The Physical Educator Vol. 76 • pp. 800–812 • 2019
https://doi.org/10.18666/TPE-2019-V76-I3-8859

PHYSICAL FITNESS

Influence of Visual and Auditory Stimuli on Exercise Intensity Among School-Age Children

Patricia Sandoval, Amanda Staiano, Holly Kihm

Abstract

This pilot study tested the efficacy of auditory and visual stimuli to increase children's exercise intensity while exercising in a classroom. Nineteen children aged 6 to 12 years participated in four exercise conditions (treadmill with and without music; cycling with and without video) with heart rate monitored continuously. This study used t tests to compare % HR above rest between conditions. Children met levels of vigorous intensity in all conditions. There was a small but nonsignificant effect in % HR for treadmill (94 ± 18 with music vs. 87 ± 18 without music, Cohen's d = 0.39) and cycling (49 ± 25 with video vs. 59 ± 30 without video, Cohen's d = 0.37). Children reached vigorous-intensity levels regardless of auditory or visual stimulus. Future research should test positive and negative effects of auditory and visual stimuli on children's exercise intensity within a school setting.

Patricia Sandoval was a research assistant on the project study and key contributer to the manuscript. Amanda Staiano is an assistant professor and director, Pediatric Obesity and Health Lab, Pennington Biomedical Research Center. Holly Kihm is an associate professor and director of the Interactive Physical Activity Lab, Southeastern Louisiana University. Please send author correspondence to amanda.staiano@pbrc.edu

Childhood obesity in the United States affects 18.5% of children and adolescents between the ages of 2 and 19 years, far surpassing the Healthy People 2020 goal of having the childhood obesity rate at 14.5% among American youth (Hales, Carroll, Fryar, & Ogden, 2017). Childhood obesity can result in the early onset of detrimental health risks such as cardiovascular disease and type 2 diabetes (Daniels et al., 2005), placing a significant financial burden on U.S. families. Children with obesity incur an estimated $19,000 in lifetime medical costs more than normal weight children (Finkelstein, Graham, & Malhotra, 2014). If left untreated, nearly 80% of overweight adolescents will remain obese into adulthood (Daniels et al., 2005). With 39.8% of adults in the United States classified as having obesity (Hales et al., 2017), more prevention measures need to be implemented for a reduction in the high prevalence of obesity among the U.S. population.

Exercise interventions can be an effective method to improve a child's body composition (i.e., increase lean body mass and reduce body fat percentage; Kelley & Kelley, 2013; Vasconcellos et al., 2014). However, many physical education teachers and clinical health educators are finding it difficult to motivate children to engage in exercise. While national and international guidelines call for children and adolescents to engage in at least 60 min of daily moderate-to-vigorous physical activity (2018 Physical Activity Guidelines Advisory Committee, 2018; World Health Organization, 2017), it is evident that most youth are not motivated to meet these physical activity guidelines consistently. Three quarters (75.2%) of today's youth do not engage in the exercise levels needed to maintain long-term health promotion (Fakhouri et al., 2014).

Prior studies in adults have indicated that auditory and visual stimuli have increased the intensity and motivation to exercise among observed populations (Hutchinson, Karageorghis, & Jones, 2015; Lin & Jing-Horng, 2013; Rhodes, Warburton, & Bredin, 2009; Waterhouse, Hudson, & Edwards, 2010; Yim & Graham, 2007). For instance, in one study of 12 male college students, participants were asked to cycle while listening to music (Waterhouse et al., 2010). Researchers manipulated the tempo of the music and observed that decreasing the tempo resulted in a decrease in participants' heart rate and total mileage cycled, whereas an increase in tempo resulted in the participants producing more power with each pedal stroke and completing more miles in the same time duration.

The purpose of this pilot study was to test the efficacy of auditory and visual stimuli on increasing the intensity of exercise among children between the ages of 6 and 12 years. With limited research on the effect of these potential motivational factors among young children, results gained from the study may serve as guidance for physical education teachers and public health professionals working to combat childhood obesity.

Method

Participants

During the spring of 2016, 19 children between the ages of 6 and 12 years attending an elementary school in southeastern Louisiana were recruited and enrolled into an after-school exercise program located at a local university laboratory (Kihm, Staiano, & Sandoval, 2017). Prior to children engaging in study-related activities, staff members obtained written informed consent from parents and verbal informed assent from participants who were under the age of 10 years. Participants 10 years and over provided written informed assent. The institutional review board approved the study protocol and all other study-related materials and handouts.

Instruments

Quantitative data collected for the two exercises performed were recorded on data sheets by the undergraduate students and then handed in at the end of each session to the lab graduate assistant, who then entered data into an excel spreadsheet. Each child's heart rate was tracked by a Polar GoFit heart rate monitor (Polar Electro, Kempele, Finland) that the children wore while exercising. Polar GoFit is an online program that syncs with heart rate monitors to provide physical educators with an overview of students' heart rate in real time. While there are limited published data on Polar GoFit (see Pettit, 2016), the Polar heart rate devices are considered a gold standard instrument for measuring heart rate and have been validated against other heart rate monitors (Boudreaux et al., 2018). Exercise intensity was determined based on the child's heart rate at the end of each exercise condition. Data were downloaded onto the Polar GoFit app, which was saved at the end of each lab session. Total distance walked/jogged or cycled by each child was recorded in miles.

Procedure

Program sessions were held in the Interactive Physical Activity Lab (I-PAL) for 13 weeks during the Spring 2016 semester. The lab was held in a classroom in the university's Department of Family and Consumer Sciences building. The I-PAL was equipped with various child-sized pieces of exercise equipment such as stationary bikes, pedal desks, treadmills, exergaming consoles, and a treadwall. Six undergraduate students collected data while supervised by the principal investigators, course instructor, and two graduate students. The undergraduate students enrolled in a research methods course and received 2 weeks of training on the protocol, and these students were also trained and certified in research methodology by the Collaborative Institutional Training Initiative certification. Participants attended the program after school, with the option of attending up to three 2-hr sessions per week.

At each session, a different exercise activity was used in the assessment of each participant's exercise levels. Before the children commenced with the activity, each child's resting heart rate was recorded. A moistened Polar heart rate monitor was placed around the child's chest, right below the chest muscles. The graduate assistant then instructed the children to relax and sit quietly for 1 min, after which their heart rate was read from the Polar GoFit app on the classroom iPad. At the end of the lab session, all data collected from the Polar GoFit app were downloaded and saved to the Polar website.

After the resting heart rate data were collected, the children were randomly divided into groups of three to four children; one or two undergraduates led each group. The children took part in a 5-min warm-up before engaging in the daily activity. During the daily activity, the undergraduate students monitored and recorded each participant's results. When all the children had completed the experiment, the undergraduate students led the group in a 5-min cooldown. The treadmill and cycling activities described next were only performed once during the 13-week program.

The treadmill activity with auditory stimuli was performed during Week 4 of lab with the aim of observing if music could positively affect a participant's exercise performance. The activity consisted of four bouts of exercise (3.0 mph, 4.5 mph, 3.0 mph, 4.5 mph) per round. Each participant completed two rounds of the activity. Depending on the child's assignment, some participants listened to Taylor Swift's song "Shake It Off" during Round 1, while other participants listened to the song during Round 2. No participant listened to the song during both rounds. Children were told, "For this activity, you will jog and walk on the treadmill for a short period." Each round consisted of a 1-min warm-up (pace of 3.0 mph), then a 1-min jog (pace of 4.5 mph), followed by a 2-min walk (pace of 3.0 mph), and ending with a 1-min jog (pace of 4.5 mph). At the end of each round, the child's heart rate and total distance jogged/walked were recorded. A 1-min water break was given between Rounds 1 and 2. While all the rounds had a set speed, if a child decided to go slower than the assigned speed, or to stop before all rounds were completed, they could do so. In that case, the undergraduate student performing the observation noted the child's decision to deviate from the established protocol.

The stationary bicycle activity with visual stimuli was performed during Week 5 of lab. The aim of the exercise was to test if watching a video of a virtual bike path through Yellowstone National Park while riding a stationary bike would increase a child's exercise level more than cycling without watching the video. This activity took part over an entire week. On the first day, all children cycled for 10 min with the video projected on the screen at the front of the room. On the second day, all the children cycled for 10 min with no video. During each day, the bicycle resistance was kept at the lowest setting and children could pedal as fast or as slow as they desired. Children were encouraged to pedal for the entire 10 min, but if the child decided to stop before the time was up, he or she was not penalized.

Data Analysis

The primary outcome variable was % HR above rest during the exercise conditions. Secondary outcome variables included HR above rest, HR, and % HR_{max}, as well as distance traveled. The formula 208 – (0.7 * Age) was used to calculate age-predicted maximal heart rate (HR_{max}; Mahon, Marjerrison, Lee, Woodruff, & Hanna, 2010; Tanaka, Monahan, & Seals, 2001), and vigorous-intensity exercise was classified as > 60% HR_{max} (Pescatello, 2014).

Independent-samples *t* tests were calculated and outcomes between condition for each modality (treadmill or cycling) compared, and confirmatory paired-sample *t* tests were calculated among the subset of children who completed both conditions. Cohen's *d* was calculated and effect size estimated.

Results

In total, 19 children had complete data for the cycling activity (16 with video and 10 without video; 7 completed both conditions) and 14 children had complete data for the treadmill activity (11 with music and 13 without music; 10 completed both conditions). Data were missing due to student absences. Table 1 shows descriptive characteristics.

Table 1
Descriptive Analysis of Sample Size (n = 19)

Descriptive statistic	*M* ± *SD*	%
Age, years	7.8 ± 1.3	
Female		82
Race		
White		71
Black/African American		12
American Indian		12
Filipino		6
Weight, kg	35.9 ± 15.7	
Height, cm	130.1 ± 9.0	
BMI, *z*-score	0.98 ± 0.99	
Obese		26
Overweight		26
Normal weight		47

Note. BMI = body mass index.

Table 2 reports the exercise intensity of children during the treadmill activity. There was a small effect size between conditions (Cohen's *d* = 0.39) for % HR above rest, though the difference was not statistically significant. There was no difference between conditions for the secondary outcomes of HR above rest, HR, % HR_{max}, or distance traveled. Effect size was small for HR above rest (Cohen's *d* = 0.19) and not statistically significantly different from the others. Results were similar in the subset who completed both conditions, based on paired-sample *t* tests. Both treadmill conditions met criteria for vigorous intensity based on % HR_{max} (84% met vigorous intensity with music and 84% met vigorous intensity without music). All children met criteria for vigorous-intensity exercise when running on the treadmill with music versus 91% without music.

Table 2
Children's Performance With and Without Music During the Treadmill Activity

Dependent variable	With music $M \pm SD$	Without music $M \pm SD$	Cohen's *d*
Heart Rate Above Rest, %	94 ± 18	87 ± 18	0.39
Heart Rate Above Rest, bpm	82 ± 14	79 ± 18	0.19
Heart Rate, bpm	170 ± 20	169 ± 24	0.05
Heart Rate, % max	84 ± 10	84 ± 12	0.00
Distance, miles	0.3 ± 0.03	0.3 ± 0.08	0.00

Note. Values are for full sample.

There was a small effect between conditions in % HR above rest in the cycling activity (cycling without video vs. cycling with video, Cohen's *d* = 0.37), though there was no statistically significant difference. There was no difference between conditions for the secondary outcomes of HR above rest, HR, % HR_{max}, or distance traveled. Effect size was small for HR above rest (Cohen's *d* = 0.26) and small or trivial for the others. Results were similar in the subset who completed both conditions, based on paired-sample *t* tests. See Table 3. Seventy-one percent of participants reached their maximum heart rate while taking part in the cycling activity with the video versus 66% without the video.

Table 3
Children's Performance With and Without Video During the Cycling Activity

Dependent variable	With video $M \pm SD$	Without video $M \pm SD$	Cohen's *d*
Heart Rate Above Rest, %	49 ± 25	59 ± 30	0.37
Heart Rate Above Rest, bpm	44 ± 22	50 ± 25	0.26
Heart Rate, bpm	136 ± 24	138 ± 23	0.08
Heart Rate, % max	67 ± 12	68 ± 11	0.09
Distance, miles	2.1 ± 1.1	1.9 ± 1.2	0.18

Note. Values are for full sample.

Discussion

The purpose of this pilot study was to test the efficacy of auditory and visual stimuli on increasing the intensity of exercise among school-age children. There were small effects, whereby children engaged in higher intensity activity while listening to music on the treadmill versus no music, whereas children engaged in lower intensity activity while cycling with a video versus without a video, though no effects were statistically significantly different. Across all four exercise bouts, children reached vigorous-intensity levels of exercise.

Few studies have tested the motivational effects of auditory and visual stimuli on children. The results from the auditory trial support previous findings by K. Lee (1987), in which upbeat music tempo positively influenced children's ability to exercise on the treadmill. However, it was surprising that the visual stimuli of the video produced a lower heart rate while children cycled; the subject and tempo of the video (cycling through a national park) may not be sufficiently stimulating to increase children's intensity. Research needs to test under what circumstances auditory and visual stimuli can elicit improved exercise performance among children, including lengthening exercise bouts and increasing intensity of exercise, and if there are unintended negative effects as observed in the video condition of cycling. Given the Lee trial was performed over 30 years ago, future research should investigate incorporating new technology into PE classrooms such as music played on a smartphone while children run, a fast-paced video played on a tablet while children cycle, and exergames that use auditory and visual stimuli in an engaging environment during structured exercise.

It is estimated that young people spend an estimated 7 hr 38 min/day consuming different modes of media (Rideout, Foehr, & Roberts, 2010). Much of that media usage is centered on listening to music (2 hr 38 min) and playing video games (1 hr 13 min; Rideout et al., 2010). Through these two popular forms of media usage during exercise bouts, children and adolescents may be more likely to engage in different modes of exercise that would grab their attention and potentially motivate them to exercise at moderate-to-vigorous activity levels. Therefore, auditory and visual stimuli may contribute to creating successful exercise interventions in physical education classrooms. Early childhood experts believe that when used appropriately, technology and interactive media can support learning and physical development among children and adolescents (National Association for the Education of Young Children & Fred Rogers Center for Early Learning and Children's Media at Saint Vincent College, 2012).

Limitations of the study include a small sample size that limited the power to detect potential differences between auditory and visual stimuli conditions. Resting heart rate was taken over a 1-min duration, which follows the American Heart Association (2018) and is used by physicians (Rabbia et al., 2002); it is recognized that a longer duration of rest is ideal but challenging in a real-world classroom environment. It is possible that the students in each group may have affected each other's effort levels, though children could not see each other's progress or heart rate during the exercise bouts. Furthermore, the exercise bouts were brief and occurred only once per condition; future studies should investigate the role of auditory and visual stimuli on children's motivation to exercise over a longer duration of time.

Visual and auditory stimuli are two low-cost initiatives that schools can incorporate into their gym class routines. With only 3.8% of elementary schools nationwide following the Surgeon General's recommendation of 150 min/week of physical education (S. Lee, Burgeson, Fulton, & Spain, 2007) and nearly half of school administrators cutting gym time to keep up with the demands of No Child Left Behind (Kohl & Cook, 2013), physical educators need to make the most use of their limited class time. Providing students with fast-paced music and exercise videos or games while in gym may be one solution. Future research studies should build on these initial data to determine whether and in what ways visual and auditory stimuli can appeal and prompt children to exercise at a moderate-to-vigorous intensity. With school as a prime setting to successfully reach a greater population of children (Harvard T. H. Chan School of Public Health, n.d.; Office of Disease Prevention and Health Promotion, 2014), physical education classes would serve as an outlet for these future research interventions to be conducted and implemented. While a significant amount of research has been conducted on the benefits of auditory and visual stimuli among adults (Hutchinson et al., 2015; Lin & Jing-Horng, 2013; Rhodes et al., 2009; Waterhouse et al., 2010; Yim & Graham, 2007), this pilot study supports the need for more research to be performed among children and adolescents.

In summary, both exercise activities demonstrated the potential for children to reach a vigorous intensity when supplied with motivating conditions such as auditory and visual stimuli, though the children engaged in vigorous-intensity exercise regardless of the presence of the stimuli. Exercise needs to be fun and stimulating for children, and viewing exercise as a monotonous routine makes it difficult for youth to engage in at least 60 min of daily moderate-to-vigorous exercise. The results obtained in these trials may serve as a foundation for future research that tests the efficacy of auditory and visual stimuli to increase the intensity of exercise among children and adolescents.

References

2018 Physical Activity Guidelines Advisory Committee. (2018). *2018 Physical Activity Guidelines Advisory Committee scientific report*. Washington, DC: U.S. Department of Health and Human Services.

American Heart Association. (2018). All about heart rate (pulse). Retrieved from http://www.heart.org/HEARTORG/Conditions/HighBloodPressure/GettheFactsAboutHighBloodPressure/All-About-Heart-Rate-Pulse_UCM_438850_Article.jsp#.Wp81_h3waUl

Boudreaux, B. D., Hebert, E. P., Hollander, D. B., Williams, B. M., Cormier, C. L., Naquin, M. R., . . . Kraemer, R. R. (2018). Validity of wearable activity monitors during cycling and resistance exercise. *Medicine and Science in Sports and Exercise, 50*, 624–633. https://doi.org/10.1249/mss.0000000000001471

Daniels, S. R., Arnett, D. K., Eckel, R. H., Gidding, S. S., Hayman, L. L., Kumanyika, S., . . . Williams, C. L. (2005). Overweight in children and adolescents: Pathophysiology, consequences, prevention, and treatment. *Circulation, 111*, 1999–2012. https://doi.org/10.1161/01.cir.0000161369.71722.10

Fakhouri, T. H. I., Hughes, J. P., Burt, V. L., Song, M. K., Fulton, J. E., & Ogden, C. L. (2014). *Physical activity in U.S. youth aged 12–15 years, 2012* (NCHS Data Brief No. 141). Hyattsville, MD: National Center for Health Statistics.

Finkelstein, E. A., Graham, W. C. K., & Malhotra, R. (2014). Lifetime direct medical costs of childhood obesity. *Pediatrics, 133*, 854–862. https://doi.org/10.1542/peds.2014-0063

Hales, C. M., Carroll, M. D., Fryar, C. D., & Ogden, C. L. (2017). *Prevalence of obesity among adults and youth: United States, 2015–2016* (NCHS Data Brief No. 288). Hyattsville, MD: National Center for Health Statistics.

Harvard T. H. Chan School of Public Health. (n.d.). Environmental barriers to activity: How our surroundings can help or hinder active lifestyles. Retrieved from https://www.hsph.harvard.edu/obesity-prevention-source/obesity-causes/physical-activity-environment/#references

Hutchinson, J. C., Karageorghis, C. I., & Jones, L. (2015). See hear: Psychological effects of music and music-video during treadmill running. *Annals of Behavioral Medicine, 49*, 199–211. https://doi.org/10.1007/s12160-014-9647-2

Kelley, G. A., & Kelley, K. S. (2013). Effects of exercise in the treatment of overweight and obese children and adolescents: A systematic review of meta-analyses. *Journal of Obesity, 2013*, 1–10. https://doi.org/10.1155/2013/783103

Kihm, H., Staiano, A. E., Sandoval, P. (2017). Project IPAL: To enhance the well-being of elementary school children. *Journal of Family and Consumer Sciences, 109*(1), 54–56. https://doi.org/10.14307/jfcs109.1.54

Lee, K. P. (1987). *The effects of musical tempos on psychophysical responding during sub-maximal treadmill running* (Unpublished master's thesis). Pennsylvania State University, University Park, PA.

Lee, S. M., Burgeson, C. R., Fulton, J. E., & Spain, C. G. (2007). Physical education and physical activity: Results from the school health policies and programs study 2006. *Journal of School Health*, 77, 435–463. https://doi.org/10.1111/j.1746-1561.2007.00229.x

Lin, J. H., & Jing-Horng, L. (2013). Interactive effects of visual and auditory intervention on physical performance and perceived effort. *Journal of Sports Medicine,12*, 388–393.

Mahon, A. D., Marjerrison, A. D., Lee, J. D., Woodruff, M. E., & Hanna, L. E. (2010). Evaluating the prediction of maximal heart rate in children and adolescents. *Research Quarterly for Exercise and Sport, 81*, 466–471. https://doi.org/10.1080/02701367.2010.10599707

Kohl, H. W., III, & Cook, H. D. (Eds.). (2013). *Educating the student body: Taking physical activity and physical education to school*. Washington, DC: The National Academies Press. https://doi.org/10.17226/18314

National Association for the Education of Young Children & Fred Rogers Center for Early Learning and Children's Media at Saint Vincent College. (2012). *Technology and interactive media as tools in early childhood programs serving children from birth to age 8* [Position statement]. Retrieved from https://www.naeyc.org/sites/default/files/globally-shared/downloads/PDFs/resources/topics/PS_technology_WEB.pdf

Office of Disease Prevention and Health Promotion. (2014). Educational and community-based programs. Retrieved from https://www.healthypeople.gov/2020/topics-objectives/topic/educational-and-community-based-programs

Pescatello, L. (2014). *ACSM's guidelines for exercise testing and prescription* (9th ed.). Philadelphia, PA: Walters Kluwer/Lippincott Williams & Wilkins Health.

Pettit, B. L. (2016). *Using Polar GoFit technology to increase children's moderate to vigorous physical activity time in physical education* (Doctoral dissertation). Retrieved from https://minds.wisconsin.edu/handle/1793/75321

Rabbia, F., Gross, T., Genova, G. C., Conterno, A., De Vito, B., Mulatero, P., . . . Veglio, F. (2002). Assessing resting heart rate in adolescents: Determinants and correlates. *Journal of Human Hypertension, 16*, 327–332. https://doi.org/10.1038/sj.jhh.1001398

Rhodes, R. E., Warburton, D. E., & Bredin, S. S. (2009). Predicting the effect of interactive video bikes on exercise adherence: An efficacy trial. *Psychology, Health, and Medicine, 14*, 631–640. https://doi.org/10.1080/13548500903281088

Rideout, V. J., Foehr, U., & Roberts, D. (2010). *Generation M^2: Media in the lives of 8- to 18-year-olds*. Menlo Park, CA: Henry J. Kaiser Foundation Family Foundation.

Tanaka, H., Monahan, K. D., & Seals, D. R. (2001). Age-predicted maximal heart rate revisited. *Journal of the American College of Cardiology, 37*(1), 153–156. https://doi.org/10.1016/s0735-1097(00)01054-8

Vasconcellos, F., Seabra, A., Katzmarzyk, P. T., Kraemer-Aguiar, L. G., Bouskela, E., & Farinatti, P. (2014). Physical activity in overweight and obese adolescents: Systematic review of the effects on physical fitness components and cardiovascular risk factors. *Sports Medicine, 55*, 1139–1152. https://doi.org/10.1007/s40279-014-0193-7

Waterhouse, J., Hudson, P., & Edwards, B. (2010). Effects of music tempo upon submaximal cycling performance. *Scandinavian Journal of Medicine and Science in Sports, 20*, 662–669. https://doi.org/10.1111/j.1600-0838.2009.00948.x

World Health Organization. (2017). *Global strategy on diet, physical activity, and health: Physical activity and young people.* Retrieved from http://www.who.int/dietphysicalactivity/factsheet_young_people/en/

Yim, J., & Graham, T. (2007). Using games to increase exercise motivation. In *Future Play '07: Proceedings of the 2007 Conference on Future Play* (pp. 166–173). New York, NY: ACM. https://doi.org/10.1145/1328202.1328232