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Association Between Sports Participation and Levels of Physical Fitness

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Abstract

Objective: Physical activity is a major component of overall health, especially in children. Increased physical activity in children provides many health benefits, and organized sports provide a great opportunity to meet the physical activity recommendations. In fact, participation in organized sports provides further health advantages, such as lower BMIs, compared to those who engaged in self organized physical activity and has shown to promote continued healthy habits throughout life. However, there has not been research looking at which sports are associated with the greatest level of fitness and provide the greatest health benefit for participants. In this study, we examine which sports are associated with the greatest levels of physical activity as measured by the plank hold, grip test, pull up, and lower body strength among children in the US.

Methods: This project uses data collected from the NHANES National Youth Fitness Survey, a one-time survey that gathered data on physical activity and fitness levels in children and teens in the U.S. in 2012. Our variables of interest were participation in sports, type of sport, plank hold, grip test, pull up, and lower body strength. We analyzed the data using a multivariate regression with plank hold, grip test, pull up, and lower body strength as the dependent variables. We compared each of these dependent variables with the following independent variables: age,

gender, participation in baseball, participation in soccer, participation in track and field/running, participation in basketball, participation in football, and participation in gymnastics/cheer.

Results: Results suggests that age and gender are the greatest determinate of physical fitness in all physical exam results. Participation in gymnastics/cheer yielded the greatest effect on physical fitness, with improved results in plank, pull-ups, and leg strength. Both football and soccer participation enhanced outcomes in 2 of 4 physical exams, with football predicting higher fitness levels in pull ups and grip strength, while soccer participation predicted higher fitness levels in plank hold and pull ups. This data helps us understand which sports promote the greatest level of physical fitness and can therefore help determine which sports are most likely to provide the greatest health benefits to participants.

Key Words: organized sports, physical activity, fitness, health, plank hold, grip test, pull up, lower body strength

Introduction

The idea that physical activity has a positive contribution to overall health has already been well established.¹⁻³ The specific contributions encompass a large list of health benefits including overall health enhancement and disease prevention. These advantages, while applicable to adults, can also be extrapolated to children.

Children who are physically active are more likely to have improved health metrics such as lower cholesterol and improved lipid profiles,¹⁻³ lower blood pressure,¹⁻³ and better bone density.² Physically active children are also more likely to have an improved immune system² and reduction in back injuries.² In children with diabetes, physical activity can alleviate symptoms by improving glucose metabolism and maximizing insulin concentrations.^{2,3} Furthermore, physical activity in children can improve mental health and self esteem.¹⁻³

Physical activity is important in management and prevention in many chronic diseases, especially in at-risk children. Activity can improve health in both healthy kids and kids with chronic disease. For adolescents, both boys and girls who performed better on tests of physical fitness, were less likely to have hypercholesterolemia and more likely to have better lipid profiles.¹ Improvements in at least one component of lipid profiles, mainly triglycerides and HDL, were also observed in children with high cholesterol who participated in aerobic exercise.¹ Aerobic exercise also showed reductions in both systolic and diastolic blood pressures for children with hypertension,^{1,3} while lower blood pressures were also observed in children who performed in the top quartile for physical fitness tests compared to children in the bottom quartile.¹ Both children of normal weight and overweight/obese youth, who are physically active and engage in exercise, mainly of aerobic origin, tend to have better measures of total and abdominal adiposity.¹ Children dealing with diabetes also experience benefit from physical

activity, as exercise has shown improvement in glucose metabolism and insulin levels.^{1,2}

Physically active children are more likely to have increased bone strength and sustained bone mineral content, which can act as protective factor against developing osteoporosis and fractures.^{2,4}

Physical activity can also improve mental health and overall well-being in the youth. Increased activity has been linked to increased energy, mood, cognition, mental performance, as well as decreased stress.² Children who are more active have decreased depression and anxiety,^{1,2} while also experiencing improvements in academic performance as noted by increased grade point average, scores on standardized tests, and classroom behavior.³

The health benefits described are dependent on type, intensity, and volume of the physical activity.² In general, the more physically active, the greater the health benefit.¹ While aerobic based activities demonstrated the most significant health benefits, there are many studies that have displayed different recommendations based on the goal of the patient. For instance, there are many programs that vary with intensity and type of exercise that are most beneficial for certain health issues, like diabetes, hypertension, mental health, bone strength, etc.^{1,3}

The Physical Activity Guidelines for Americans recommends at least 60 minutes of moderate/vigorous activity daily for children and adolescents. Activities that include aerobic exercise, bone strengthening, and muscle strengthening movement should be incorporated into daily physical activity at least three days a week for each type. The Physical Activity Guidelines for Americans also emphasized the participation in physical activities that are age-appropriate, enjoyable, and offer variety.⁵ The recommended 60 minutes can be cumulative and may include activities such physical education, recess, sports, and before and after school programs.³

One possibility to help make sure children are meeting the recommended amount of physical activity is organized sports. The U.S Department of Health & Human Services and the World Health Organization have suggested that sport participation can act as a strategy to promote physical activity in the youth.⁶ According to the annual High School Athletics Participation Survey conducted by the National Federation of State High School Associations (NFHS), the number of high school sports participants reached an all time record high at almost 8 million in 2017-2018.⁷ Plus there has been a decrease trend in physically inactive children between the ages of 6-12, as the percentage of children in this age group who did not engage in sports activity has reached a low of 17% in 2017.⁸ With an increased rise in sports participation, more children will be physically active, as those involved in organized sports spend more time engaged in physical activity and exercise than their non-participant peers.⁶ Thus, those who participate in sports are more likely to experience the health benefits associated with increased activity levels.

Participants in sports have been shown to have increased bone strength as well as decreased BMI. Adolescent boys involved in sports had a lower prevalence of an overweight BMI compared to the population in NHANES. Plus, those who participated in three or more sports had significantly lower BMI percentiles than those who participated in only one or two sports.⁹ Furthermore, in a comparison between organized sports and self-organized physical activity and their relationship on developmental factors, only organized sports demonstrated a statistically significant relationship with BMI, suggesting that organized sports may contribute to lower BMI.¹⁰ Additionally, children participating in organized sports had a positive correlation with overall physical activity level, while no such correlation was made in self-organized physical activity.¹¹ Therefore, participation in sports makes it more likely that children and adolescents

will meet physical activity recommendations and reap the health benefits of increased physical activity.

High School sports participation has also been linked to increased physical activity and fitness in adults. Those who participated in high school athletics reported more hours of weekly exercise and had increased times on a treadmill test where participants worked to complete exhaustion.¹² Meaning that those who participate in high school sports are more likely to stay active as they age, and thus have better cardiovascular health. This is important because only two-thirds of adults meet the minimum level for health enhancing physical activity, and even fewer reach the weekly recommend levels of physical activity.¹³ Therefore, participating in sports not only improves health in children and adolescents, but also promotes healthy lifestyles in adults.

There has been research done on the benefits of sports participation and its association with physical activity. As expected, those who engaged in sports had a better understanding of good health, were more physically active, and scored better on muscular fitness related tests.¹⁴ However, there has been little research on what sport is most likely to yield the greatest results in fitness related tests. Thus, the purpose of this study is to determine which sports are associated with the greatest level of physical fitness as measured by the plank hold, grip test, pull up, and lower body strength test.

Methods

Context/Protocol

This project is based on the NHANES National Youth Fitness Survey, which was a one-time survey conducted in 2012 to collect data on physical activity and fitness levels in children

and teens in the U.S. The survey involved a household interview and a physical activity and fitness exam. Participants included any child age 3-15 who completed the survey during this time period. 1,640 children and adolescents in this age group were interviewed and 1,576 were examined. Participants were selected from an independent sample of households within segments of primary sampling units (mostly counties). Individuals from these households were selected based on matching criteria for sex and age only. Income and race were not a selection criterion. The sample included participants located in 15 primary sampling units across the country, thus representing approximately 3000 counties in the United States. No specific region or geographical location was released to protect identification of participants.

Data Collection

The data was collected from the NHANES National Youth Fitness Survey, which is a publically available data set. Similar sports were grouped together (track and field/running and gymnastics/cheerleading). Exclusion criteria included any sport in which the number of participants was less than 60, regardless of whether or not the sport was primarily played by boys or girls. Table 1 includes the lists of sports that were analyzed and the number of participants in each sport. The response to age, gender, participation in sports, as well as the physical examination results of physical activity, specifically plank hold, grip test, pull up, and lower body strength were examined. Missing or questionable data was excluded from analysis.

Table 1. Number of children who have participated in sports.

Sport	Male	Female	Total
Baseball	72	39	111
Basketball	126	69	195
Football	88	4	92

Cheer/Gymnastics	10	61	71
Track/Running	67	67	134
Soccer	96	71	167

Data Analysis

The data from NHANES National Youth Fitness Survey was analyzed using SPSS data analysis. It was analyzed to see the effects that sports participation had on the results of plank hold, grip test, pull up, and lower body strength. Both gender and age in years were selected for. Data from similar sports were combined, such as track and field and running, cheerleading and gymnastics. An average of the results for lower body strength was taken to have the results represent combined leg strength, as each leg was measured individually. The data was analyzed for the different sports individually, but also took into account participants who played multiple sports.

The data was analyzed using a multivariate regression with plank hold, grip test, pull up, and lower body strength as the dependent variables. Each of these dependent variables was compared to the following independent variables: age, gender, participation in baseball, participation in soccer, participation in track and field/running, participation in basketball, participation in football, and participation in gymnastics/cheer.

Results

Table 2 shows the average results of the physical fitness tests. For all the children in this study, which included 459 males and 311 females with a mean age of around 10 years old, the average number of seconds the plank position was held was 60.96 seconds. The mean for

number of correctly completed pull-ups was 4.94 pull-ups. The mean leg strength for all children was 54.60 lbs., and the average result of combined grip strength among children was 45.85 kg.

Table 2. Descriptive statistics for physical fitness outcomes

Outcome	n	Mean (SD)	Range
Plank (s)	1431	60.96 (\pm 45.52)	449
Pull Up (pull-ups)	1310	4.94 (\pm 5.55)	30
Leg Strength (lbs.)	1198	54.60 (\pm 29.29)	196.65
Grip Strength (kg)	601	45.85 (\pm 21.42)	97.20

Table 3 shows the effects of age, gender, and playing a certain sport on the physical fitness outcomes. Age and male gender were the most significant contributors ($p < 0.05$) to improved physical fitness test outcomes in all tests. Baseball had one statistically significant positive beta coefficient with regard to plank hold. Basketball and Track/Running had no statistically significant effects on any of the fitness test outcomes. Football had a positive correlation toward number of pull-ups completed and grip strength. Soccer had a positive correlation in plank hold and pull-ups, while Cheer/Gymnastics had positive correlations in plank, pull-ups, and leg strength.

Table 3. Beta Coefficients (95% confidence intervals) for male gender, age, and sports participation. The statistically significant results are bolded.

	Plank	Pull Up	Leg Strength	Grip Strength
Male Gender	-4.691	-2.460	-4.496	-6.142
Age (years)	5.998	0.434	6.708	5.279
Baseball	9.781	0.269	2.427	1.473
Basketball	2.811	0.378	-0.554	0.083
Football	5.568	2.450	3.660	2.305
Cheer/Gymnastics	11.176	1.516	10.542	1.512
Track/Running	-1.744	0.485	1.986	0.727
Soccer	8.151	0.942	-0.444	-1.723

Discussion

The Role of Gender and Age in Fitness

Based on the results of the study, being older and a male improves physical fitness scores. These two variables had the greatest effect on overall physical fitness, as both variables had a significant impact on all test results. The results could indicate differences in amount of physical activity between genders. Boys are known to be more physically active than girls. A prior study done on data from the National Health and Nutrition Examination Survey with youth ages 6 to 19 found that girls participate in less moderate to vigorous physical activity compared to boys.¹⁵ Other studies found that girls are more likely to be sedentary, and when active will likely play low to moderate intensity sports compared to the high intensity sports noticed in boys.¹⁵ This is also supported by our data, which shows that of the six sports selected, there were 148 more male participants (Table 1). Another explanation could be the gender difference in genetic makeup and muscle characteristics. All of these physical fitness tests had a strength component that was necessary to do well. The difference in strength may also be attributed to the difference in muscle between genders. Males have both more total skeletal muscle and more skeletal muscle relative to total body mass.¹⁶ A study that determined men to be stronger than women in both the upper and lower body and with respect to relative lean body mass found that men had significantly larger type I fibers areas and mean fibers areas in the biceps brachii and larger type II fiber areas and mean fiber areas in the vastus lateralis.¹⁷

The effect that age has on physical fitness can be attributed to the maturation of the musculoskeletal and nervous systems as children and adolescents mature. Muscle mass increases in childhood and adolescence, leading to an increase in muscle strength as one ages. Muscle strength continues to increase on average until age 20 in untrained women and age 20 to 30 in untrained men.¹⁸ The nervous system also develops as a child ages, which contributes to

muscular strength. If myelination of nerves is absent or incomplete, movement becomes challenging and achieving high levels of strength and power is near impossible.¹⁸

Gymnastics and Cheer as a Predictor for Fitness

We also found that of all the sports examined, kids who participated in gymnastics or cheerleading had the highest scores on the physical fitness tests, which indicates that these sports might have the most significant impact on overall physical fitness. The impact gymnastics/cheer has on physical fitness can be contributed to these sports involving many muscle groups and incorporating total body workouts. Gymnastics requires high levels of anaerobic and flexibility capacities and integrates jumping, pushing, explosive strength, and pulling skills with balance and artistry. To be successful, a balance between physical fitness and technical skills is required with emphasis on strength, flexibility, and coordination.¹⁹ In fact, talent scouts for gymnasts noted that power speed, isometric and explosive strength, strength endurance, and dynamic and static flexibility were the largest contributors to success in the sport.¹⁹ Therefore, the incorporation of so many muscles groups in both the training and participation of the sport is one of the reasons gymnasts have such high levels of physical fitness. Another explanation is due to the intense and demanding training regimen of these athletes. The training consists of warm ups, stretching, strength training, practicing specific skills and routines, as well as going through dance and choreography. The intensity of the training is also important, as it was noted that the mean heart rate during training was around 60-65% of maximal values in children.²⁰

Fitness Benefits of Specific Sports

Overall, the results determined that playing sports does improve physical fitness, but mainly in the areas directly related to the sport. This makes sense, as the more one uses a muscle, the more it hypertrophies and the stronger it becomes. Therefore, if one continuously uses certain

muscles during sports, those muscles will become stronger and the participant will be more physically fit in tests that require use of those muscles.

For instance, our results showed that gymnastics/cheer led to improved physical fitness in the plank hold, pull-ups, and leg strength. Considering gymnastics is a sport involving use of the entire body, with focus on strength, power, balance, endurance, and flexibility, the use of core muscles is essential. The repeated use of core muscles explains the increases in time for plank hold found in gymnastics/cheer participants. Gymnastics also requires strength and power of the lower limbs, especially in events such as floor exercises and vault. These events consist of sprinting into a dynamic take-off from the ground. One study found that gymnasts who specialize in floor and vault had increased power in the lower extremities, consistent with our results showing an increase in lower leg strength.²¹ Gymnastics also has extensive use of the upper body, particularly in events such as rings and horizontal and parallel bars. Overcoming the resistance of hanging, during these events, leads to an increase in strength and muscle mass.²¹ This correlates to the increased number of pull-ups gymnasts/cheerleaders performed from our data (Table 3).

The movements and techniques in baseball could also explain the results of increased plank holds of participants in our study. Hip and Torso rotation is crucial to the fundamentals of baseball. Strength and power are important, but it is the ability to transfer the forces from the lower body to the upper body that is essential. Both hitting and throwing require this transfer of force, and the hips and torso are responsible for this process.^{22,23} Thus, the fundamentals of baseball require use of the core, and even just participating causes activation of these muscles. Therefore, baseball players are more likely to have stronger cores, supporting our data of participants holding planks for longer periods of time.

The values of football could explain the improved results in pull-ups and grip strength in its participants. Football is a high intensity and high impact collision sport, which requires power, strength, and speed from its players. Due to the constant involvement of colliding with opposing players, being able to generate an increased momentum is advantageous.²⁴ Therefore, there is an emphasis to become strong and powerful. In fact, strength training is a key aspect of football, with emphasis placed on increasing size, strength, and power due to the payoff it provides on the field.^{24,25} Thus, in a sport that focuses on size and strength, and also suggests weightlifting for player advantage, it is quite reasonable to see improved results in pull-ups and grip strength.

The mechanics of soccer can explain the increased time in plank holds for its participants. Soccer involves twisting and rotating the trunk during play, whether it be kicking or passing the ball.²⁶ In addition, previous studies have found that trunk muscle strength and stability can improve performance via associations between trunk strength and sprinting, agility, and jumping performance.²⁷ The constant involvement of the trunk most likely led to stronger cores in the participants causing improved results in the plank hold. However, the results for participants achieving a greater number of pull-ups is a bit more complex and difficult to understand. There was little information on the effects soccer had on upper body strength, and with a sport that is so predominantly lower body driven, a logical explanation was hard to find. However, the best hypothesis is that soccer participants are acquiring more physical activity and also are more likely to be involved in training than non-participants. This could be a likely explanation for the pull-up results.

Limitations

One limitation of this study is the minimal amount of fitness tests that were considered for physical fitness. The four tests examined all required strength to succeed. While strength is a key component of fitness, there are many other aspects that comprise a physically fit individual, that this project failed to recognize. For instance, two key variables left out were cardiovascular fitness and flexibility. Therefore, this project failed to recognize participants in sports where aerobic exercise is predominant, as physically fit. Moving forward, incorporating tests that can include these variables will help provide a better understanding on how each sports affects total fitness, and not just fitness in regards to strength.

Another limitation is that the data cannot determine how active the children who participated actually were. Participation in a sport does not necessarily mean the child is invested or actively engaging, and therefore may not accurately predict the effects the sport has on physical fitness and health. A suggestion for the future would be to increase the age group examined and collect data from levels of athletics that traditionally are more competitive, such as either the high school or college level. While, this is not ideal to measure how sports affect physical fitness in children, it might be a better predictor of which sport actually has the greatest effect.

This study did not account for the time spent participating in each sport, which certainly may have contributed to the results. Gymnasts spend an inordinate amount of time in their training. The sport is time consuming, as the average time spent training for gymnasts at major championships was around 30 hours/week. An optimal training plan for elite US female gymnasts consists of two daily sessions 6 times per week, with one morning session lasting 2-3 hours and one afternoon session lasting 3-4 hours. Recommended training for English gymnasts increases from 9 to 18 hours/week between the ages of 8 to 16 years old, while the former Soviet

Union starts at 8 hours/week at 5-6 years of age and increases to 32-36 hours/week for elite athletes at 16-18 years of age.²⁰ These findings may support a direct correlation between the amount of physical activity and physical fitness. Gymnastics exceeded the time recommendations of physical activity for children, possibly enhancing the performance of these athletes in physical fitness tests. However, this conclusion cannot be drawn from this study due to the failure to consider the effects participation time had on physical fitness.

Conclusion

In conclusion, the benefits of sports participation on physical activity and health is well understood.^{1-3,6,9-12} With the knowledge of which sport actually provides the greatest overall physical fitness to its participants, there is a better understanding of what activities/exercises should be encouraged for children in order to reap the optimal health benefits of sports participation. Being aware that gymnastics/cheer provides the greatest fitness benefits for children, followed by football and soccer, these activities should be encouraged for children and adolescents. These sports should be promoted in schools, while similar exercises and games should be incorporated into gym classes and recess. Schools should also make attempts to create clubs or organizations for children to participate in such activities in order to provide access to these opportunities. Most sports are costly and might not be accessible to children of lower income families. The schools could provide a chance for these children to get involved. In addition, parents and children should be made aware of the benefits of sports participation, as well as the fact that certain sports can provide greater promises on their child's fitness and health. This can lead to a greater rise in participation in these sports, or even just more children becoming engaged in similar events. This could lead to more children reaching the required physical activity recommendations and receiving the many health benefits of exercise. Ideally,

with the correct implementation of this knowledge, more children will be physically fit leading to a healthier life and healthier future.

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