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Establishment of a School Implemented Exercise Program to Prevent Injury and Promote Health among Youth: Is There a Link between Balance and Physical Health?

Samir Z. Chaudhry
UCONN, samirchaudhry22@gmail.com

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AUTHOR: SAMIR CHAUDHRY
Thesis Advisor and Editor: Professor Laurie Devaney

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Introduction

Injuries are a leading cause of disability for all ages regardless of sex, race, ethnicity or socioeconomic status (healthypeople.gov). This means injury can disable a person's ability to do certain tasks like walk, jog or even go grocery shopping. These disabilities can be permanent. More research has also found that 4.4% of adolescents 12-17 years of age missed 11 or more days of school in the span of 12 months because of illness or injury (cdc.gov). However, the question is why are these children getting injured at such a young age? Moreover, a study done in Canada mentions that the leading cause of injury in adolescents is sport related injury. The study estimates that 29.4% of adolescent participants were injured (Emery, 2005). While this study was done in Canada, similar studies in North America have concluded sports are the leading cause of injury which require medical attention among adolescents (Bean, 2014). Therefore, one can argue there is a sufficient need to establish an injury prevention program for adolescents.

Injury prevention and physical fitness go hand in hand. Physical fitness itself is important in preventing diabetes, ischemic heart disease, and hypertension (who.int). The problem is that levels of physical activity among a population may fluctuate. An example of this is middle schools around the United States, where participation in all types of physical activity declines as age or grade in school increases (cdc.gov). Even more interesting is that it has been noted 14% of young people report doing no recent physical activity, while nearly half of Americans aged 12-21 years are not vigorously active on a regular basis (cdc.gov). It is then understandable that approximately 17% of adolescents in the United States were found to be obese in 2011 (cdc.gov). If the benefits of physical activity are certain, why is the falling level of participation in physical activity at school along with a shocking prevalence of obesity an epidemic in the United States?

Participation in physical activity is falling rapidly in adolescents, and those adolescents who do participate in vigorous physical activity are engaged in what is considered to be the number one cause of injury in adolescents. The evidence urges an intervention. An intervention program can be defined as the intentional process of providing all youth with the support, relationships, experiences, resources and opportunities needed to become successful and competent adults (healythypeople.gov). There has been growing evidence that well-designed youth development interventions can lead to positive outcomes. With the issue of rising obesity, diabetes onset, and injury risk within adolescents the proper response is to establish an intervention program within school. In addition to establishing a program, rigorous evaluation on the program should be done in order to determine what works, why it works and what composes a successful intervention program. Thorough documentation will allow possible replication and edits as needed to be used in other localities by other administrators (healthypeople.gov).

School provides an excellent local hub to reach all adolescents in an effective manner which is being significantly underused. It is startling that today 22.7% of middle schools allow students to be exempt from physical education classes (cdc.gov) and that only 7.9% of middle schools provide daily physical education or its equivalent for the entire school year (cdc.gov). Middle school participation in physical education has decreased, however, the need for physical activity in adolescents of this age has only increased. The World Health Organization recommends that children and youth aged 5-17 should have at least 60 minutes of moderate to vigorous intensity physical activity daily (cdc.gov). Thus, if an intervention program were to be placed, having one at school would be the most efficient. This is because school is the lowest common denominator for reaching almost every adolescent in the United States. Well-designed school based interventions directed at increasing physical activity in physical education classes have also been shown to be effective (healthypeople.gov). In addition, social support from family and friends positively correlates with regular physical activity (healthypeople.gov). Establishing a school intervention program would be best and thus provides the rationale for Husky Move.

Husky Move is an intervention program used to prevent injury risk and promote exercise among adolescents in which kids can be linked to mentors, teachers and their peers to encourage physical activity and participation. The exercises done within Husky Move focus on establishing competency in fundamental movement skills (FMS). These skills are garnered from exercises including running, hopping, jumping and balancing. FMS are positively associated with increased physical activity levels and associated with lower weight status in children (Husky, 2016). Husky Move has two primary aims. First, the program aims to evaluate the effect of the exercise on injury risk factors, obesity and physical activity monitoring for children in an urban school. Additionally, Husky Move aims to change children's knowledge and attitudes towards physical activity (huskysport.uconn.edu). The primary objective of this study in this paper will be a component of the program Husky Move.

Body Mass Index is one of the parameters that was measured within this study. Body Mass Index (BMI) is a person's weight in kilograms divided by a person's height squared in meters. BMI is also positively correlated with measures of body fat. Analyzing BMI results can give estimates as to whether a person is determined to be underweight, normal (healthy weight), overweight or obese. While it is true that BMI can be an indicator to whether a person is overweight or possibly obese it cannot be the determining factor. A child over the 95th percentile for BMI in their respective age and gender group is considered obese (cdc.gov). This comparison among age group needs to be done because for children and teens BMI is interpreted differently than for adults. Thus, a children or teen's BMI must be checked against a scale for age and sex-specific BMI data to determine what is underweight and overweight. This is because the amount of body fat changes drastically in these ages due to puberty and the amount of body fat changes differs between boys and girls as well. There is clearly a very strong correlation between BMI and body fatness, meaning BMI is a good preliminary indicator of comparative body fat within a population. The accuracy of BMI increases with higher levels of BMI. There are exceptions especially with athletes because athletes and non-athletes with the same BMI will have a different level of body fatness (cdc.gov).

The relationship between BMI and increased physical activity has been determined to be a negative correlation. This has been confirmed by numerous previous studies (Tiruneh, 2009). The relationship between physical activity and BMI is assumed to be inversely correlated because if one were to have an energy intake under his energy expenditure he would be losing weight. Essentially performing physical activity will get rid of the extra calories in the body. There is a consensus that the association between physical activity and BMI is stronger in obese people than the non-obese. This information with the vast variance within body weight in different age and gender groups have led researchers to move away from the inverse linear model between BMI and physical activity. Researchers instead prefer to explain that the relationship between BMI and physical activity can better be explained by an inverse logarithmic model (Tiruneh, 2009).

Balance is the ability to maintain equilibrium. This generally improves in people from ages 3 to 18. Classic research suggests that females have better static and dynamic balance during childhood and this advantage stays throughout life. It has been shown that physical activity in general increases flexibility, coordination and balance of the person (Emery, 2005). Proprioceptive balance training is actually used in many sports rehabilitation programs following sports-related injuries and has become widely recognized as an efficient method in injury prevention of lower extremities (Emery, 2005). However, these rehabilitation programs were multifaceted and included many other aspects of training that can also affect results. Cassidy, D. J. et al. (Emery, 2005) have although concluded, that using a six week proprioceptive balance-training program in adolescents proved effective to increase static and dynamic balance while also preventing all self-reported athletic injury over the observation period. This study also included evidence to support the training program reduced ankle sprain likelihood in these same subjects (Emery, 2005). Therefore, providing sufficient evidence that balance is a vital component of any injury prevention program because static and dynamic balance training have shown evidence for reducing injury in adolescents.

BMI and balance are both important concepts to take into account when creating an injury prevention program which relies on exercise. While they are important parameters to consider on their own with their relation to injury risk and overall health, this study will look at whether they are dependent upon each other. There is evidence in the literature that suggests results regarding a possible correlation between the two is controversial. Although, it has been clearly shown that children who are obese have produced poor balance scores in balance tests (D'hont, 2009) there is still little or no evidence suggesting a strong correlation between increasing BMI and poor balance among adolescents. The primary objective of this study was to investigate the relationship between BMI and balance for an adolescent.

Methods

Participants within the study were 74 adolescent age students (10-15 years old) at an urban middle school in Northeastern United States. The exclusion criteria was the same for all ages. A paper was sent home for all children's parents detailing the injury prevention program and what was needed from a child to participate. The slip had to be signed in order for the child to opt out of participation. No children returned the slip and so all children were determined as participants of the study. The study done was approved by the UCONN IRB. The data collectors and raters of the subjects were university graduate students.

Balance was measured by the Balance Error Scoring System (BESS). The BESS is a convenient, inexpensive and objective test using to measure postural instability. It takes less than ten minutes to conduct and can be done anywhere with the proper equipment (knownconcussion.org). The subjects were tested for three postural stances on two different surfaces. The three stances are a double leg stance, a single leg stance and a tandem stance position. The double leg stance position is when the subject is standing both feet together on the ground with the hands on the hips. The single leg stance is when the subject stands on the non-dominant foot with the hands on the hips. Finally, the tandem stance is when the subject stands with both hands on the hips and heel to toe with the dominant foot in front of the non-dominant foot. In order to determine the subject's dominant foot ask which foot they kick a soccer ball with. Each stance was be done for a twenty second trial. (Figure 1 Appendix I) Any errors were measured for each subject. (Figure 2 Appendix I).

All subjects were measured for BMI. BMI was measured traditionally by using a ratio between height in meters and weight in kilograms. This method was used because it is less invasive for the students instead of using calipers which would accurately measure body fat percentage but may be uncomfortable for the children. Additionally, BMI is routinely utilized in research as a measure for health risk including identifying if a person is overweight or obese by comparing the numbers against standardized numbers for a specific gender and age group. Thus, using BMI can be advantageous in comparing numbers to the literature.

All BMI data was averaged in corresponding age and gender groups. Data was analyzed with SPSS v22 which calculated descriptive results for BMI and BESS scores. The Pearson correlation was analyzed followed by linear regression to determine the correlation and predictive value of BMI with respect to BESS score. In other words, measuring whether the BMI of a subject will help better predict the BESS score of an adolescent.

Data

Table 1. Descriptive Demographics

Descriptive Demographics	
Age range	10 to 16
Mean age	12
Mean height	60.14 in
Mean weight	114.94 lb

Table 2. Weight, Height and BMI by age

Age	Mean Weight (lb)	Median Weight (lb)	Mean Height (in)	Median Height (in)	Mean BMI (Kg/m^2)
10	95.66	87.54	56.3	56.5	20.77
11	95.6	85.33	57.2	85.33	20.3
12	103.6	95.3	59.96	60.25	20.18
13	141.08	125.24	62.68	62	24.76
14	143.08	140.7	65.64	67	23.43
15	175.87	175.87	67.5	67.5	27.36

Table 3. Average BMI for girls and boys within each age group

Age	Mean BMI (boys)	Mean BMI (girls)	BMI percentile (boys)	BMI percentile (girls)
10	19.27	21.84	80th	80th
11	19.73	18.83	75th	75th
12	20.19	20.17	80th	75th
13	21.25	25.85	75th	95th
14	18.87	24.19	40th	90th
15	24.55	30.17	85th	above 95th

Table 4. **Descriptive Statistics**

	Mean	Std. Deviation	N
BESSTOTAL	14.46	4.80	74
BMI	21.86 kg/m^2	5.86	74

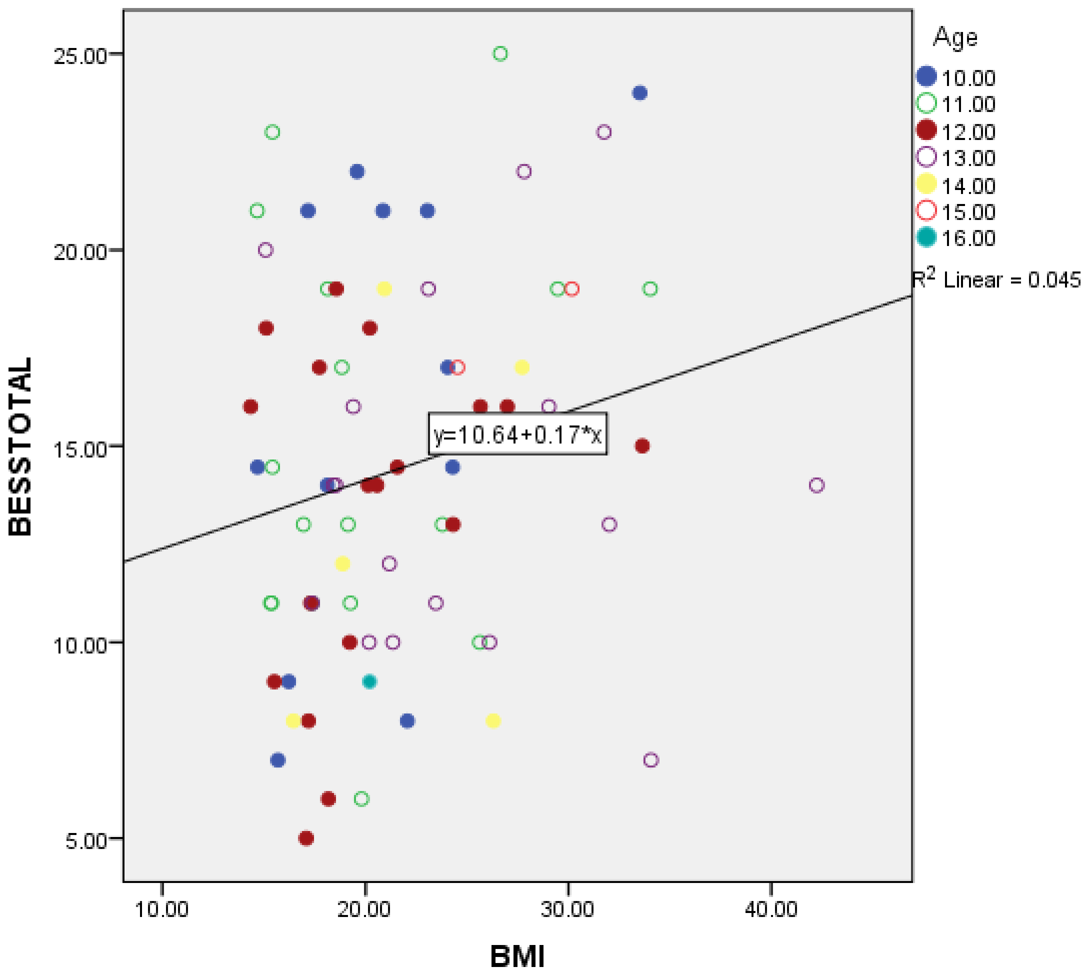
***Table 5.* Correlations**

		BESSTOTAL	BMI
Pearson Correlation	BESSTOTAL	1.000	0.213
	BMI	0.213	1.000
Sig. (1-tailed)	BESSTOTAL	.	0.034
	BMI	0.034	.
N	BESSTOTAL	74	74
	BMI	74	74

***Table 6.* Model Summary**

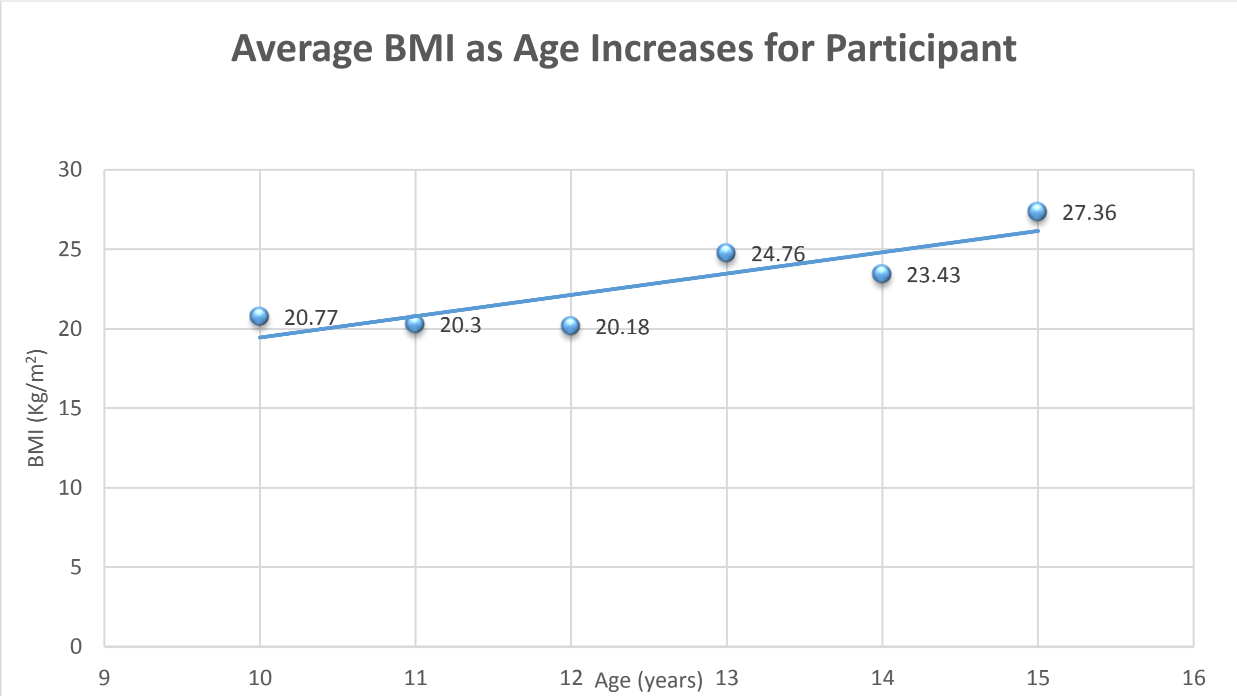
					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	0.213[a]	0.045	0.032	4.73	0.045	3.422	1	72	0.068

a. Predictors: (Constant), BMI



[redacted]

Graph 1. Scatter Plot of BESS Total vs. BMI



Graph 2. Average BMI as Age Increases for Participant with trend line

Results

Seventy-four middle school aged adolescents from an urban middle school were assessed in which 24 were males and 45 were females. The mean age of participants was 12 while the age of participants ranged from 10-16 years old. Table 1 shows the basic properties of the population of participants worked with. The average height of the population was 60.14 inches. The average weight was 114.94 pounds.

Statistics on average height, median height, average BMI, average weight and median weight were grouped for all individual age groups of participants. This is shown in Table 2. Graph 1 shows a scatter plot with a line of best fit showing BESS score and BMI graphed against each other. These values were graphed with the independent variable age versus dependent variable BMI with a trend line shown in graph 2. In Table 3 average BMI by age and gender was displayed. Table 3 then depicts what percentile each average BMI falls under using figures

5 and 6 for interpretation of BMI.

The BMI recorded for all subjects showed a mean of 21.86 kg/m^2 with a variance of 34.34 and a standard deviation of 5.86. The BESS total score mean among all subjects was recorded at 14.45 with a variance of 23.04 and a standard deviation of 4.8. As seen in table 5 the 1-tail significance test shows the significance of the correlation between BMI and BESS score to be 0.034. In table 6 it shows that the adjusted R-square is calculated to be 0.045 which means that 4.5% of the variance in the BESS score can be attributed to the BMI. In table 6 the F-change statistic is 3.422% with a $p = 0.068$ meaning it is statistically significant.

Discussion

The main objective of this study was to investigate the relationship between BMI and BESS score. The 1 tail significance test shows the significance of the correlation between BMI and BESS score to be 0.034. The correlation between BMI and BESS score was moderate and statistically significant. The adjusted R-square is calculated to be 0.045 which means that 4.5% of the variance seen in BESS score can be attributed to BMI results. The F-change statistic was 3.422% with a significance of $p = 0.068$). Conventional statistics would render this statistically insignificant. It would be interesting to do the same study with a larger population and see the results at 0.068. Perhaps a stronger correlation between BESS score and BMI could be determined. It is important to remember this is only one urban middle school in the United States and it is not a fair representation of all urban middle schools let alone all middle schools in the United States.

Of course, there were drawbacks in the experimental design that could call into question some of the results. For example, the experiment was not completely random in choosing participants. Additional concerns could arise from the lack of data points or participants in each gender and age group when determining BMI. It is more accurate to use percentile in assessing BMI for adolescents. Most subjects were found to be in one group with regards to percentile and that is the healthy weight group. This was not done as the data used was mean BMI data. Thus, each subject was not stratified by percentile. It is possible that repeating the experiment with a larger population could lead to more focused conclusions and reliable data, perhaps with the use of percentiles for BMI data as well.

Conclusions

The primary objective of this study was to determine a relationship between BMI and balance. BMI, if used to predict balance, helped predict balance better by a small amount. The correlation itself between BMI and BESS score was moderate but it was statistically insignificant.

Appendix I: Relevant Figures

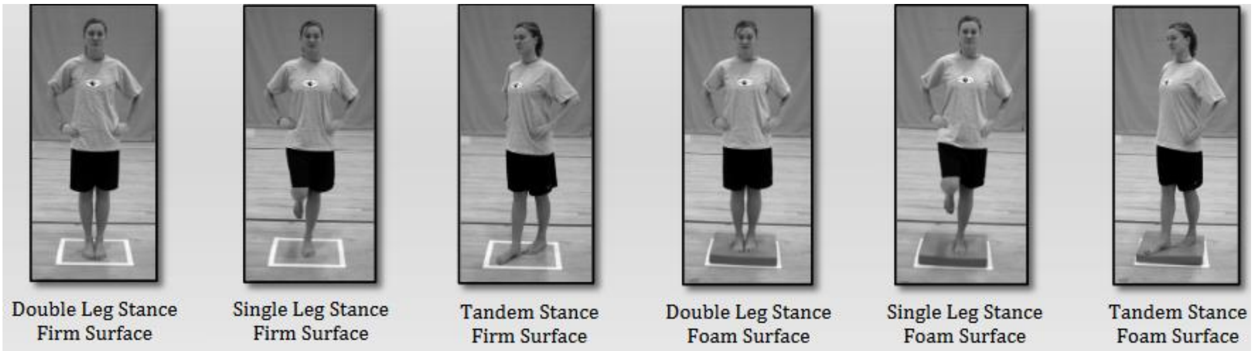


Figure 1. Depicted stances for the BESS test. Retrieved from http://knowconcussion.org/wp-content/uploads/2011/06/BESS.pdf

Errors:
- **Moving the hands off the hips**
- **Opening the eyes**
- **Step, stumble or fall**
- **Abduction or flexion of the hip beyond 30˚**
- **Lifting the forefoot or heel off of the testing surface**
- **Remaining out of the proper testing position for greater than 5 seconds**

The maximum total number of errors for any single condition is 10.

If a subject commits multiple errors simultaneously, only one error is recorded.

B.E.S.S. SCORECARD

Count Number of Errors max of 10 each stance/surface	FIRM Surface	FOAM Surface
Double Leg Stance (feet together)		
Single Leg Stance (non-dominant foot)		
Tandem Stance (non-dominant foot in back)		
TOTAL SCORES: total each column		
B.E.S.S. TOTAL: (Firm+Foam total)		

Figure 2. BESS score table. How to score and describe errors. Retrieved from http://knowconcussion.org/wp-content/uploads/2011/06/BESS.pdf

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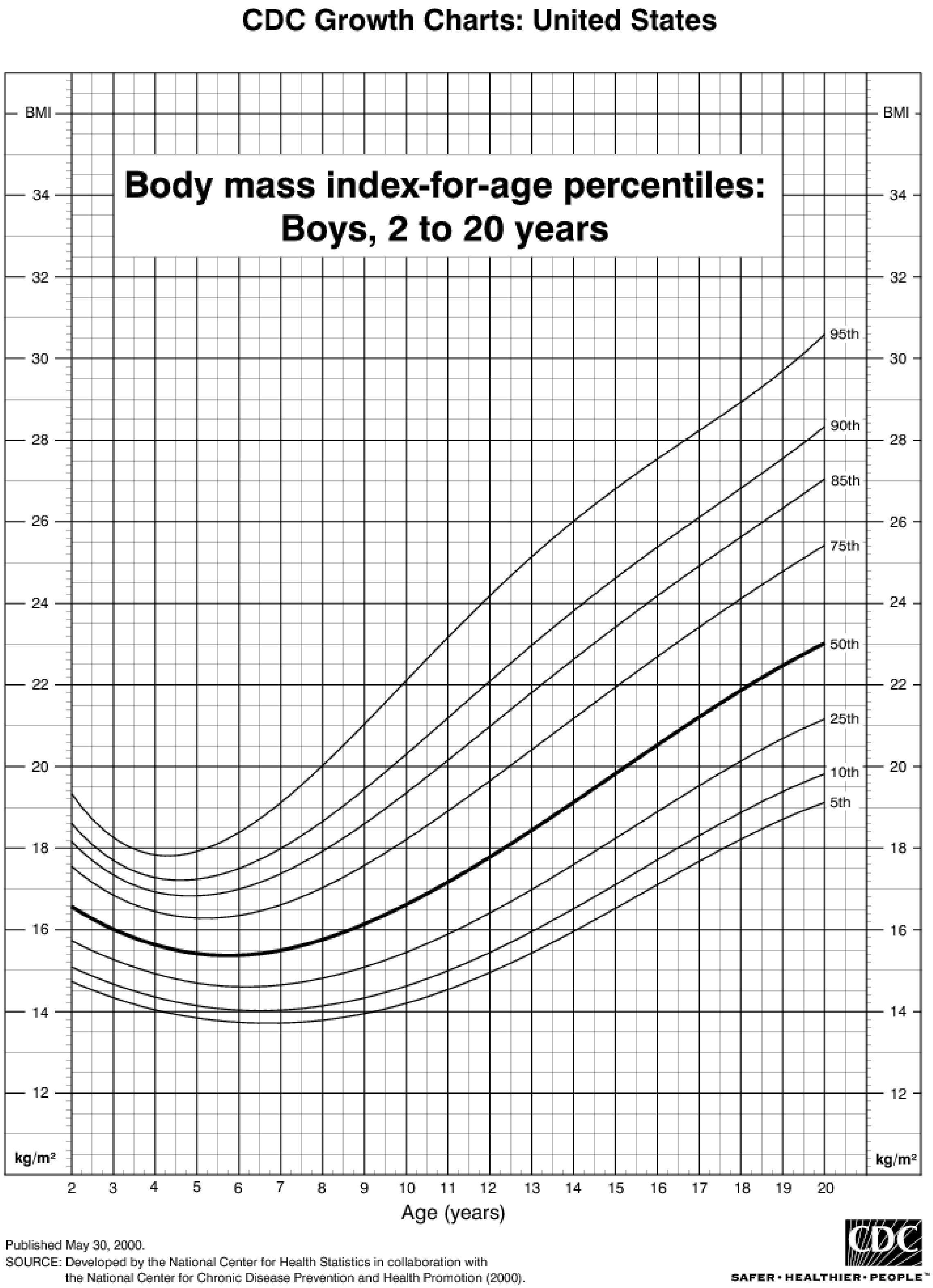
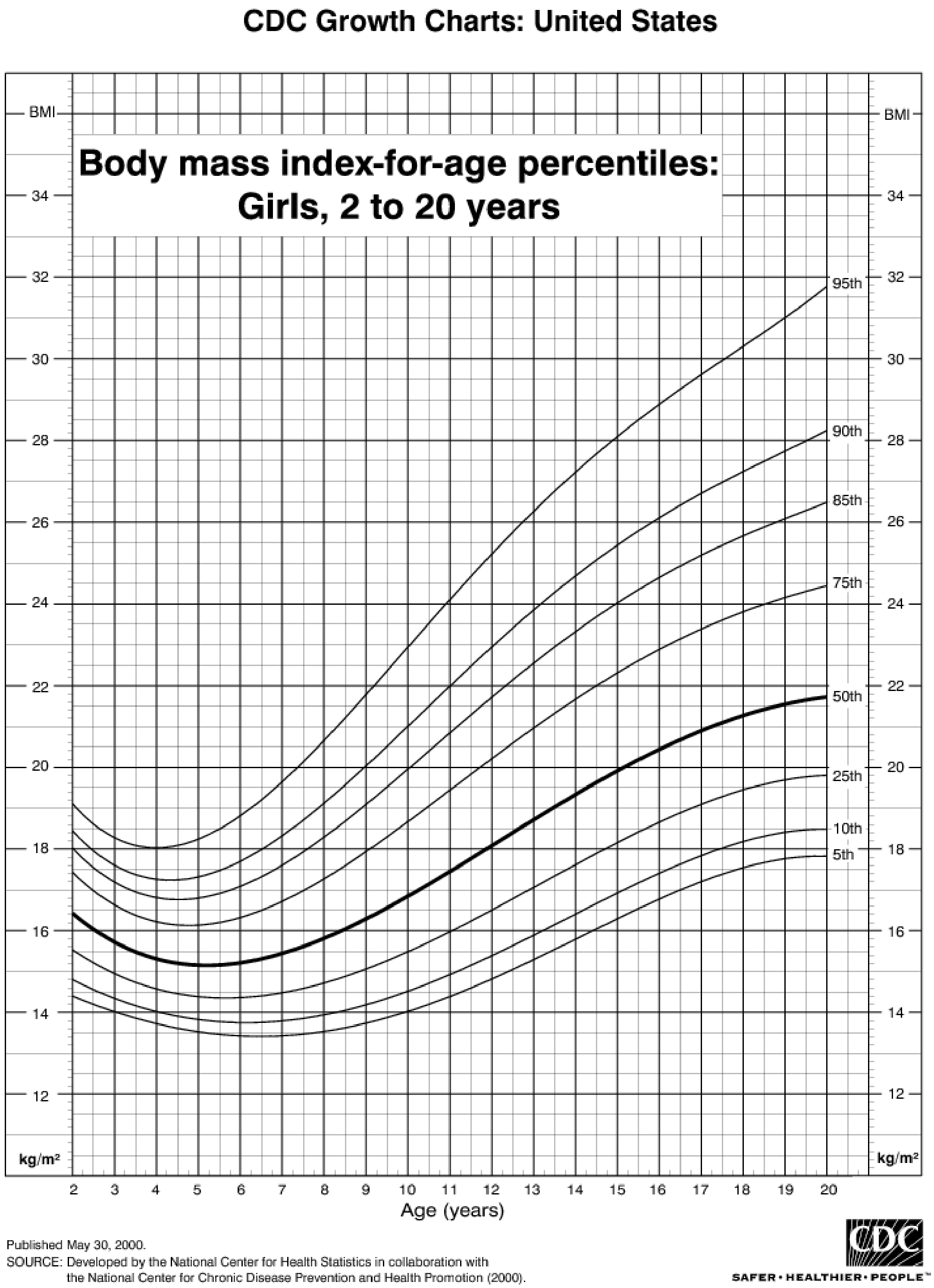


Figure 5. BMI and BMI percentile by age for boys. Retrieved from http://www.chartsgraphsdiagrams.com/HealthCharts/bmi-percentiles-boys.html


CDC Growth Charts: United States
Body mass index-for-age percentiles:
Girls, 2 to 20 years
BMI
34
32
30
28
26
24
22
20
18
16
14
12
kg/m²
95th
90th
85th
75th
50th
25th
10th
5th
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Age (years)
Published May 30, 2000.
SOURCE: Developed by the National Center for Health Statistics in collaboration with
the National Center for Chronic Disease Prevention and Health Promotion (2000).
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