type 2 diabetes mellitus is the most common endocrine metabolic disorder in childhood and adolescence. Beside this, they are also suffering from heart diseases and high blood pressure. If their obesity increases they could be attacked by liver cirrhosis in the long run."

VI. Various diseases for the lack of physical activity

Low levels of physical activity and a sedentary lifestyle among children have been implicated in the development of cardiovascular disease, obesity, hypertension, type 2 diabetes and other chronic diseases later in life (26–29). Many studies examining secular trends in physical activity patterns in children reveal that a less physically active or a more sedentary lifestyle is becoming increasingly common (30–32); from a public health perspective, these observations are worrisome in terms of future risk for chronic diseases. These trends may be related to changes in physical and social environment stemming from urbanisation, which is not only recognized as the most important demographic shift worldwide during the past century, but is also an ongoing process leading nearly two-thirds of the world's population to be living in urban areas within the next 30 years (33). Whereas better living conditions have been shown to offer a potential advantage for improved physical fitness in urban compared to rural children (34,35),

nevertheless, urban residence has been linked to sedentary lifestyle due to lack of adequate space for play, concerns for safety, automatic transportation and computerization of many activities (36). This uncertainty is reflected on the results Physical Activity Patterns and Sedentary Behaviors of Children from Urban and Rural areas of Cyprus Eirini Bathrellou, Chrystalleni Lazarou, Demosthenes B. Panagiotakos, Labros S. Sidossis Department of Nutrition - Dietetics, Harokopio University, Athens, Greece from several studies that investigated physical activity patterns and sedentary behaviors of urban and rural children, which have been inconsistent: some have shown that urban children adopt a more sedentary lifestyle and have higher prevalence of overweight and obesity compared to their rural peers (37–39), whereas others found no differences and concluded that the place of residence, urban or rural, is not a major factor determining the physical activity patterns of children (40–42). The benefits of exercise extend far beyond weight management. Research shows that regular physical activity can help reduce your risk for several diseases and health conditions and improve your overall quality of life. Regular physical activity can help protect you from the following health problems.

- Heart Disease and Stroke. Daily physical activity can help prevent heart disease and stroke by strengthening your heart muscle, lowering your blood pressure, raising your high-density lipoprotein (HDL) levels (good cholesterol) and lowering low-density lipoprotein (LDL) levels (bad cholesterol), improving blood flow, and increasing your heart's working capacity. Optimizing each of these factors can provide additional benefits of decreasing the risk for Peripheral Vascular Disease.
- High Blood Pressure. Regular physical activity can reduce blood pressure in those with high blood pressure levels. Physical activity reduces body fat, which is associated with high blood pressure.
- Noninsulin-Dependent Diabetes. By reducing body fat, physical activity can help to prevent and control this type of diabetes.
- Obesity. Physical activity helps to reduce body fat by building or preserving muscle mass and improving the body's ability to use calories. When physical activity is combined with proper nutrition, it can help control weight and prevent obesity, a major risk factor for many diseases.
- Back Pain. By increasing muscle strength and endurance and improving flexibility and posture, regular exercise helps to prevent back pain.
- Osteoporosis. Regular weight-bearing exercise promotes bone formation and may prevent many forms of bone loss associated with aging.
- Self Esteem And Stress Management. Studies on the psychological effects of exercise have found that regular physical activity can improve your mood and the way you feel about yourself. Researchers have found that exercise is likely to reduce depression and anxiety and help you to better manage stress.

- Disability. Running and aerobic exercise have been shown to postpone the development of disability in older adults.
- Arthritis. Exercise can reduce pain, help maintain muscle strength in affected joints and reduce joint stiffness.
- Physical activity is especially important in children with asthma. Activities such as running[9] and swimming[10] are associated with improved fitness and decreased severity of asthma symptoms. Regular exercise and level of physical conditioning are major determinants of exercise tolerance in children with controlled asthma.[11][12],10 Recent studies indicate a comorbidity of asthma and obesity in urban children[13][14]; however, the direction of the association is uncertain.[15] Regardless of the cause and effect, physical activity is an important contributor to fitness in children with asthma.

VII. Cause for the difference between rural and urban children

Physical activity was hindered by inadequate recreational resources, unsafe streets, and distance, but was promoted by the natural environment and support for youth sports. The cause for the difference between rural and urban children in case of physical activity are:-

- 1) The number of playing grounds is not available to fulfil the requirements of all the children in an urban area.
- 2) Some school and college have physical education as their course but not all.
- 3) The number of physical education provided by the schools and college is not sufficient at all.
- 4) The parents does not have the time or does not feel safe to send their children to the playground.
- 5) Urban children spends more time on computer games or tv.

From the above statements it can be said that, the urban children need to increase the physical activity to remain safe and sound and to remain also free from diseases. The purpose of this study is to present an in-home system based on Kinect platform to increase the physical activity of an urban children regularly.

VIII. How Much Physical Activity Do Youth Need

- ▶ Children and adolescents should do 60 minutes (1 hour) or more of physical activity daily
- ▶ *Aerobic Activities:* Most of the 60 or more minutes per day should be either moderate- or vigorous-intensity aerobic physical activity. Vigorous-intensity physical activity should be included at least 3 days per week.
- ▶ Examples of aerobic activities include bike riding, walking, running, dancing, and playing active games like tag, soccer, and basketball.

- ▶ *Muscle-strengthening Activities:* Include muscle-strengthening physical activity on at least 3 days of the week as part of the 60 or more minutes.
- ▶ Examples of muscle-strengthening activities for adolescents include push-ups, pull-ups, and weightlifting exercises.
- ▶ *Bone-strengthening Activities:* Include bone-strengthening physical activity on at least 3 days of the week as part of the 60 or more minutes.
- ▶ Examples of bone-strengthening activities include hopping, skipping, jumping, running, and sports like gymnastics, basketball, and tennis.
- ▶ Some activities may address more than one category at a time. For example, gymnastics is both muscle-strengthening and bone-strengthening while running is aerobic and bone-strengthening.
- ▶ Activities should be age-appropriate, enjoyable, and offer variety.

IX. Approaches to physical education in schools and colleges

- ▶ The promotion of physical activity within schools and Physical Education (PE) has attracted growing interest in recent years. Schools have been acknowledged as the primary institution with responsibility for promoting activity in young people and more specifically, school PE has been recognized as having a key role to play.
- ▶ Given the growing concerns over the physical activity levels of many young people and the possible health consequences, targeted efforts to promote physical activity would seem to be warranted. In this respect, the promotion of physical activity within schools and the physical education (PE) curriculum has attracted growing interest in recent years.
- ▶ The role of schools and PE in promoting health and the link between health and education has increasingly been recognized by Government in the United Kingdom (UK).

X. Examples of physical activities in schools and colleges

- ▶ Light
 - ▶ Walking slowly
 - ▶ Sitting using computer
 - ▶ Standing light work (cooking, washing dishes)

- ▶ Fishing sitting
- ▶ Playing most instruments
- ▶ Moderate
 - ▶ Walking very brisk (4 mph)
 - ▶ Cleaning heavy (washing windows, vacuuming, mopping)
 - ▶ Mowing lawn (power mower)
 - ▶ Bicycling light effort (10-12 mph)
 - ▶ Bad minton recreational
 - ▶ Tennis doubles
- ▶ Vigorous
 - ▶ Hiking
 - ▶ Jogging at 6 mph
 - ▶ Shoveling
 - ▶ Carrying heavy loads
 - ▶ Bicycling fast (14-16 mph)
 - ▶ Basketball game
 - ▶ Soccer game
 - ▶ Tennis singles

XI. Contribution of physical activities in school and colleges

- ▶ Youth who are physically active get physical and mental health benefits.
- ▶ Comprehensive school-based physical activity programs can help youth meet most of their physical activity needs.
- ▶ School-based physical activity programs benefit communities as well as students and schools.

XII. Limitation of activities in school and colleges

- ▶ Not Every school or college have physical education as co-curricular activities.

- ▶ To have physical education as academic purpose playground is essential, which is not available at all the cases.
- ▶ Within the short period of time in academic course, the need for physical exercise is not fulfilled.
- ▶ When exercising for academic purposes, physical exercise becomes boring. But if combined with different games physical exercise can be made fun.

XIII. Physical Exercise for Urban Children

Light activity for children includes a range of activities, such as:

- ▶ standing up
- ▶ moving around
- ▶ walking
- ▶ less energetic play

Examples of energetic activities

- ▶ running around
- ▶ jumping on a trampoline
- ▶ riding a bike
- ▶ dancing
- ▶ swimming
- ▶ climbing
- ▶ skipping rope
- ▶ gymnastics

XIV. Classification of physical activities for different ages

- ▶ Toddlers (1-3 years): 30 mins of structured physical activity (planned and organized) At least 60 mins of unstructured physical activity (free play).
- ▶ Preschoolers (3-5 years): 60 mins of structured physical activity At least 60 mins of unstructured physical activity.
- ▶ Children (6-9 years): At least 60 mins of moderate-to-vigorous-intensity physical activity every day, including: Vigorous-intensity activities at least 3 days a week. Activities that strengthen muscle and bone at least 3 days a week.

- ▶ Children (10-12 years): At least 60 mins of moderate-to-vigorous-intensity physical activity every day, including: Vigorous-intensity activities at least 3 days a week. Activities that strengthen muscle and bone at least 3 days a week.
- ▶ Teens (13-17 years): At least 60 mins of moderate-to-vigorous-intensity physical activity every day, including : Vigorous-intensity activities at least 3 days a week. Activities that strengthen muscles and bones at least 3 days a week.

XV. Kinect as a sensor

The Kinect is a low-cost, off-the-shelf, readily available markerless sensor that can gather positional information about an individual's motion. These properties captured the interest of researchers for developing affordable platforms for rehabilitation and exercising. Lowes *et al.* [17] showed the feasibility of using a Kinect platform to assess upper extremity function in individuals with dystrophinopathy. The authors of [18] use a Kinect to trigger events in a virtual world based on user's gestures. In [19], the user resolves mental activities by executing various motions captured by the Kinect. Lange *et al.*'s game based on Kinect [20] is designed to elicit specific therapeutic motions when controlling a virtual avatar in order to improve balance in patients. The Kinect system of Huang [21] is used for the rehabilitation of young adults with motor impairments. Schonauer *et al.*'s solution [22] provides a multimodal input (including a full body motion capture system, a Kinect and bio-signal acquisition devices) to a game engine targeting rehabilitation of patients with chronic pain of the lower back and neck. Several studies are also aimed at comparing the performance of Kinect with respect to other motion capture systems in the context of rehabilitation activities [23-25]. The comparison of the precision in the computation of joint angles between Kinect and the Vicon optical motion capture showed that Kinect offers a range of disparity that guaranties enough precision for most of the clinical rehabilitation treatments prescribed nowadays for patients [23]. Stone *et al.* [24] obtained similar results for Kinect versus Vicon for the screening of ACL injuries. In particular, the Kinect skeletal model was shown to likely offer acceptable accuracy for use as part of a screening tool for elevated ACL injury risk, but the quantification of movement is not discussed. A similar study [16] showed that Kinect achieves competitive motion tracking when compared to OptiTrack motion capture system for spinal cord injury rehabilitation.

All these studies show that the Kinect is an appropriate solution for tracking a subject during in-home exercising with a reasonable precision. Therefore the work in this paper aims at quantifying human movement during an exercise sequence using this sensor. The analysis goes beyond the state-of-the-art solutions by monitoring more joints and offering more advanced reports on the movement such as: the position and trajectory of each joint, the average velocity, the fatigue of the user and the working envelope of each member. This data can be visualized and compared to a standard (e.g. a healthy user for rehabilitation purposes) or an ideal performance (e.g. perfect sport pose for exercising) in order to

give the user a measure on his/her own performance. This information can be used by a therapist or professional sports trainer to evaluate the progress of a patient or of a trainee.

XVI. Existing works

The Biggest Loser

Release Date: 26/11/2010

Freedom of Movement: Players can elect to workout controller-free allowing for greater focus on the program. Create Your Own Avatar: In the new game, players can create and customize their own avatar and watch as their body transforms both on and off the screen. Track Your Progress: Players can track their progress through the game's calendar, which displays a recommended routine for that day, challenges, weigh-in information, along with personalized nutrition information such as calories burned and calories consumed. The game also allows players to input outside activity so that it counts toward their overall goal.

UFC Personal Trainer

Release Date: 28/06/2011

The game includes several type of movement based health fitness strategies. User can do regular physical exercise on routine based using this game. There is a fixed time limit for every exercise to be performed.

Fighters Uncaged

Release Date: 4/10/2010

Fighters Uncaged is the ultimate fighting game published to-date for play on Xbox 360. Utilizing the motion capturing capabilities of the Xbox 360 Kinect system, players put away their standard wireless controllers and become the controller themselves as they take on the varied and seedy characters of the game world in tournament style fighting action using their fists, knees, feet, elbows and anything else they need to.

Kinect Sports

Release Date: 20/10/2010

All six of the events in *Kinect Sports* support multiplayer both locally and online, with a mixture of competitive and cooperative play options. In addition, players can also take part in eight sport-based mini games, or join in the Party Play mode designed to accommodate a larger number of players amassed in the same room, divided into two teams.

XVII. Limitation

All these games are based on specific physical activities based on various needs. As example various kinds of training, yoga etc. They don't meet the needs of daily physical exercise. Some other research were based on therapy and rehabilitation process for patients. Some other research areas are based on wearable sensors. However, wearing sensors on the body causes discomfort and limits natural movement. Moreover, the incorrect placement of such sensors, particularly of markers can induce errors in the measurements and therefore in the results of the evaluation of performance. From here derives the interest into affordable vision-based marker less sensors that do not require sensors to be attached to the user.

XVIII. Proposal

This article discusses a Kinect-based framework for human movement quantification for in-home physical exercise monitoring. A Kinect-based solution for performance tracking, as the one proposed in this work, can be useful as an in-home training platform, due its affordability. The sophisticated tools and technologies offered in a therapy office are generally too expensive to have at home. Moreover, it was shown that where considered safe, every opportunity to increase the intensity of therapy should be pursued in order to improve dysfunctional movements [43]. In this case, in-home exercising is more flexible and convenient for the patient, while also allowing for more frequent repetition of exercises. While therapy sessions alone often cannot fulfill the required frequency of practice, in-home exercises can achieve this goal. Beyond its professional use in a therapy, a Kinect training platform can be helpful for people simply wanting to improve their physical condition by guided exercising. Our proposal includes:-

- To find out different types of physical activities, by exercising which can prevent different diseases or improve health.
- To reduce the chance of various diseases among urban children that can happen for the lack of physical exercise by creating an in-home physical exercise monitoring system.
- To create a gaming system for in-home physical exercise monitoring based on Kinect platform.
- The gaming system will provide feedback on how the user performs and what to do differently and to suggest suitable exercise recommendations.
- To map various types of physical exercise in the game so that the user can take part in those activities.
- The data collected from the performance of the user will be compared to the data of a standard healthy user.
- We will provide feedback to the users or parents so they can know which areas should be improved by their children.
- It will indicate areas where additional effort is required or pinpoint fast the situations where the patient or subject doesn't respond well to the training program.
- To make physical exercise entertaining, safe and affordable.
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XIX. Game Characteristics

- In the game, we will provide different types of physical exercise related scenario.

- User will choose between them and select which one he/she wants to play.
- But before any of the sub games, user must first complete the warm up. So that any unexpected outcome can be avoided.
- In warm up, user will have to jog for a period of time.
- We will fix the time for a sub game. Then how much they ran in for example in the running game or how many jumps they made in a fixed interval of time will be compared to that of a standard user and result will be generated.
- We will increase the intensity of the exercise with the passage of time.
- We will map the game with entertaining scenarios, so that children may find it compelling to play the game.
- For example
- In case of running, we can create an enemy who is going to catch the user.
- In case of jumping, we can create a scenario like temple running game.

XX. Solution Approach

BMI

Body mass index (BMI) is a measure of body fat based on your weight in relation to your height, and applies to most adult men and women aged 20 and over. For children aged 2 and over, BMI percentile is the best assessment of body fat.

BMI does not measure body fat directly. However, research indicates that BMI correlates to direct measures of body fat such as underwater weighing and dual-energy X-ray absorptiometry (DXA), and is considered an inexpensive and easy-to-perform alternative for these.

Here are some key points about BMI. More detail and supporting information is in the main article.

- Body mass index (BMI) is a measure of relative size based on the mass and height of an individual.
- The Quetelet Index was devised by Adolphe Quetelet, a Belgian mathematician, astronomer and statistician, in 1832. It was later termed "body mass index" in 1972 by Ancel Keys.
- BMI is a simple, inexpensive and noninvasive surrogate measure of body fat.
- Factors such as age, sex, ethnicity and muscle mass are not accounted for in BMI.
- For adults 20 years and older, BMI is interpreted by using standard weight status categories that are the same for all ages, and for both men and women.

- For children and adolescents between 2-20 years old, BMI is interpreted relative to a child's age and sex.
- BMI is a reasonable indicator of body fat for both adults and children.
- Because BMI does not measure body fat directly, it should not be used as a diagnostic tool.
- BMI should be used as a measure to track weight status in populations and as a screening tool to identify potential weight problems in individuals.
- Other measures of body fat, such as skinfold thicknesses, bioelectrical impedance, underwater weighing and dual energy X-ray absorption, maybe more accurate than BMI.

$$BMI = Weight/Height^2$$

Metric BMI Formula

$$Weight (kg) / Height (m)^2$$

With the metric system, the formula for BMI is weight in kilograms divided by height in meters squared (kg/m²). Since height is commonly measured in centimeters, divide height in centimeters by 100 to obtain height in meters.

Imperial BMI Formula

$$(Weight (lbs.) * 703) / Height (inches)^2$$

When using pounds and inches, the formula needs to be altered slightly. Multiply your weight in pounds by 703. Divide that by your height in inches, squared.

Classification of Adult:

18.5 to 24.9	Normal weight
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25 to 29.9	Over weight
30+	Obesity
40+	Extreme obesity

XXI. BMI for Children and teens

Girls and boys develop differently and have different amounts of body fat at different ages, so a child's age is taken into consideration when looking at their BMI. For children and teens, BMI age- and sex-specific percentiles are used. The interpretation of BMI is both age- and sex-specific for children and teens. BMI-for-age growth charts take into account these differences and allow translation of a BMI number into a percentile for a child's sex and age.²

Nearly 1 in 3 children or teens in the US are overweight or obese. Carrying extra weight as a child or teenager can pose significant health risks, both during childhood and into adulthood.¹⁴ Maintaining a healthy weight during childhood is especially important for heart health. Research shows that nearly 60% of overweight children aged 5-17 had at least one risk factor for cardiovascular disease and 25% had two or more. Also, obese children have an 80% chance of staying obese their entire lives.

Heart disease, often caused by high blood pressure or high cholesterol, is not the only health risk of obesity. Childhood obesity may also lead to significant health problems, including:

- Type 2 diabetes
- Asthma
- Sleep apnea
- Psychological stress, including low self-esteem, caused by the social stigma of being obese

BMI for children and teens is worked out the same way as for adults. However, the BMI number and age then needs to be located on a sex-specific BMI-for-age chart to indicate whether the child is within a healthy range



Figure 1 BMI-for-age charts are recommended to assess weight in relation to stature for children ages 2-20 years.

Although BMI is used to screen for overweight and obesity in children and teens, BMI is not a diagnostic tool.¹⁵ A child may have a high BMI for age and sex, but to determine if excess fat is a problem, a health care provider would need to perform further assessments. These assessments might include skinfold thickness measurements, evaluations of diet, physical activity, family history and other appropriate health screenings. Healthy weight ranges cannot be provided for children and teens for the following reasons:

- Healthy weight ranges change with each month of age for each sex
- Healthy weight ranges change as height increases.

Classification of percentiles for children over age 2, or teens:

Less than the 5th percentile	Underweight
5th percentile to less than the 85th percentile	Healthy weight
85th to less than the 95th percentile	Overweight
Equal to or greater than the 95th percentile	Obese

CDC Age Specific, Sex Specific BMI Chart for Obesity

Age	Weight(Boy)	Weight(Girl)
6-7	22	21
8-9	35	33
10-11	49	50
12-13	61.5	63
14-15	77.5	79

XXII. Caloric Expenditure

Many parents have lamented that they want the energy of their kids. It's true that children expend a lot of calories over the course of a day. Knowing how many calories your child burns during a typical day helps you ensure that she's getting enough calories to support her activity

but not so many that she starts to gain weight, which can be unhealthy. Monitor your child's calorie expenditure to keep her healthy and on track with development.

Sports

Kids of most ages can participate in team sports. Not only do they build social skills and physical development, but participating in practice and games helps a child burn calories and stay physically fit. A 75-pound child burns nearly 400 calories per hour playing basketball, about 300 calories per hour playing touch football or soccer, approximately 200 calories per hour while swimming, about 150 calories per hour playing volleyball and about 100 calories per hour bowling, according to calculations from HealthStatus.com. A heavier child will burn more calories and one who weighs less burns fewer calories.

Outdoor Activities

Children don't have to be involved in team sports to burn calories. Many outdoor games and activities burn calories and help your child stay in good shape. In one hour, a 75-pound child can burn about 100 calories fishing or playing Frisbee, 135 calories riding a bike or raking, 150 calories washing the car or mowing the lawn, 170 calories skating, 200 calories hiking and 350 calories jumping rope. Mix and match your child's favorites for maximum benefits.

Indoor Activities

Playing outside provides higher calorie burn potential because there's more room to move around and get active, but that doesn't mean that being stuck inside doesn't also burn calories. Mix outside games and sports with inside fun to balance out your child's overall calorie burn. Per hour, a 75-pound child burns approximately 35 calories sleeping, reading or sitting still, 50 calories playing cards or board games, 60 calories studying, 90 calories playing billiards or cooking, 100 calories playing the piano or guitar and 200 calories dancing or boxing with a punching bag.

XXIII. Future work

- Implement multiplayer feature.

- Conduct a field work with urban children to determine the efficiency of the system.

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