2015

# Empowering Girls with Chemistry, Exercise and Physical Activity

Emily Clapham
*University of Rhode Island*, eclapham@uri.edu

Lori E. Ciccomascolo
*University of Rhode Island*, loricicco@mail.uri.edu

***See next page for additional authors***



Citation/Publisher Attribution
Emily D. Clapham, Lori E. Ciccomascolo & Andrew J. Clapham (2015) Empowering Girls with Chemistry, Exercise and Physical Activity, Strategies, 28:4, 40-46, DOI: 10.1080/08924562.2015.1044143
Available at: http://dx.doi.org/10.1080/08924562.2015.1044143

# Empowering Girls with Chemistry, Exercise and Physical Activity

Emily D. Clapham, Ed.D.
eclapham@uri.edu
University of Rhode Island

Lori E. Ciccomascolo, Ed.D.
loricicco@mail.uri.edu
University of Rhode Island

Andrew J. Clapham
aclapham@chm.uri.edu
University of Rhode Island

Abstract

Research suggests that a girl's career interests in the areas of science, technology, engineering and mathematics (STEM) declines between grades 6 and 8. Similarly, in middle school, there is a decrease in physical activity among girls. Researchers at the University of Rhode Island (URI) conducted a chemistry-based science camp that took place over the public school spring break with the goal of increasing girls' interest in chemistry and physical activity. The camp included 42 middle school aged girls in grades 6 through 8 from schools throughout Rhode Island. Interdisciplinary curricula were created to link chemistry with physical activity concepts used in physical education classes. Overall, the girls enjoyed the interdisciplinary curriculum and found the connection between science and physical activity to be interesting; as a result, similar science-based interdisciplinary curricula may have the capacity to promote physical activity as well as STEM career interests in girls.

Key words: Curriculum & Instruction, Kinesiology, Middle School Physical Education, and Teaching

## Introduction

Girls lose interest in both science and physical activity when they reach the middle school level (Girl Scouts of America, 2013; CDC, 2013). This loss of interest in areas such as science, technology, engineering and mathematics (STEM) and physical activity impacts girls as they enter important life phases (e.g. high school, college, and future careers), and lifestyle choices associated with these phases (Girl Scouts of America, 2013). Middle school students are extremely vulnerable to behaviors that place them "at risk" physically, socially, emotionally, and academically due to the many changes occurring in their lives and the increase in decision-making opportunities. (Mohnsen, 1997; Staurowsky, E.J. et. al, 2009).

## Chemistry/STEM Background

According to data from the National Science Foundation (NSF) only 25 percent of computing/math positions and 11 percent of engineering positions were held by women (NSF, 2014). In contrast, women make up 47 percent of the employed workforce (NSF, 2014). The NSF estimates that approximately five million individuals work directly in science, engineering, and technology, just over 4 percent of the work force (2014). Many science and engineering occupations are predicted to grow faster than the average rate for all occupations, and some of the largest increases will be in computer-related fields; fields where women currently hold one-quarter or fewer positions (AAUW, 2013). Attracting and retaining more women in the STEM workforce will maximize innovation, creativity, and competitiveness (e.g., homes designed by women with women's needs in mind). With a more diverse workforce, scientific and technological products, services, and solutions are likely to be better designed.

A lack of interest in STEM may be a product of older stereotypes about girls doing poorly in math, of low confidence in their abilities, or girls turning to their high verbal skills during career planning (Girl Scouts of America, 2013; Mason, 2010; National Engineers Week Foundation, 2010). Research demonstrates how negative stereotypes about women's math abilities are transmitted to girls by their parents and teachers as early as preschool and elementary school, shaping girls' math attitudes and ultimately undermining performance and interest in STEM (Gunderson, Ramirez, Levine & Beilock, 2011; NSF, 2006). Research also points to the notion of "a sense of belonging" as an important factor in women's intentions to continue in the field of math. An environment that communicates the idea of math ability being a field trait and not something that hard work can increase can erode a girl's sense of belonging (Fine, 2010). Further, girls are typically more interested in careers where they can help others (e.g., teaching, child care, working with animals) and make the world a better place (Girl Scouts of America, 2013). Additionally, gender barriers often hinder girls from their interest in STEM. More than half (57%) of all young girls say that peers their age don't typically consider a career in STEM. Nearly half (47%) of all girls say that they would feel uncomfortable being the only girl in a group or class. Furthermore, 57% of all girls say that if they went into a STEM career, they'd have to work harder than a man just to be taken seriously (Girl Scouts of America, 2013, NSF, 2006). Finally, fewer girls than boys take advanced placement (AP) exams in STEM-related subjects such as calculus, physics, computer science, and chemistry, and girls who take STEM AP exams earn lower scores than boys on average (AAUW, 2013).

## Physical Activity Background

Regular physical activity in childhood and adolescence improves: strength and endurance, helps build healthy bones and muscles, helps control weight, reduces anxiety and stress, increases self-esteem, and may improve blood pressure and cholesterol levels (CDC, 2013). The U.S. Department of Health and Human Services recommends that young people aged 6–17 years participate in at least 60 minutes of physical activity daily (CDC, 2013; USDHHS, 2014).

Physical activity decreases in all adolescents throughout middle and high school. In 2011, 29% of high school students surveyed had participated in at least 60 minutes per day of physical activity on all 7 days before the survey, and only 31% attended physical education class daily (CDC, 2013). However, it should be noted that this decrease in physical activity is more pronounced in adolescent girls. Over eighteen percent of females and 38.3% of males had at least 60 minutes/day of physical activity. In addition, 27.2% of females and 34.6% of males attended physical education class daily (CDC, 2013). Furthermore, only 35% of females aged 6-11 years are reaching the goals of 60 minutes of physical activity a day, and this decreases to 3% in 12- to 15-year-olds (Troiano, Berrigan, Dodd, Masses, Tilert, McDowell, 2008). As students get older their physical activity decreases, a disturbing trend seen more so in girls compared to boys (CDC, 2013; Troiano et al., 2008; YRBS, 2011).

Connecting Chemistry to Physical Activity:

A significant amount of research has indicated a positive relationship between academic achievement and physical activity and fitness in school-aged children (Buck, Hillman, & Castelli, 2008; Castelli, Hillman, Buck, & Erwin, 2007; Coe, Pivarnik, Womack, Reeves, & Malina, 2006; Welk et al. 2010; Wittberg, Cottrell, Davis, &

Northrup, 2010). Scholars have suggested that improvements in academic achievement as a result of increased physical activity may be due to increased arousal and reduced boredom, which may result in increased attention span and concentration (Coe et al., 2006) and increased self-esteem which may lead to improvements in on-task classroom behavior (Shepard, 1996). There are also physiological responses to regular physical activity including "increased cerebral blood flow, changes in hormone levels, greater arousal and stimulation, alterations in brain neurotransmitter activity, and improved nutrient intake" (Eveland-Sayers, Farely, Fuller, Morgan, & Caputo, 2009, p. 103), all of which have been associated with enhanced academic performance.

Due to increased emphasis on academics and testing requirements in schools, PE teachers are encouraged to incorporate interdisciplinary activities into their daily lessons. The use of interdisciplinary lesson plans that connect chemistry and physical activity concepts in physical education classes might help girls maintain an interest in science and physical activity by incorporating science concepts into fun physical activities. This concept is directly connected to the New PE philosophy. According to Sullivan & Clapham (2009 & 2014) the New PE has the following characteristics:

- Class is called Physical Education as we educate the physical
- (and more than the physical too)
- Everyone active, all inclusive, small groups
- No humiliation and intimidation
- Cooperative focus with enjoyment
- Fitness is blended with other physical education content
- Motivational devices are used to personalize and monitor physical activity
- Enjoyment levels are raised
- Individuals work at own physical level and challenge themselves by setting personal goals
- Wellness or health related focus
- Each child has their own piece of equipment (most of time or all active in some way)
- Each child is working towards their own personal fitness goals throughout the

lesson
- Standards based curriculum and assessment; more authentic assessment
- Technology supports the pedagogy (pedometers, heart rate monitors, computers, PDA's, smart boards, tablets, gaming devices…)

Physical education settings are perfect for reinforcing concepts learned in other disciplines. Experts in promoting girls' awareness and interest in STEM suggest offering programs that are engaging, have a "wow" factor, convey key concepts and applications, are doable with minimal or inexpensive materials and work well in a one-hour time frame (Lawrence & Mancuso, 2012).

## Description of the Camp/Methods

A week long camp took place Monday through Friday over a public school vacation for 42 Rhode Island middle school girls in grades 6-8. The URI Chemistry Department recruited the girls for the camp though an email sent to middle school science teachers. The purpose of the camp was to use and introduce innovative curriculum in science and physical education. It was the investigators' goal to create curricula that could be replicated and utilized by middle school physical education teachers in daily physical education classes. Interdisciplinary chemistry and physical activity lessons were taught to the camp participants to foster interest and appreciation of science and physical education.

The camp, sponsored by the URI Chemistry Department, took place each day from 8:30am to 4:30pm. Chemistry professors, graduate students and guest speakers presented chemistry topics and experiments from the field. The topics throughout the camp included: Nano-science, non-Newtonian Fluids, Ph of common objects, rainbow chemistry, women in science, polymer chemistry, and magic show experiments. There

were also field trips to the Narragansett Bay Commission and Boston Museum of Science.

The URI Department of Kinesiology sponsored 60 minutes of physical activity (PA) each day of the camp. This took place from 12pm to 1pm each day. During the 60 minutes of PA each day, a 1-week (4 lesson) interdisciplinary unit was developed to reinforce and complement the chemistry topics that were covered during the camp and to introduce new health and physical activity topics. Music with empowering, pro-female messages was played during the lessons and included “Girl is On Fire” by Alicia Keys, “Miss Independent” by Kelly Clarkson, “Born this Way” by Lady Gaga, “Firework” by Katy Perry, “Run the World (girls) by Beyonce’ and “Beautiful” by Christina Aguilera.

The girls were also given a white Polar Active activity monitor to wear throughout the camp to monitor the amount and type of physical activity. Each Polar Active was individually programmed with each girl’s height, weight, birth date and gender. The instructor explained how to use the Polar Actives (i.e., wear them like a watch on your wrist) and that they measured amount of physical activity in steps, level of physical activity by category (easy, moderate, moderate-vigorous, vigorous and vigorous +) and calories expended. The importance of monitoring physical activity was also thoroughly explained to the camp participants (e.g. to be aware of physical activity level and amount to live a healthy lifestyle). Please see figure 1 for a picture of a Polar Active.

Description of the Chemistry and Physical Education Lessons and Activities:

Lesson 1: Introduction: What is an activity monitor or Polar Active? How do I use a Polar Active? What will I be doing with the Polar Active?

Warm-up Description: Blob tag: Cone off a large space and let players know to stay between the cones at all times. Begin the game with two girls ("the blob") holding hands. If "the blob" tags a player, the girls will join "the blob" by holding their hands. Once "the blob" forms a group of 5, the girls are told that mitosis (cell division) has occurred and the teams will be made into two smaller groups of 2 and 3. The girls will understand that it is a bit easier for "the blob" to move around. Once the blob tags everyone, the game was over.

Interdisciplinary Chemistry and Physical Education Topics: Questions: What type of chemical reactions occur in your body? What do we fuel our bodies with? (food). Do the different types of food we choose to eat (fuel) causes chemical reactions in our bodies? Why is it important to fuel our bodies with good food?

Action: The instructor will lead a discussion on various chemical reactions that occur in the body on a regular basis (i.e.. saliva breaks down food, sweat cools your body and carbohydrates provide your body with energy). The instructor will also discuss food as fuel for the body and the importance of eating healthy food with Choosemyplate.gov.

Interdisciplinary Physical Activity: Healthy Plate Scramble: Create Teams of 3-4 girls and give each team a hula-hoop (plate). Each team will set up their plate in a circle around bean-bags (food groups). The girls will be told to create a healthy plate of food with fruits, vegetables, grains, protein and dairy. The bean bags will be coded by color: red will represent protein, blue will represent dairy, green will represent vegetables, yellow will represent grains, and purple will represent fruit. The girls will attempt to grab one beanbag out of the middle of the floor at a time. Only one girl from each team will be asked to choose a bean-bag when they are told. Once all of the beanbags are gone from

the middle of the floor, the girls will need to take the appropriate color they need from the other teams (similar to Capture the Flag). The girls will not be able to guard their beanbags (food groups) in their hoop (plate).

Closure: Handouts will be given to the girls from choosemyplate.gov.

Lesson 2: Introduction: What is the pH of your body fluids? (Blood has a pH of 7.4, sweat has a pH of 4 and tears have a pH of 6.5).

Warm-up Description: Blood, Sweat and Tears Tag: The instructor will split the girls into two teams. Each team will be sent to opposite sides of the gym or space provided. Each team will need to choose one body fluid to represent (i.e., blood, sweat or tears like "rock, paper, scissors"). For the purpose of the activity, blood beats tears because it has a higher pH, tears beat sweat because it has a higher pH and sweat beats blood because it can wash away blood. The teams will start on opposite baselines and walk to the center of the gym in a line formation together. They can chant as they walk "blood, sweat, tears, repeat". Once they get into the middle, like "rocks, paper, scissors", they say "blood, sweat, tears" then the body fluid they chose as a team. The winning team will try to tag the losing team, while the losing team retreats to their baseline. Anyone who is tagged will need to join the winning team. The purpose of the activity is to learn the differences in pH between the three body fluids.

Interdisciplinary Chemistry and Physical Education Topic: Questions: What is the connection between care and treatment for athletic injuries with stretching and nanoscience? What is nanoscience? (The study of small things and can be connected to physical activity by using small movements and muscle contractions).

Interdisciplinary Physical Activity: Yoga poses will be introduced to the girls. The instructor will explain that yoga can be empowering, prevent athletic injuries, and relate to nanoscience by using small movements to substantially improve muscular strength by toning small muscles. Common yoga poses such as the Tree pose, Child pose, Bridge pose, Cobra pose, Plank pose, Downward dog, Warrior pose, and Sun salutation will be introduced. Please see the appendix for a description of each of the poses.

Closure: The girls will be given handouts on the yoga poses.

Lesson 3: Introduction: The girls will learn about the chemistry of marine environments, water and salts. Why does saline play an important role in one's body functions? What are electrolytes? (Electrolytes help nutrients move into the body's cells and help wastes move out. They also aid in the stabilization of the body's pH level. Electrolytes can affect your heart rhythm, your muscles' ability to contract, your brain function and energy level). Why is hydration so important? It is important to drink a lot of water, and other low-sugar sports drinks or snacks to replace the electrolytes that one loses during strenuous exercise). What are some things that are made up of saline?

Warm-up Description: Saline Sprint tag game: The instructor will randomly select several taggers. The taggers will be given a rubber chicken to use. When tagged with the rubber chicken the girls will be asked to name something (e.g. ocean water, tears, sweat, saline spray) with a saline make-up and then tell a friend in order to get back into the game. The taggers will be switched up every couple of minutes.

Interdisciplinary Chemistry and Physical Education Topic:

Questions: How does one prevent injuries, especially knees? (Jumping and landing lightly and changing posture). What are polymers?

Action: The girls will be told to use a quarter squat with a natural bend in the knee, chin up, chest out, and buttocks back. They girls will be shown how polymers in athletic shoes can assist in preventing injuries by providing cushioning to aid in absorbing shock.

Closure: Name a polymer! The girls will be asked to name things that are physical activity related that have polymers. Some examples can include rubber PE equipment balls, plastic jump ropes, hula-hoops, and other PE clothing like sports bras, athletic shoes, and dry fit clothing.

Interdisciplinary Physical Activity: The girls will participate in jumping using proper form on several different surfaces e.g. turf, gym floor, and grass. Several jumping stations, including ladders, will be set up to create various movement patterns, jumping with jump ropes, high jumps, and plyometric jumping activities. The girls will rotate through the jumping stations.

Lesson 4: The girls will go on a field trip that is interdisciplinary (chemistry and physical activity) in nature. The girls in this camp visited the Boston Museum of Science and wore their Polar Actives on the trip.

Lesson 5: Introduction: What are some benefits of physical activity? Isn't physical activity fun? How much PA did you get this week? What Type of PA?

Warm-up Description: Instructors will review all science topics covered all week with fitness relay races with science vocabulary words (polymer, saline, explosive movements, perceived exertion, nanoscience, mitosis, Non-Newtonian Fluids, pH of blood, sweat and tears). The girls will be split up into 10 groups of 4-5. Each girl will dribble a basketball in between the cones to the opposite side of the gym and then take a shot find a vocabulary word and the correct definition and then dribble back. Once the girl has

successfully dribbled back and passed the basketball to the next girl in line, she can take a seat and her teammate will complete the same challenge. The girls were encouraged to cheer for their teammates!

Interdisciplinary Chemistry and Physical Education Topic: What is the scale of perceived exertion and how does it relate to physical activity (using the Polar Actives).

Action: The girls will do explosive movements, experiencing Non-Newtonian Fluids, by walking through "kiddie" pools of cornstarch and water. The girls will learn that viscosity depends on the force applied to the liquid or how fast an object is moving through the liquid.

Interdisciplinary Physical Activity: The girls will participate in a Fitness Obstacle Course with explosive movements and "kiddie" pools with cornstarch and water (forms a quicksand substance). A fitness obstacle course will be set up outside with hoops that the girls will jump through, cones to zigzag and sprint through, high jumps using correct form, jump bands to jump over, and "kiddie pools" of corn starch and water to run through to finish.

Closure: The girls will be given a Scale of Perceived Exertion handout. The girls will be asked about their perceived exertion for each physical activity they completed. The girls will be given printouts of their daily and weekly physical activity data from the Polar Actives. The instructor will discuss and review the amount and type of their physical activity and discuss setting future physical activity personal goals. The girls will be asked which activities they liked the best and why. Please see table 1 for a display of the lessons and activities.

Conclusion

Overall, the girls enjoyed all of the activities and found science and physical activity fun and interesting. It is critical to instill a love of science and physical activity in middle school girls, since they often lose interest in these two areas during this time in life. The loss of interest in science and physical activity is significant because it impacts girls' lifestyle and career choices as they enter in high school and transition into college. As such, a middle school physical education class is an ideal environment to present fun and engaging science- based interdisciplinary lessons like the curricula presented, to improve a girl's health and well-being and to enhance potential connections between physical activity and academic achievements in STEM. Connecting physical activity and sport to STEM activities for girls is also a matter of gender equity. Since 1972, Title IX has provided an equal opportunity for girls and women to participate in sport and physical activity. But just as Title IX has provided an equal opportunity for girls with an interest in sport and physical activity to pursue that interest, the law continues to mandate greater educational opportunities, funded by federal agencies, for both girls and boys, including STEM education (NCGWE, 2012). Similar to physical activity and sport, Title IX has provided more of an opportunity for girls to explore different educational possibilities that were typically more male-dominated, like STEM, and has positively affected girls' achievement in math scores on the SATs over the last two decades (NCGWE, 2012). Chemistry and physical activity can be connected in interdisciplinary physical education lessons to help stimulate girls' interest in science and physical activity. Interdisciplinary curricula like these could also aid in increasing and sustaining the interest of girls in STEM fields and participation in a physically active lifestyle.

**References:**

American Association of University Women. (2013) Chapter 1: Women and Girls in Science, Technology, Engineering, and Mathematics. Retrieved on June 1, 2013 from: http://www.nature.com/scitable/content/chapter-1-women-and-girls-in-science-18040707

Buck, S.M., Hillman, C.H., & Castelli, D.M. (2008). The relation of aerobic fitness to stroop task performance in preadolescent children. *Medicine and Science in Sports and Exercise,* 40(1), 166-172.

Castelli. D.M., Hillman, C.H., Buck, S. M., & Erwin, H.E. (2007). Physical fitness and academic achievement in third- and fifth-grade students. *Journal of Sport and Exercise Psychology*, 29, 239-252).

Centers For Disease Control and Prevention (2013). How much physical activity do children need? Retrieved on June 1, 2013 from: http://www.cdc.gov/physicalactivity/everyone/guidelines/children.html

Centers For Disease Control and Prevention (2013). Youth Risk Behavior Surveillance—United States 2011. Retrieved on October 9, 2013 from http://www.cdc.gov/mmwr/pdf/ss/ss6104.pdf

Clapham, E.D & Sullivan, E.C. (2014). Tacking and Jibing: Finding Wind for Technology and the New PE. PowerPoint Presentation at Eastern District AAHPERD Convention (February, 2014). Newport, RI: EDA AAHPERD.

Coe, D.P., Pivarnick, J.M., Womack, C.J., Reeves, M.J., & Malina, R.M. (2006). Effect of physical education and activity levels on academic achievement in children. *Medicine and Exercise Science in Sport and Exercise*, 38(8), 1515-1519.

Eveland-Sayers. B.M., Farely, R.S., Fuller, D.K., Morgan, D.W., & Caputo, J.L. (2009). Physical fitness and academic achievement in elementary school children. *Journal of Physical Activity and Health*, 6, 99-104.

Fine, C. (2010). Delusions of Gender: *How Our Minds, Society, and Neurosexism Create Differences*. NYC, NY: W.W. Norton & Company.

Gunderson, E.A., Ramirez, G., Levine, S.C., & Beilock, S.L. (2011). The role of parents and teachers in the development of gender-related math attitudes. *Sex Roles*, 66, 153-166.

Lawrence, D.A. & Mancuso, T.A. (2010). Promoting Girls' Awareness and Interest in Engineering. *Technology and Education Teacher*, September 2012, 11-16.

Mason, M.A. (2010). Still earning less. Chronicle of Higher Education. Retrieved on August, 7, 2014 from http://chronicle.com/article/Stll-Earning-Less/63482/.

Mohnsen, B.S. (1997). *Teaching middle school physical education*. Champaign, IL: Human Kinetics.

Staurowsky, E.J., DeSousa, M.J., Ducher, G., Gentner, N., & Williams, N. (2009). Her Life Depends On It II: Sport, Physical Activity, and the Health and Well-Being of American Girls and Women. East Meadow, NY: Women's Sports Foundation.

National Coalition for Women and Girls in Education (NCWGE). Title IX at 40: Working to Ensure Gender Equity in Education. Washington, DC: NCWGE, 2012.

National Science Foundation (2006). New tools for America's work force: girls in science and engineering (NSF 06-59). Arlington, VA: Author.

National Science Foundation, 2013. Women, Minorities, and Person's with Disabilities in Science and Engineering. Retrieved on January 28, 2014 from http://www.nsf.gov/statistics/wmpd/2013/sex.cfm.

Shephard, R.J. (1996). Habitual physical activity and academic performance, Nutrition Reviews, 54(4), S32-S36.

The Girl Scouts of America. (2013). Generation STEM: What Girls Say About Science, Technology, Engineering and Math. Retrieved on June 1, 2013 from: http://www.girlscouts.org/research/pdf/generation_stem_full_report.pdf

Troiano, R.P., Berrigan, D., Dodd, K.W., Masse, L.C., Tilert, T., McDowell, M. (2008). Physical activity in the United States measured by accelerometer. *Medical Science Sports Exercise*, 40(1):181-188.

United States Department of Agriculture. (2013). Printable Materials and Ordering. Retrieved on June 1, 2013 from: http://www.choosemyplate.gov/print-materials-ordering/graphic-resources.html

United States Department of Health and Human Services. (2008). Physical Activity Guidelines for Americans. Office of Disease Prevention and Health Promotion. Retrieved on August 5, 2014 from: http://www.health.gov/paguidelines/guigelines/.

Welk, G.J., Jackson, A.W., Morrow, J.R., Haskell, W.H., Meredith, M.D., & Cooper, K.H. (2010). The association of health-related fitness with indicators of academic performance in Texas schools. *Research Quarterly for Exercise and Sport*, 81(3), S16-S23.

Wittberg, R., Cottrell, L.A., Davis, C.L., & Northup, K.L. (2010). Aerobic fitness thresholds associated with fifth grade academic achievement. *American Journal of Health Education*, 41(5), 284-291.