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EXAMINATION OF ADOLESCENT PHYSICAL
ACTIVITY AND OVERWEIGHT LEVELS

by

Maika E. Nelson

A thesis submitted to the faculty of

Brigham Young University

in partial fulfillment of the requirements for the degree of

Master of Science

Department of Physical Education

Brigham Young University

April 2004

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BRIGHAM YOUNG UNIVERSITY

GRADUATE COMMITTEE APPROVAL

of a thesis submitted by

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This thesis has been read by each member of the following graduate committee and by majority vote has been found to be satisfactory.

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As chair of the candidate's graduate committee, I have read the thesis of Maika E. Nelson in its final form and have found that (1) its format, citations, and bibliographical style are consistent and acceptable and fulfill university and department style requirements; (2) its illustrative materials including figures, tables, and charts are in place; and (3) the final manuscript is satisfactory to the graduate committee and is ready for submission to the university library.

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ABSTRACT

EXAMINATION OF ADOLESCENT PHYSICAL ACTIVITY AND OVERWEIGHT LEVELS

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Master of Science

Research suggests declines in physical activity may occur after age 12. The purpose of this study was to determine the relationships between adolescent physical activity, BMI, and nutrition. Adolescents, ages 12-17 (N = 223), wore pedometers for 11 consecutive days and completed a nutrition survey, the Youth Adolescent Questionnaire. Activity levels did not differ among the ages of 12-17 year old adolescents, and boys were more active than girls. There was a low, but significant relationship between BMI and physical activity levels for both boys and girls. Energy intake was not related to BMI or physical activity levels in boys or girls.

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EXAMINATION OF ADOLESCENT PHYSICAL
ACTIVITY AND OVERWEIGHT LEVELS

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Abstract

Research suggests declines in physical activity may occur after age 12. The purpose of this study was to determine the relationships between adolescent physical activity, BMI, and nutrition. Adolescents, ages 12-17 (N = 223), wore pedometers for 11 consecutive days and completed a nutrition survey, the Youth Adolescent Questionnaire. Activity levels did not differ among the ages of 12-17 year old adolescents, and boys were more active than girls. There was a low, but significant relationship between BMI and physical activity levels for both boys and girls. Energy intake was not related to BMI or physical activity levels in boys or girls.

Introduction

The increasing percentage of adolescents who are overweight raises health concerns for all people due to associated health consequences. As physical activity habits are decreasing, the number of young people overweight or obese is increasing (16, 26). The Surgeon General reported that participation in all types of activity dramatically declines as age or grade in school increases and indicated that including physical activity in a daily routine will contribute to better control of a healthy weight, preventing the development of overweight and obesity (7). Data from the 1999-2000 National Health and Nutrition Examination Survey (NHANES) found that 15% (nearly 9 million) of youth ages 6 to 19 years are overweight (25). This is triple what the proportion of overweight 6 to 19 year olds was in 1980 (25). The increase in the prevalence of overweight adolescents is of great concern due to the likelihood that overweight adolescents will become overweight adults (25).

The Surgeon General has reported several benefits of physical activity (7). Physical activity builds and maintains healthy bones, muscles and joints; weight is controlled, lean muscle is gained, and fat is reduced. Long-term benefits of physical activity counteract the negative effects of unhealthy weight levels by decreasing the risk of cardiovascular disease mortality, lowering blood pressure, controlling obesity, improving glucose control, reducing the occurrence of osteoporosis, and preventing some cancers. Although it is not guaranteed, it is more likely that active children will become active adults than inactive children will become active adults (14) and fit individuals,

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whether or not they have unhealthy weight levels, have lower rates of mortality and morbidity (4). It is important that physical activity habits are developed early in life to preclude the development of health risks associated with physical inactivity.

Recent research has found stable patterns of physical activity in children aged 6 to 12 years old (29). Several studies using self-reported data found a decline in physical activity patterns among adolescents aged 12 to 18 years old (1, 5, 15, 19, 26, 27). This study will use objective research to further understand the relationship between excessive weight and adolescent physical activity levels.

The purposes of this study were to a) determine physical activity patterns across 12 to 18 year old boys and girls, b) determine if physical activity patterns are related to body mass, as reflected by body mass index (BMI), and c) determine the relationship between physical activity and BMI while controlling for energy intake.

Methods

Participants

Adolescents from one middle school and one high school in a Utah school district were asked to volunteer to participate. Participants were selected from physical education classes in the middle school and from health and nutrition classes in the high school. A total of 223 students, 95 boys and 128 girls, participated in this study (0.4% African American, 7.2% Hispanic, 0.4% Native American, 4.5% Pacific Islander/Asian, and 87.4% Caucasian). This study was conducted in the early fall season. Permission to conduct the study and human subjects approval was obtained from the public school district, the school principals, and the University Institutional Review Board as well as

from the participants and their parent/guardian. All participants returned an informed consent signed by both themselves and their parent/guardian.

Instruments

Physical activity levels were measured using the My Life Stepper 2515 digital pedometer (MLS 2500 series, Walk4Life, Plainfield, IL). The pedometer objectively measures physical activity levels by recording accumulated daily steps. Pedometers are unobtrusive, lightweight, and convenient to use in assessment of physical activity levels (23). Within a pedometer there is a horizontal, spring suspended lever arm. The vertical movement that occurs with each step during walking or running causes an electrical circuit to close and a step to be recorded. The validity of pedometers has been confirmed in several studies (2, 3, 9, 11, 23). In a study by Crouter et al. the accuracy for measuring step count of the Walk4Life LS 2525 pedometer (from the same series of pedometers that were used in the current study) was found to be within $\pm 1\%$ of actual steps taken at 80 m/min (9). Limitations of the pedometer include the inability to assess intensity and frequency of activity as well as upper body activities such as catching, throwing or lifting (30). Despite these limitations pedometers still provide an objective measure of physical activity (2).

Dietary intake levels were measured by administering the Youth Adolescent Questionnaire (YAQ) (17, 18). This is a semiquantitative, self-administered food frequency questionnaire that was developed to reflect the eating habits of older children and adolescents (ages 9 to 18 years). The survey contained 152 questions and took

approximately 20-30 minutes to complete. The YAQ is based on participants' typical weekly dietary habits over the past year. Participants reported their typical food intake by selecting the frequency category that applied to the amount eaten of a particular food. The reproducibility of the YAQ was tested by administration of the questionnaire twice, one year apart, to 179 youths (9 to 18 years old) (19). It was demonstrated that the YAQ is able to reliably determine levels of nutrient intake in an adolescent population and it may be used in school-based settings (18).

Procedures

Each participant was assigned a pedometer that they used throughout the data collection period. A total of eleven days, nine weekdays and two weekend days, made up the duration of the data collection period. It has been determined that among adolescents (grades 7 through 12), monitoring physical activity for 4 to 5 days will result in a reliability of 0.70 and between 8 and 9 days of monitoring are required to achieve a reliability of 0.80 (22). The reason for the extended period of time is due to large differences in weekday and weekend physical activity behavior. Eleven days of data collection were used in this study to include weekend days and to allow for lost data while obtaining an adequate number of days to maintain a high rate of reliability in the step counts. The pedometers were numbered for identification purposes during data collection. Prior to any data collection, participants at both the middle school and the high school were introduced to and given the opportunity of experimenting with the pedometers. Being able to practice using the pedometer helped dispel the participants' curiosity and increase their comfort with wearing the pedometer. The pedometers were

distributed to the participants in their classes by the researchers with assistance from the teachers. Researchers instructed the participants on how to wear and use the pedometers when the pedometers were distributed. Measures of height, using a triangle square balance, and weight, using the Tanita Body Composition Analyzer BF-350, for each participant were taken at the start of the data collection period by the researchers. The YAQ was administered the first or second day of data collection.

Pedometers were worn each day from the time participants got dressed in the morning until the time they went to bed. The pedometers were fastened to the waistband of participants' clothes, directly above the right knee. Each participant was given a daily log sheet that required a record of their step count, if they removed the pedometer and for how long, and what type of activity they participated in that day. Participants were instructed to record this information each night when they removed the pedometer. The ability of adolescents to accurately record this information without the daily aid of researchers was validated in a pilot study. Participants reset their pedometers each morning to begin a step count for the new day. Researchers reported to the schools during the selected classes to answer any questions and solve any problems that arose during the eleven days of data collection.

Data Collection and Analysis

All statistical analyses were conducted using SPSS (version 11.5). Reliability analysis revealed that the minimum number of days that could be accepted as valid data for weekday and weekend step counts was three weekdays and two weekend days

($R = .7721$). Therefore, mean daily step counts were calculated for all participants who had a minimum of three weekdays and two weekend days of activity.

The first day of step recording was eliminated from the analysis because participants received the pedometers at different times throughout the day, making that day an incomplete assessment of daily activity levels. Data was eliminated if any recorded daily step count was below 1000 steps because step counts below this number indicated that the pedometer was not worn for the entire day and therefore was not an accurate measure of the day's activity. This eliminated 0.6% of our daily step count data. Data was eliminated if it was further than two standard deviations away from the mean of the corresponding gender and age group (5, 9, 29). This eliminated 3.3% of our daily step count data and 0.9% of our participants. Data from all 18 year old participants was eliminated due to the small number of participants in this age group (2.7% of our participants). There were 34.8% of our participants who did not have three weekdays and two weekend days of data and were therefore eliminated. Overall, 37.5% of our participants were eliminated.

Differences in step counts among ages and between genders were calculated using ANOVA. Pearson correlations were used to determine relationships between BMI, mean step counts, total caloric intake, and total fat intake. Partial correlations were conducted on BMI and mean step counts while controlling for total calories and total fat.

Results

Descriptive statistics for BMI, mean step counts, total caloric intake, and total fat intake for all participants by age and gender can be found in Table 1. A univariate

ANOVA based on mean step counts, age, and gender revealed no significant differences among ages ($F = .803, p = .549$), but did find a significant difference between genders ($F = 39.489, p = .000$). Therefore, all further analyses were collapsed across age, but conducted on boys and girls separately. For boys, Pearson correlations between BMI, mean step counts, total calories and total fat revealed significant correlations only between BMI and mean step counts ($r = -.203, p = .049$) and between total calories and total fat ($r = .966, p = .000$). For girls, significant correlations were found between BMI and mean step counts ($r = -.362, p = .000$) and between total calories and total fat ($r = .945, p = .000$). For boys, partial correlations between BMI and mean step counts while controlling for total calories and total fat revealed no significant relationship ($r = -.201, p = .056$). For girls, partial correlations between BMI and mean step counts while controlling for total calories and total fat revealed a significant relationship ($r = -.365, p = .000$).

The mean total daily caloric intake and total daily fat intake for boys was $2,310 \pm 1,174$ kcal and 83 ± 44 grams, respectively. The mean total daily caloric intake and total daily fat intake for girls was $1,776 \pm 768$ kcal and 63 ± 29 grams, respectively. Results from the YAQ revealed that BMI was not related to either total caloric intake (boys: $r = -.072, p = .402$; girls: $r = -.039, p = .622$) or total fat intake (boys: $r = -.104, p = .226$; girls: $r = -.071, p = .373$). Physical activity levels also showed no relationship with total caloric intake (boys: $r = .047, p = .654$; girls: $r = .060, p = .507$) or total fat intake (boys: $r = .008, p = .937$; girls: $r = .068, p = .452$).

Discussion

Physical activity levels can be determined using pedometer step counts helping us understand the activity patterns of youth. Recent research has revealed a stable pattern of physical activity levels among 6 to 12 year old children (29). This study was designed to determine the current physical activity levels of youth ages 12 to 17 and to better understand the relationship between physical activity and overweight levels in this population.

Stability of Mean Step Count

The mean daily step counts in this population showed no significant changes between the ages of 12 and 17 (Figure 1). The overall mean daily step count for male adolescents was $12,335 \pm 3,465$ steps, ranging from a low of $10,914 \pm 3,432$ steps at 14 years of age to a high of $13,178 \pm 3,709$ steps at 12 years of age. The overall mean daily step count for female adolescents was $9,471 \pm 2,526$ steps, ranging from a low of $9,015 \pm 2,140$ steps at 14 years of age to a high of $9,941 \pm 3,304$ steps at 16 years of age. The stability of activity levels across ages is similar to results from a recent study conducted in a younger population of children. Vincent and Pangrazi examined the activity patterns of 711 children aged 6 to 12 years old and found no significant decrease in activity across age (29). Mean daily step counts for male children were $13,162 \pm 3,045$ steps and ranged from a low of $12,300 \pm 2,076$ steps at 6 years of age to a high of $13,989 \pm 3,947$ steps at 12 years of age. Mean daily step counts for female children were $10,923 \pm 2,625$ steps

and ranged from a low of $10,479 \pm 3,009$ steps at 11 years of age to a high of $11,274 \pm 2,021$ steps at 7 years of age. The results of Vincent and Pangrazi indicate that physical activity levels are stable between the ages of 6 and 12, suggesting that the decline in activity may occur after the age of 12 (29). The similarity between the current study and Vincent and Pangrazi reveals a stable pattern of activity from childhood through adolescence (29). This leads to the possibility that activity patterns do not decline until young adulthood.

While the results of these two studies indicate steady activity levels, current literature has identified a decrease in physical activity among youth. The 1992 National Health Interview Survey - Youth Risk Behavior Survey and the Amsterdam Growth and Health Study revealed decreases in physical activity during adolescence (5, 27). Both of these studies used subjective data (surveys and interviews) to support the finding of decreasing adolescent physical activity.

The results of the current study are in contrast to the two previously mentioned studies with regards to adolescent physical activity levels. The differences in results between previous studies and the current study may be due to methods of data collection, family support, opportunities for activity in a school setting, and selection bias.

The previous studies used surveys and interviews, subjective measures, in which participants recalled past activity, whereas the current study used pedometers, an objective measure, to measure actual activity. Self-report methods, such as surveys or questionnaires, are limited by recall bias and results vary depending on the instrument

and scoring procedures used (24). Objective measures lessen the participant's responsibility to remember how much activity they completed each day.

Family support and opportunities for activity in a school setting were similar between the schools in the current study, but may be different in other parts of the country. In this community there is an emphasis on family oriented activities in which families support participation in things such as sports teams. In addition, both schools had new facilities that provided opportunities for fitness activities including weight lifting and indoor sports.

Participants in this study were from physical education classes in the middle school and nutrition and health classes in the high school. Middle school students are required to take physical education classes and high school students are required to take health classes while nutrition classes are an elective class. Participation in this study was voluntary, and less active youth may have chosen not to participate leading to possible selection bias in this sample.

Differing Levels of Activity Among Genders

There was a significant difference in mean step counts between boys and girls in this study (boys were more active than girls). This result was expected and is in accord with findings throughout the current literature. Several studies confirm greater activity in boys compared to girls (5, 27, 28, 29).

Physical Activity and BMI

The prevalence of overweight youth is increasing (16). Based on the CDC BMI-for-age growth charts, the 1999-2000 NHANES statistics show that the prevalence of overweight 12 to 19 year olds is 15.5%, increasing from 11% since 1988-1994 NHANES III (16). Overweight is defined as $\geq 95^{\text{th}}$ percentile of BMI and at risk for overweight is defined as $\geq 85^{\text{th}}$ percentile of BMI, according to age (6, 16). In the current study, 28.4% of the boys and 23.6% of the girls are considered at risk for overweight while 10.5% of the boys and 10.2% of the girls are classified as overweight (6).

It would seem logical that adolescents with higher levels of physical activity would have lower BMI values. Accordingly, this study revealed a low, but significant correlation between BMI and mean step count in both boys ($r = -.203, p = .049$) and girls ($r = -.362, p = .000$). Participants with higher levels of physical activity had lower BMI values and those participants with lower levels of activity had higher BMI values. Step counts accounted for 4.1% ($r^2 = .041$) and 13.1% ($r^2 = .131$) of the variance in BMI for boys and girls, respectively.

The reproducibility of height and weight measurements enables BMI to be a reliable indicator of adiposity and BMI is a sound measure of fatness in children and adolescents (10). While BMI is a useful measure of overweight or obesity, the relationship between weight-for-height measures and adiposity is age-dependent and varies by race and gender (20). Growth and development in the adolescent age group could influence the relationship between step counts and BMI. Body composition during growth is highly variable and dependent upon the developmental stage of an individual,

different proportions of lean and adipose tissue will influence a given weight-for-height (20). Boys tend to accumulate greater amounts of lean tissue during puberty while girls tend to enter puberty at an earlier age than boys and accumulate greater amounts of adipose tissue, therefore girls have higher BMI values at any given age (8, 20). These differences could be contributing to the low relationship between step counts and BMI.

Nutrition and BMI

It is assumed that nutrition influences BMI levels along with physical activity. In order to control for the influence of nutrition in the current study, participants completed the YAQ, a nutritional questionnaire (17, 18). There were no significant relationships found between BMI and total daily caloric intake or total daily fat intake. Relationships between physical activity, total daily caloric intake, and total daily fat intake were insignificant as well. These interesting results may be due to the participants' inability to recall their nutritional information. Food intake tends to be underreported on dietary surveys (13). Participants in this study were required to report their typical dietary habits over the past year. Recalling this information could have been difficult, due to varying patterns of eating throughout the year (hot chocolate in the winter, strawberries in the summer).

Physical Activity, BMI, and Nutrition

The increasing prevalence of overweight and obese individuals indicates that the population tends to have a caloric intake that is greater than caloric expenditure (21). Pearson correlations revealed significant relationships between step counts and BMI for boys ($r = -.203, p = .049$) and for girls ($r = -.362, p = .000$) as well as between total

calories and total fat for boys ($r = .966, p = .000$) and for girls ($r = .945, p = .000$). For boys, controlling for total calories and total fat slightly changed the relationship between step counts and BMI making it no longer significant ($r = -.201, p = .056$). For girls, controlling for total calories and total fat caused the relationship between step counts and BMI to slightly increase ($r = -.365, p = .000$), revealing that total caloric intake and total fat intake may act as suppressor variables. The results of this study suggest that nutrition (total caloric intake and total fat intake) does not strongly influence physical activity and BMI levels in adolescents. These results should be viewed with caution, and further research should seek to clarify this relationship.

Limitations

Limitations in this study include the use of BMI as an indicator of obesity, the inability of pedometers to measure intensity of activity, and the self-report nature of the nutritional questionnaire.

The use of BMI as an indicator of obesity is a limitation because BMI is a ratio of weight to height and may not be the most precise indicator of obesity in this age group, due to the adolescent growth spurt (12). Patterns of growth among adolescents in accumulation of lean tissue and adipose tissue are highly variable and will influence any given weight-for-height (20).

Individuals who participate in vigorous activity, such as soccer, may not have as many steps in one day as individuals who participate in light activity, such as walking, because the intensity of vigorous activity is greater and is not continued for as long of a

duration. One limitation to pedometers is that they only reflect step count, leading to the belief that a lightly active individual is more active than a highly active individual.

The ability of participants to correctly recall dietary information limits the accuracy of the nutritional survey. This age group most likely does not prepare meals on a regular basis and therefore would have difficulty recalling the amount of a specific food eaten. Even more difficult to report are seasonal foods such as strawberries and hot chocolate. Food intake typically is found to be underreported on dietary surveys (13).

Generalizability of this study is limited due to the size and characteristics of this population. All of the participants were from a predominantly Caucasian, conservative population, located in a suburban area. The results of this study may not be an accurate depiction of the rest of the United States.

Conclusion

The results of this study conclude that levels of activity do not differ among the ages of 12 to 17 year old boys and girls. Boys were found to be more active than girls. It was also revealed that there is a low, but significant relationship between BMI and physical activity levels for adolescent boys and girls. Nutritional analysis of total caloric intake and total fat intake found no relationship with physical activity or BMI levels. Although the results of physical activity across ages differ from previous reports, consideration should be given to them because pedometers are a direct measure of physical activity.

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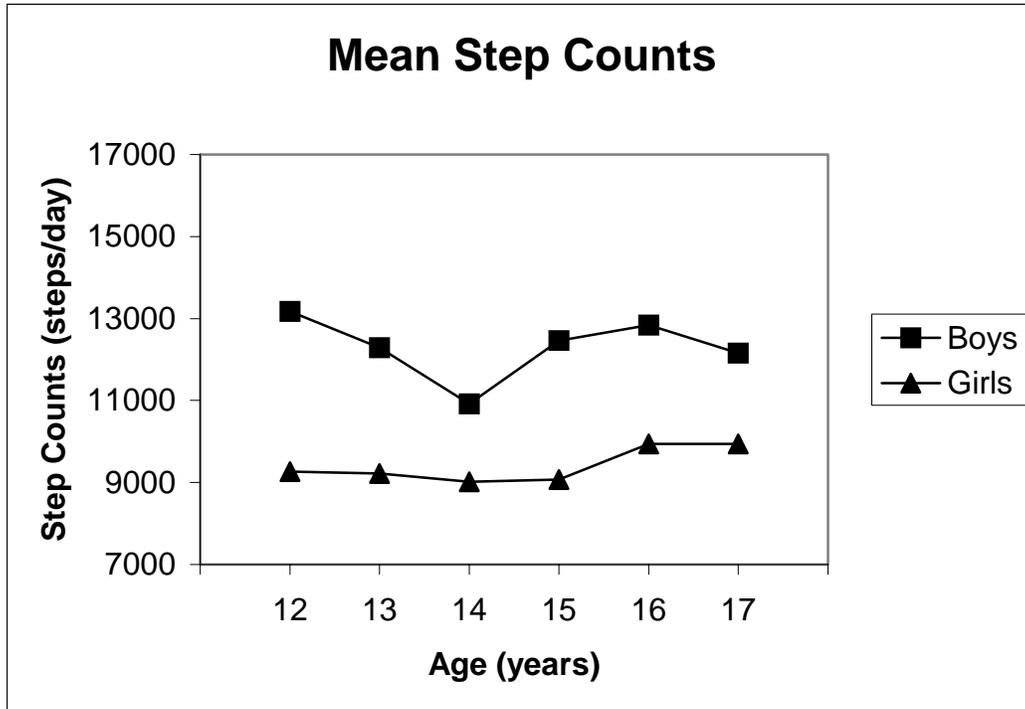
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Table 1 Descriptive Statistics for BMI, Step Count, Total Calories, and Total Fat

(Means \pm Standard Deviations)

Age	Gender	N	BMI	Step Count (steps/day)	Total Calories (kcal/day)	Total Fat (g/day)
12	M	5	17.2 \pm 2.2	13178 \pm 3709	2074 \pm 1281	78 \pm 55
	F	19	20.3 \pm 4.2	9265 \pm 2606	1475 \pm 477	52 \pm 16
13	M	9	20.7 \pm 4.0	12289 \pm 3170	2112 \pm 1202	80 \pm 45
	F	14	22.2 \pm 4.9	9216 \pm 2485	1608 \pm 607	55 \pm 20
14	M	12	20.4 \pm 4.8	10914 \pm 3432	2577 \pm 1149	94 \pm 50
	F	10	22.7 \pm 6.5	9015 \pm 2140	2137 \pm 1372	72 \pm 46
15	M	25	22.6 \pm 4.4	12463 \pm 3661	2132 \pm 883	77 \pm 36
	F	32	21.8 \pm 3.7	9071 \pm 2084	1869 \pm 756	65 \pm 28
16	M	26	22.9 \pm 4.2	12845 \pm 3914	2534 \pm 1453	87 \pm 51
	F	27	23.7 \pm 5.4	9941 \pm 3304	1751 \pm 590	62 \pm 25
17	M	18	23.7 \pm 4.8	12160 \pm 2697	2289 \pm 1108	81 \pm 41
	F	26	22.7 \pm 4.0	9938 \pm 2260	1810 \pm 756	66 \pm 33
Grand Mean	M	95	22.1 \pm 4.6	12335 \pm 3465	2310 \pm 1174	83 \pm 44
	F	128	22.3 \pm 4.7	9471 \pm 2526	1776 \pm 768	63 \pm 29

Figure 1 Mean Step Counts by Age and Gender



Appendix A
Prospectus

Chapter 1

Introduction

The increasing availability of modern conveniences and sedentary entertainment greatly contributes to the risk of becoming overweight or obese, particularly during adolescence. According to the US Department of Transportation, the increase in number of personal vehicles is approximately 1.5 times the growth in the population. In addition, it was found that the average household traveled about 4,000 more miles in 1995 compared to 1990 (US Department of Transportation, 1999). This increase in convenient travel affects not only adults, but young populations as well. McCann and DeLille (2000) reported that between 1977 and 1995 the number of children making trips by foot or bicycle declined 37%. In 2000 a report by the US Department of Health & Human Services (USDHHS) found that 57% of students in grades 9 through 12 spent 0-2 hours viewing television each school day. The Youth Risk Behavior Surveillance (YRBS) data found that 38.3% of adolescents had watched television ≥ 3 hours per day during the average school day (Grunbaum et al., 2002). Adolescents who spend multiple hours each day in sedentary activities will have minimal time available for participation in physical activities.

In addition to being sedentary after school, *Healthy People 2010* reported a decline in participation in daily school physical education for students in grades 9 through 12 (USDHHS, 2000). In 1991 forty-two percent of 9th through 12th graders participated in daily school physical education. By 1995 this number had decreased to 25% and in 1999 it increased slightly to 29% of students in grades 9 through 12. The

Surgeon General (Centers for Disease Control & Prevention (CDC),1999) reports that of the high school students enrolled in physical education classes, only 19% were active for 20 minutes or more, five days a week. As students progress in school, the number of those participating in vigorous activity declines. The participation in vigorous activity of 9th, 10th, 11th, and 12th grade students is 73%, 65%, 58%, and 61%, respectively (USDHHS, 2000). The Surgeon General (CDC, 1999) determined that nearly half of American youths between the ages of 12 and 21 do not participate in vigorous activity on a regular basis and approximately 14% of young people report no recent physical activity.

The development of overweight or obesity at young ages is of particular concern due to the difficulty of reducing weight and health consequences associated with unhealthy weight. The US Department of Health and Human Services (2002) reported on data gathered from the 1999-2000 National Health and Nutrition Examination Survey (NHANES) that showed 15% (nearly 9 million) of youth ages 6 to 19 years are overweight. This is triple what the proportion of overweight youth was in 1980. The YRBS data further show that nationwide, 13.6% of adolescents were at risk for becoming overweight and 10.5% were overweight (Grunbaum et al., 2002). Troiano, Flegal, Kuczmarski, Campbell, and Johnson (1995) reported that individuals who are overweight at young ages are likely to become overweight adults. In addition to greater risk of being overweight in adulthood, overweight individuals are at increased risk for adverse health outcomes. Problems associated with obesity and overweight include increased mortality from all-causes and cardiovascular disease, and increased risk of coronary heart disease,

hypertension, dyslipidemia, diabetes mellitus, gallbladder disease, osteoarthritis, and some cancers (Blair & Brodney, 1999; Troiano et al., 1995).

The Surgeon General has reported several benefits of physical activity (CDC, 1999). Physical activity builds and maintains healthy bones, muscles and joints. Weight is controlled, lean muscle is gained, and fat is reduced. The development of high blood pressure is prevented or delayed and can be reduced in some adolescents with hypertension. Luepker (1999) reports that regular physical activity results in improved strength and energy. Through regular physical activity, better cardiorespiratory fitness, subsequently, endurance is gained. Improvements in lean body mass and reduced body fat lead to a better physical appearance and a healthy control of weight. Although it is not guaranteed, it is more likely that active children will become active adults (Luepker, 1999). In the study by Luepker (1999), several long-term benefits of physical activity among adults were recognized. The risk of cardiovascular disease mortality is decreased, blood pressure is lowered, obesity is controlled, glucose control is improved, occurrence of osteoporosis is reduced, and some cancers are prevented through participation in regular physical activity. It is important that physical activity habits are developed early in life to prevent the development of health risks associated with physical inactivity. Research is needed to determine the relationship between the development of overweight/obesity and adolescent physical activity levels.

Statement of Problem

The purposes of this study are to determine if physical activity patterns are related to increased levels of overweight and obesity, as reflected by BMI, and to measure physical activity patterns across 12-18 year old boys and girls.

Hypothesis

Null hypotheses to be investigated:

1. Physical activity patterns are not correlated with BMI.
2. There will be no significant differences in physical activity levels among the age groups for boys or for girls.

Alternative hypotheses to be investigated:

1. Physical activity patterns are correlated with BMI.
2. There will be significant differences in physical activity levels among the age groups for boys and for girls.

Definition of Terms

BMI – the body mass index is a ratio of weight to height expressed as weight (in kilograms) divided by height (in meters squared). Values of BMI allow for comparison of body size between age and gender (Dietz & Robinson, 1998; Daniels, Khoury, & Morrison, 1997).

Overweight – adolescents with BMI values at their age that correspond to 25 kg/m² in adults, according to international cut off points for BMI (Cole, Bellizzi, Flegal, & Dietz, 2000).

Obesity – adolescents with BMI values at their age that correspond to 30 kg/m² in adults, according to international cut off points for BMI (Cole et al, 2000).

Physical activity – any bodily movement that is produced by the contraction of skeletal muscle and that substantially increases energy expenditure (Balady et al, 2000).

Assumptions

The participants will not change their physical activity patterns due to increased awareness.

Delimitations

The study will be delimited to:

1. Seventh to 12th grade students from Alpine school districts in Utah.
2. The use of the pedometer as the only measure of physical activity levels.

Limitations

The following are limitations:

1. The data collection period lasts ten days.
2. The sample may not be representative of all adolescents, ages 12 to 18 years.
3. The limitation of using BMI as an indicator of overweight and obesity.
4. Pedometers may not produce precise measures of physical activity.

Significance of the Study

Determining the age at which physical activity patterns decrease is important in the prevention of overweight and obesity. Discovery of the age at which a decrease is seen in physical activity patterns and an increase is seen in BMI may aid in the prevention of these health consequences. Prevention of overweight and obesity early

in life will lead to better health in the later years of life. Recent research has found stable patterns of physical activity in children aged 6-12 years (Vincent & Pangrazi, 2002). This study will evaluate if and when physical activity patterns decrease while BMI increases in adolescents aged 12-18 years.

Chapter 2

Review of Literature

Introduction

The increasing percentage of adolescents who are overweight or obese has caused great concern for the health of people of all ages. While activity habits decrease, the number of young people who are overweight or obese increases (Ogden, Flegal, Carroll, & Johnson, 2002; USDHHS, 2000). The Surgeon General (CDC, 1999) reported that participation in all types of activity dramatically declines as age or grade in school increases and indicated that including physical activity in a daily routine will contribute to better control of a healthy weight, preventing the development of overweight and obesity. Data from the 1999-2000 NHANES (USDHHS, 2002) found that 15% of youth ages 6 to 19 years are overweight. This proportion is triple what the proportion of overweight 6 to 19 year olds was in 1980 (USDHHS, 2002). The increase in the prevalence of overweight adolescents is of great concern due to the likelihood that overweight adolescents will become overweight adults (USDHHS, 2002). Being overweight or obese results in serious health consequences later in life. A review by Power, Lake, and Cole (1997) reported that increased mortality, coronary heart disease,

atherosclerosis, colorectal cancer, functional limitations, diabetes, high cholesterol, and hypertension are all negative consequences associated with overweight and obesity. Blair and Brodney (1999) concluded that regular physical activity reduces health risks associated with overweight and obesity and fit individuals, whether or not they have unhealthy weight levels, have lower rates of mortality and morbidity. Luepker (1999)

suggests that increasing physical activity among youth in the US may help reduce the obesity epidemic.

Health Consequences of Overweight and Obesity

Overweight and obesity result in multiple health consequences. Comorbid conditions associated with obesity include Type 2 diabetes, impaired glucose tolerance, hyperinsulinemia, dyslipidemia, cardiovascular diseases, hypertension, sleep apnea, gallbladder disease, osteoarthritis of weight-bearing joints, reduced fertility, and some cancers (Troiano et al, 1995). Being overweight during childhood and adolescent years increases the risk for being overweight in adulthood, the risk being greater for those with higher degrees of overweight in earlier years (Troiano et. al, 1995).

Sallis and Patrick (1994) reported that significant health concerns, including cardiovascular disease, non-insulin-dependent diabetes mellitus, osteoporosis and some cancers, can be prevented early in life by making physical activity a regular lifestyle routine. Physical activity improves the quality of life, psychological health, and the

ability to complete physically demanding tasks as well as participate in leisure activities (Sallis & Patrick, 1994).

In a consensus statement, Sallis and Patrick (1994) determined that adolescents should engage in regular, if not daily, physical activity in order to decrease the risk of mortality later in life. Two guidelines for adolescent physical activity were established in this consensus. The first guideline is: All adolescents should be physically active daily, or nearly every day, as part of play, games, sports, work, transportation, recreation, physical education, or planned exercise, in the context of family, school, and community activities. The second guideline is: Adolescents should engage in three or more sessions per week of activities that last 20 minutes or more at a time and that require moderate to vigorous levels of exertion. In order to achieve greater aerobic fitness benefits, a minimum of three 30-minute sessions of moderate to vigorous physical activity should be completed each week. This consensus statement purports that adoption of this minimum standard of physical activity may lead to beneficial health effects. Enhancing bone development is critical during the adolescent years. Participating in daily weight bearing activities during adolescence will improve skeletal health later in life. Daily energy expenditure will also reduce the risk of becoming overweight or obese, preventing the development of diseases associated with these conditions. Enhanced psychological health, increased HDL cholesterol, and increased cardiorespiratory fitness are benefits of regular participation in moderate to vigorous physical activity during the adolescent years (Sallis & Patrick, 1994).

A review by Power et al. (1997) found several associations between adiposity early in life and long-term health risks. Adolescent overweight, mainly in men, increased the risk for mortality from coronary heart disease, atherosclerosis, and colorectal cancer. This risk is greatest in the fattest 25% of adolescent males. Morbidity from these diseases is also increased in overweight individuals. Other consequences found to be associated with increased weight include gout, arthritis, functional limitation, increased cholesterol levels, and hypertension (Power et al., 1997).

DiPeitro, Mossberg and Stunkard (1994) followed 504 overweight Swedish children, monitoring lifetime overweight, morbidity, and mortality. Every ten years, by questionnaire, follow-up information was gathered on weight history and prevalence of cardiovascular disease, diabetes, cancer and mortality. Both males and females had increasing BMI levels with age. A positive correlation was found between youth BMI and adult BMI and this correlation seems to be stronger the more proximal the assessments. For example, there was a positive correlation of 0.24 between BMI at prepuberty (males aged 2-9; females aged 2-7) and BMI at age 55; the correlation of BMI at puberty (males aged 9-15; females aged 7-13) and 55 years was higher at 0.31; whereas the correlation between BMI at postpuberty (males aged 15-20; females aged 13-20) and aged 55 was strongest, reaching a value of 0.46. During this study 55 deaths occurred, 43.6% of which were due to cardiovascular disease. The individuals who had died by the 40-year follow-up were heavier than individuals who were still alive. Of the individuals not deceased, 36% had cardiovascular disease, 18% had hypertension, 10%

had diabetes, and 5% had cancer. In most age categories, individuals with cardiovascular disease and diabetes were heavier than those without these diseases. The greatest increase in BMI was seen during postpuberty in individuals with cardiovascular disease and diabetes. This study concluded that being overweight during adolescent years may carry over into adulthood leading to increased risk for negative health consequences (DiPeitro et al., 1994).

Increasing Percentage of Adolescent Overweight/Obesity and Decreasing Physical Activity Patterns

The American College of Sports Medicine (Balady et al., 2000) recommends that adults engage in 30 minutes or more of moderate intensity physical activity on most, preferably all, days of the week. *Healthy People 2010* (USDHHS, 2000) statistics show that only 23% of adults engage in regular vigorous physical activity, and just 15% of adults engage in 30 minutes of moderate-intensity activity on five or more days per week. Approximately 40% of adults are completely inactive during leisure time. With the high prevalence of inactivity there is a corresponding increase in the prevalence of obesity. Data from the 1999-2000 National Health and Nutrition Examination Survey (USDHHS, 2002) reveal that 31% of individuals over the age of 20 – nearly 59 million people – are classified as obese. The obesity epidemic during the adult years is due in large part to the failure of preventing the increasing occurrence of childhood obesity (Rippe, Crossley, & Ringer, 1998).

Rippe et al. (1998) reported that in the past 20 years the prevalence of obesity in younger populations has more than doubled. Ogden et al. (2002) analyzed statistics from

NHANES III showing that in 1988-1994 the prevalence of overweight was 10.5% among 12- to 19-year-olds, 11.3% among 6- to 11-year-olds, and 7.2% among 2- to 5-year-olds. The 1999-2000 NHANES statistics showed that the prevalence of overweight youth increased to 15.5% in 12- to 19-year-olds, 15.3% in 6- to 11-year-olds, and 10.4% in 2- to 5-year-olds.

Luepker (1999) stated that obesity has a strong relationship to physical activity and suggested that increasing levels of obesity in children may be the direct result of decreasing levels of physical activity. Physical education participation declines as children age from 9th to 12th grade. This decline could be due to a number of factors including increased emphasis on academic success and reduced budget, facilities and other resources, all of which decrease the amount of time spent in physical education.

Luepker reported that of the time spent in physical education, the majority of that time is used for organization and non-exercise activity.

In the study by Luepker (1999) it was determined that physical activity contributes to improved health in youth by improving strength and energy, enhancing cardiorespiratory fitness leading to better endurance, improving the muscle/fat ratio leading to a better physical appearance, and enabling the healthy control of weight. Luepker suggests that it is more likely that an active child will become an active adult than an inactive child will become an active adult. Being physically active will decrease

the risk of becoming overweight or obese. This is why it is important that individuals learn and understand the benefits of physical activity at an early stage of life.

In a recent study by Vincent and Pangrazi (2002), the activity patterns of 711 children age 6- to 12-years were examined. The children wore sealed pedometers for 4 consecutive days to monitor their daily step count. Mean step counts for male children ranged from 12,300 steps at 6 years of age to 13,989 steps at 12 years of age. Mean step counts for female children ranged from 10,479 steps at 11 years of age to 11,274 steps at 7 years of age. This study showed no significant decrease in activity levels of children between the ages of 6 and 12. The results of this study indicate that activity levels do not decline between the ages of 6 and 12 suggesting that the decline in activity may occur after the age of 12.

Casperson, Pereira, and Curran (2000) recently analyzed leisure-time physical activity data collected from the 1992 National Health Interview Survey - Youth Risk Behavior Survey of 10,645 male and female respondents between the ages of 12 and 21 years. At 14 years of age leisure-time physical inactivity was approximately 6% for both males and females. By the age of 20, the prevalence of adolescent leisure-time physical inactivity for males and females increased to about 24%. Between the ages of 12 and 17 years, adolescents who reported participating in regular, sustained activity decreased from 40% to 24% for males and 30% to 20% for females. At age 14, male participation in regular, vigorous activity declined from 76% to a low of 42% at age 21. In females prevalence of regular, vigorous activity was 66% at age 12, by the age of 20 participation in regular, vigorous activity decreased to 28%. The greatest increases in physical

inactivity were seen in the 15-18 year age group. Inactivity for males aged 15-18 years increased 4.2% per year while inactivity for females in this same age category rose 3% per year. This study found that as individuals age, physical activity patterns decline. This decline is most apparent in adolescents between the ages of 15 and 18 years. The data from this study support the conclusion that decreased physical activity levels during adolescence may contribute to the increased occurrence of obesity.

VanMechelen, Twisk, Post, Snel, and Kemper (2000) analyzed the Amsterdam Growth and Health Study and found decreases in physical activity during adolescence. This study collected physical activity data on 181 subjects from 1977 to 1991. Habitual physical activity data (HPA) was collected at ages 13, 14, 15, 16, 21, and 27. The HPA level of females nonsignificantly decreased over the study period from 9.1 hours per week to 8.4 hours per week. Males HPA levels significantly decreased from 10.6 hours per week to 7.3 hours per week, a 31% decrease. This study found that from the age of 13 (the start of adolescence) to the age of 27 (adulthood) there was a significant decrease, 42% in males and 17% in females, in total average weekly energy expenditure. The decrease in physical activity levels during adolescence was due in large part to decreased participation in non-organized sports activities. While participation in organized sports activities remained fairly stable for males and females, participation in non-organized sports activities greatly declined between the ages of 16 and 21 for both groups. This study confirms the occurrence of a decreasing trend in physical activity levels with age.

Vincent, Pangrazi, Raustorp, Tomson, and Cuddihy (in press) assessed the relationship between physical activity and BMI levels of children in the United States, Sweden, and Australia. It was found that American children had significantly lower mean step counts for boys and girls than the other two countries. American children also had higher BMI levels than both the Australian and Swedish children. The correlations between step count and BMI were not significant for any of the age groups except for American boys ages 11 and 12, and American girls aged 9. Analysis of overweight/obese and non-overweight/obese children supports the tendency that less active children have higher BMI levels. The mean BMI levels of American boys aged 7 and 9-12 years and American girls aged 11-12 years were classified as overweight. This study showed that the American children had the lowest step counts and highest BMI levels compared to Swedish and Australian children. This supports the notion that American children have increasing levels of overweight and decreasing levels of physical activity. Studying these patterns in adolescents will further help to determine the age at which activity levels decrease, perhaps leading to increased BMI levels.

Reliability and Validity of the Pedometer in Assessing Adolescent Physical Activity

Levels

Several methods have been used to assess activity levels in all age groups. These methods include pedometers, uniaxial and triaxial accelerometers, heart rate monitors, direct observation, questionnaires, motion sensors, doubly labeled water, and indirect calorimetry (Freedson & Miller, 2000; Welk, Corbin, & Dale, 2000). Pedometers are one of the methods that have been found to accurately assess physical activity levels.

Pedometers allow for the objective monitoring of physical activity patterns by measuring step counts, a marker of total volume or duration of activity (Welk et al., 2000). Tudor-Locke (2002) reported that these instruments are small, light weight, unobtrusive, and can be worn comfortably at the waist. Typically, inside a pedometer there is a horizontal spring suspended lever arm that moves up and down with normal walking or running. Each movement that is detected causes an electrical circuit to close and an additional step to be recorded and displayed on the feedback screen. Due to the inability of pedometers to monitor velocity of movement, they only measure accumulated steps per day or during a certain amount of time. While most pedometers only measure step count, some have additional features that enable total time of activity, expended calories, and distance traveled to be measured.

Bassett et al. (1996) reported that earlier pedometer models had questionable validity and reliability, however, newer electronic pedometers have been developed that are valid and reliable. Bassett (2000) found the Yamax DW-500 able to record steps and distance within 2% of actual values and displayed good inter-instrument agreement.

Pedometers do have some limitations. They lack the capability to provide data on frequency (how often a person is active during the day) and intensity (walking versus running) of physical activity (Bassett, 2000). Despite these limitations, pedometers can still be accurately used for research. Bassett reported several benefits of using pedometers in physical activity research. Pedometers are very useful in distinguishing between groups with various levels of walking. In population studies pedometer use has found an

age-related decline in the amount of steps per day. Bassett reported that pedometer studies have revealed a dose-response relationship between steps per day and cardiovascular risk factors, and they have found an age-related decline in walking. It has also been found that pedometers can be used as a motivational tool by providing feedback to individuals working toward a behavior modification goal (Freedson & Miller, 2000). Bassett determined that even with the limitations of pedometers, they are able to provide valid data on the number of accumulated steps per day.

Bassett et al. (1996) found that electronic pedometers provide an accurate estimate of distance walked and number of steps taken. The Yamax pedometer demonstrated the most accurate measurement of steps taken, recording 100.7% of left and 100.6% of right steps taken. Two other models were also tested for accuracy. The Pacer pedometer recorded 102.6% (left) and 87.5% (right) of actual steps taken, while the Eddie Bauer pedometer recorded 94.0% (left) and 91.6% (right) of actual steps taken. When stride length was incorporated into distance measurement, the average distance for two identical pedometers was within 11% of each other. The Yamax was the most accurate, recording only a 0.05 km, or 1%, difference.

The speed of walking was found to influence the accuracy of the pedometer step count (Bassett et al., 1996). At slow speeds actual step count is underestimated due to the failure to register footsteps because vertical acceleration at the hip is not as great at speeds under 2.0 mph. Faster speeds also resulted in an underestimation of distance due to an increased stride length. When individuals walk between 2.0 mph and 4.0 mph, the most accurate pedometer brand should record values within 20% of the actual distance

walked. If walking is done at intermediate speeds, the accuracy can increase to within 10% of actual distance covered.

Eston, Rowlands, and Ingledeu (1998) studied the accuracy of pedometers for measuring activity levels in children. In play activities that were not regulated, high correlations of 0.92 and 0.88 were found between steps and oxygen uptake and heart rate, respectively. When activity was regulated using treadmill walking the correlation between pedometer step count and oxygen uptake remained high at 0.78. This study supports the potential of the pedometer as an accurate measure of activity levels in children (Eston et al., 1998).

It is important that pedometer step counts be monitored for an adequate number of days in order for the results to be reliable. Trost, Pate, Freedson, Sallis, and Taylor (2000) studied how many days of monitoring are needed when using objective physical activity measures in youth. They found acceptable reliability scores ranging from 0.76 to 0.87 with 7 days of monitoring. It was determined in this study that among adolescents (grades 7 through 12), monitoring physical activity for 4 to 5 days will result in a reliability of 0.70 and between 8 and 9 days of monitoring are required to achieve a reliability of 0.80. In order to achieve a reliability of 0.90, activity patterns should be monitored for 18 to 20 days. Trost et al. (2000) determined the reason for the extended period of time is due to large differences in weekday and weekend physical activity behavior. In comparison to children, adolescent youth participate in significantly lower levels of moderate-vigorous physical activity on weekends versus weekdays. This makes it critical that weekend

activity is taken into consideration when monitoring activity levels in adolescents. Tudor-Locke et al. (in review) used pedometer step counts and BMI to establish criterion-referenced standards for optimal physical activity levels that would promote healthy body composition. It was determined that 6- to 12-year-old boys should accumulate 15,000 steps per day while 6- to 12-year-old girls should accumulate 12,000 steps per day in order to maintain a healthy BMI level.

Reliability and Validity of BMI Measurements

Several methods for evaluating body composition have been used in research. These methods include skinfold measurements, hydrostatic weighing, bioelectrical impedance analysis, dual energy x-ray absorptiometry (DXA) and body mass index (BMI). The use of BMI is beneficial in large scale epidemiological studies because it is safe, simple and inexpensive to obtain (Pietrobelli, Faith, Allison, Gallagher, Chiumello, & Heymsfield, 1998).

Pietrobelli et al. (1998) studied the need for an accurate and reliable measure of body composition when evaluating the various factors contributing to childhood obesity. This study determined that body fatness in children and adolescents can be measured with accuracy and validity by using BMI. Body mass index, measured in kilograms per meter squared, was significantly associated with total body fat (kg), measured by DXA, in children and adolescents. A positive correlation was found between age and BMI, total body fat (kg), and percent body fat. Children who were older had a greater BMI and total body fat than younger children. Body mass index explained 85% of the variance in total body fatness between male subjects and 89% of the variance in total body fatness

between female subjects. Across the age range the association between BMI and total body fat was consistent with older children having greater values than younger children. Across this age range of 5-19 years, sixty-three percent of the variance in percent body fat for boys was explained by BMI, while 69% of the variance in percent body fat for girls was explained by BMI.

The study by Pietrobelli et al. (1998) showed good correlations between BMI and other methods of assessing body fat. Body mass index correlated strongly with skinfold thicknesses showing r values between 0.68 and 0.85. Similar results were found when comparing BMI and bioelectrical impedance, with resulting r values ranging from 0.65 to 0.85. The correlation between BMI and DXA is good, showing an r of 0.79. Pietrobelli et al. determined that a higher BMI is associated with greater fatness and thus, it is a reliable technique to determine body fatness. These results confirm that screening for overweight adolescents can accurately be conducted by using BMI as a valid and reliable measure.

Due to dramatic changes of BMI as children age, the definition used to determine overweight and obesity in adults must be modified to be appropriate for younger populations (Cole et al., 2000). Overweight and obesity in childhood can be determined using international body mass cut off points developed in a study by Cole et al. Youth between the ages of 2 and 18 who have a BMI for their age category that correlates with an adult BMI of 25 kg/m² are considered overweight. Those who have a BMI for their age category that correlates with an adult BMI of 30 kg/m² are considered obese. These international standards were developed by averaging data from Brazil, Great Britain,

Hong Kong, Netherlands, Singapore, and the United States. The data included 97,876 males and 94,851 females monitored from birth to 25 years of age. The cut off points that resulted from this study enable the comparison of overweight and obesity prevalence in youth at an international level (Cole et al., 2000).

Dietz and Robinson (1998) reported on the usefulness of BMI in assessment of body fatness. Body mass index is easily calculated from measures of height and weight, both of which are standard measures that are taken in clinical settings. The reproducibility of height and weight measurements enables BMI to be a more reliable measure of adiposity than measures such as skinfold thickness. The International Task Force on Obesity supports the use of BMI as a sound measure of fatness in children and adolescents. The adult cutoff point of 30 for BMI is applicable to adolescents, because at later stages of adolescence, elevated BMI is associated with patterns of risk for obesity-related mortality and morbidity in early adulthood (Himes & Dietz, 1994). Using other measures of body fatness in field settings, such as a school, can be time consuming and expensive. The skinfold method is time consuming and accuracy depends on the abilities of the administrator. Methods such as hydrostatic weighing and DXA are costly and possibly difficult for youth to complete. For clinical and public health purposes, Dietz and Robinson (1998) confirm that BMI is the measure of choice when assessing obesity.

Summary

As the occurrence of obesity increases, and participation in physical activity decreases among adolescents, the future health status of society becomes a great concern. Increasing physical activity levels among adolescents may contribute to a reduction in the

development of overweight and obesity. Individuals who are overweight or obese early in life tend to be overweight or obese later in life. By establishing healthy lifestyle patterns at young ages the health consequences of physical inactivity can be diminished, contributing to healthier, more enjoyable adult years. Monitoring physical activity patterns and weight status in adolescents using pedometers and BMI measures will help determine when the decrease in activity and increase in body weight begin. Research in this area will enable the development of preventive measures that can be taken to reduce the obesity epidemic.

Chapter 3

Methods

This descriptive study has two main purposes: (1) To analyze the relationship between physical activity patterns and overweight/obesity levels using body mass index (BMI) measurement and (2) To measure physical activity patterns across 12-18 year old boys and girls.

Subjects

Approximately 600 students in grades 7-12 from the Alpine school district, a predominantly Caucasian population, will be asked to participate. Participants will be a sample of the population and participation will be on a volunteer basis. Each participant will be assigned a pedometer to wear for the duration of the study. Permission to conduct the study and human subjects approval will be obtained from the public school system and the University Institutional Review Board as well as from the participants and their parent/guardian.

Instruments

Physical activity patterns will be assessed using pedometers to measure daily step count and assessment of overweight/obesity will be accomplished using BMI (height and weight). Pedometers are designed to accurately measure physical activity levels while BMI is a tool for assessing overweight/obesity levels.

Pedometers

Physical activity levels will be measured using the My Life Stepper 2515 digital pedometer (MLS 2500 series, Walk-4-Life, Plainfield, IL). The pedometer objectively

measures physical activity levels by recording accumulated daily steps. Pedometers are unobtrusive, lightweight, and convenient to use in assessment of physical activity levels (Tudor-Locke, 2002). Within a pedometer there is a horizontal, spring suspended lever arm. The vertical movement that occurs with each step during walking or running causes an electrical circuit to close and a step to be recorded. The validity of pedometers has been confirmed in several studies (Bassett, et al. 1996; Bassett, 2000; Freedson & Miller, 2000; Tudor-Locke, 2002). Bassett (1996) determined the accuracy of five pedometers for measuring distance walked. Accuracy of the pedometers ranged from 87.5% to 102.6%. The most accurate pedometer was the Yamax, recording 100.7% and 100.6% of left and right steps, respectively. Pedometers are unable to measure intensity and frequency of activity while duration can only be assessed by monitoring step counts (Welk et al., 2000). Despite these limitations pedometers still provide an objective measure of physical activity (Bassett, 2000).

Body Mass Index

Overweight/obesity levels will be determined using BMI. Body mass index is a ratio between height and weight. It is equal to body weight, in kilograms, divided by height, in meters squared. The use of BMI as a measure of adiposity is appropriate in the school setting due to the ease of obtaining reliable results (Daniels et al., 1997). In a study by Pietrobelli et al. (1998), BMI explained approximately 85% and 89% of the variance of fatness between subjects in boys and girls, respectively. This study also found that across the age range the association between BMI and total body fat is generally

consistent. The BMI cut point values for children are the same as the cut points for adults (Cole et al., 2000). Youth with a BMI value that corresponds to an adult BMI of 25 kg/m² are considered overweight while those with a BMI value that corresponds to an adult BMI of 30 kg/m² are considered obese (Cole et al., 2000).

Procedures

Each participant will be given a pedometer to use throughout the ten days of data collection. The pedometers will be numbered for identification purposes during data collection. During their physical education class (junior high) or Chapter I (high school) students will have the opportunity to experiment with the pedometer prior to any testing. Being able to practice using the pedometer will diminish the students' curiosity and increase their comfort with wearing the pedometer. The pedometers will be distributed to the students in their classes by the researcher with assistance from the school physical education specialist and research assistants. Measures of height and weight for each participant will be taken at the start of the data collection period. Participants will wear the pedometer for ten days. Pedometers will be worn each day from the time participants get dressed in the morning until the time they go to bed. The pedometers will be fastened to the waistband of participants' clothes, when no waistband is available a small belt will be provided on which to attach the pedometer. The participants will be given a daily log sheet that will require a record of their step count, exercise time, if they removed the pedometer and what physical activity they participated in for that day. Participants will be instructed to record this information each night when they remove the pedometer. The

pedometers will be reset by participants each morning to begin a step count for the new day. Researchers will report to the schools during the selected classes to answer any questions and solve any problems that may arise during the ten days of data collection.

Design & Statistical Analysis

Measures of height and weight of each participant will be taken at the beginning of the data collection period. Throughout the study step counts will be recorded on a daily basis. To determine the activity levels of the participants, descriptive data (N's, means, and standard deviations) for step count by age and gender will be calculated. Descriptive data (N's, means, and standard deviations) for BMI by age and gender will be calculated to establish the prevalence of overweight/obesity in the population. Statistical analysis using Pearson Correlations will be conducted between step counts and BMI to determine if a relationship exists. One Way ANOVA will be conducted by age and gender to determine if significant differences exist among the age groups for boys and girls.

Measures of total caloric intake will be collected using the Youth/Adolescent Questionnaire (YAQ). Statistical analysis using Pearson Correlations will be conducted between total caloric intake, step counts, and BMI to determine if relationships exist. Additionally, regression analysis will determine how much of the variance in BMI is accounted for by total caloric intake and by step counts.

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