Acoustics in Physical Education Settings:

The Learning Roadblocks

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The purpose of this study was to measure noise levels in elementary, middle, and high school physical education settings and compare them to the American Speech-Language-Hearing Association (ASHA) guidelines and the American National Standards Institute (ANSI) standards for acoustics in educational settings.

Mean unoccupied noise levels for 22 physical education settings were 52.0 dBA (range = 38.6 to 61.3 dB) on the A-weighted scale, which is higher than the ASHA and ANSI recommendations. Only one of the physical education settings exhibited noise levels within the recommended ASHA criteria of 40 dBA and none of the settings met the standards set by ANSI. Two-tailed t-tests were used for comparison of the overall mean noise levels in outdoor, gymnasium, and covered physical education settings to the standards established by ANSI and ASHA. The findings showed that all of the settings were significantly ($p < .05$) higher than the established standards. Strategies for reducing high noise levels in physical education settings are discussed.

Schools are viewed as places of learning where speaking and listening are the primary modes of communication and the most common primary goal of the classroom educational process is to share experiences, exchange ideas, and transmit knowledge (American Speech-Language-Hearing Association, 1995). Educators are constantly searching for strategies which will improve the educational process, however, the primary process of speaking and listening is often overlooked (Ryan, 2009). The audibility of teachers and peers is an essential factor in determining the academic performance of school children (Flexer, Millin, & Brown, 1990). However, acoustic conditions in most classrooms are less than optimal (McSporran, Butterworth & Rowson, 1997) and have been viewed as "hostile listening environments" that undermine the learning of children in school (Massie, Theodoros, McPherson, & Smaldino, 2004, p. 47). While research has shown that typical classrooms may be acoustically challenging (Berg, Blair, & Benson, 1996; Crandell, 1993; Sanders, 1965), the acoustic conditions in physical education settings are without a doubt more challenging than in the typical classroom.

In a gymnasium, outside teaching stations and in a typical classroom, speech is transmitted from teacher to students through a combination of direct and reflected sound (Ryan, 2010). The level of direct sound falls by 6 dB for every doubling of distance from the talker (Boothroyd, 2006). If a teacher's speech level is 72 dB, this level will drop to 66dB at two feet, 60dB at four feet, 54 dB at eight feet, and so on. A student's location in a gymnasium establishes the specific combination of direct and reflected sound a student hears and the distance between the teacher and students determines the amount of acoustical energy in a direct and reflective sound wave reaching the students (Ryan, 2009). The distance sound travels in gymnasiums and other physical education settings would on average be much larger than the typical classroom. Speech energy the students receive through direct and reflected sound waves is more intense than when only direct sound waves reach the listener. Thus, sound energy in an environment with some amount of reflection or reverberation could improve the sound level. However, too much reflection can have a negative effect on speech understanding. A gymnasium is a difficult listening environment due to its size (increased distance leading to decreased sound levels) and its reflective surfaces

resulting in long reverberation times that can reduce speech understanding (Ryan, 2009). Further, a teacher teaching outside can only rely on direct sound resulting in decreased speech levels.

Undesirable noise levels in an educational setting may also have a harmful effect on hearing. A study by Jiang (1997), found that gymnasiums were as noisy as factories, and elementary school gymnasiums produced average sound measurements as high as 94.4 dB SPL, which is equivalent of the sound produced by a jack hammer (Nash, 2004).

30 dB =	whisper
60 dB =	conversation, dishwasher
80 dB =	alarm clock
90 dB =	jackhammer
100 dB =	snowmobile, chain saw
120 dB =	jet plane takeoff
140 dB =	firearms, air raid siren

Table 1. Average Noise Levels of Everyday Sounds

Physical education teachers also experience vocal fatigue and abuse as a result of having to overcome poor acoustics such as distance, reverberation, and noise (Ryan, 2009). For a teacher to provide speech at levels that reach the maximum intelligibility for children, they should be within approximately 6 feet from the students (Crandell & Smaldino, 1994). Achieving this distance is difficult in a typical classroom setting, but is practically impossible in physical education settings which may have 30-40 students or more that are often spread out over a large area such as a gymnasium or outdoor field (Ryan & Yerg, 2001).

Numerous studies have been conducted to document the deleterious effects (e.g. learning problems, off-task behavior) of excessive classroom noise (Crandell & Bess, 1987; Crandell & Smaldino, 2000; Johnson, 2000; Smaldino & Flexer, 1991). As a result of many of these studies, in 1995 the American Speech-Language-Hearing Association (ASHA) published "Position Statement and Guidelines for Acoustics in Educational Settings," that called for background noise levels in classrooms not to exceed 30 dBA. This specification was reaffirmed in 2002 when the American National Standards Institute (ANSI) published "ANSI S12.60-2002 Acoustical Performance Criteria, Design Requirements and Guidelines for Schools" (ANSI, 2002), that, based on room size, recommends that background noise level not to exceed 35 dBA. However, ANSI defines large areas including gymnasiums as "ancillary learning spaces" and recommends that the maximum background noise level in those locations not to exceed 40 dBA (ANSI, 2002).

Regardless of the number of classroom studies and the position statement by the ASHA, the one area that would benefit the most appears to be left out by researchers. Physical education teachers often teach in a different environment than the "typical" classroom, however, that environment is their classroom. To date, researchers in physical education have sparingly focused on the way acoustics affect physical education teachers and student behavior. Prior to investigating behaviors related to acoustics in physical education settings, an understanding of the baseline levels of noise must be established. Baseline data would allow a comparison to the ASHA guidelines (30 dBA) and ANSI standards (40 dBA) with the goal of better understanding and improvement of acoustic in physical education settings. Therefore, the focus of this research effort was to measure noise levels in elementary, middle, and high school physical education settings and compare them to the ASHA guidelines and ANSI standards.

Method

Physical education environments. Acoustic environments were measured in unoccupied indoor and outdoor settings in 12 elementary, 4 middle, and 6 high schools in Northwest Florida. Nine outdoor, 7 gymnasium, and 6 covered area settings were evaluated. Outdoor physical education areas included soccer, softball, and football fields and paved basketball and tennis courts. Covered areas are commonly used in elementary settings in the Southeast and have open sides and floors made of concrete.

Noise Measurements. Using the protocols outlined by Crandell, Smaldino, and Flexer (2005, pp. 126-127), ambient noise levels were recorded for each physical education setting. A NOISHCDPC Sound Decibel Digital Meter which met American National Standard Specification for Sound Level Meters (ANSI S1.4-1983), set on the 'A' weighted scale and on slow response, was used to record the noise levels for each setting. Ambient noise levels in unoccupied classrooms provide a baseline measure of the basic acoustics of the classroom by itself.

Results

Mean unoccupied noise levels for the 22 physical education settings were 52.0 dBA (range= 38.6 to 61.3 dBA). Comparing the three different physical education settings produced mean scores of 50.5 dBA (SD 2.16) for outdoors, 50.6 dBA (SD 6.37) for gymnasiums, and 56.1 dBA (SD 4.05) for covered areas. Individual physical education settings noise levels, on the A-weighting scale, are shown in Figure 1.

The solid line indicates the accepted acoustical guidelines by ASHA and the dotted line represents the acoustical standards set by ANSI. It should be noted that only one of the physical education settings in the figure exhibited noise levels within the recommended ANSI criteria of 40 dBA and none of the settings met the standards set by ASHA (30 dBA). The mean noise levels by school type were 53.3 dBA (SD 4.39) for elementary, 47.6 dBA (SD 6.79) for middle school, and 52.5 dBA (SD 3.01) for high schools. Two-tailed t-tests were used for comparison of the overall mean noise levels in outdoor, gymnasium, and covered physical education settings to the standards established by ANSI and ASHA. The findings showed that all of the settings were significantly ($p < .05$) higher than the established standards.

Discussion and Conclusion

The purpose of this study was to measure noise levels in elementary, middle, and high school physical education settings and compare them to ASHA guidelines and ANSI

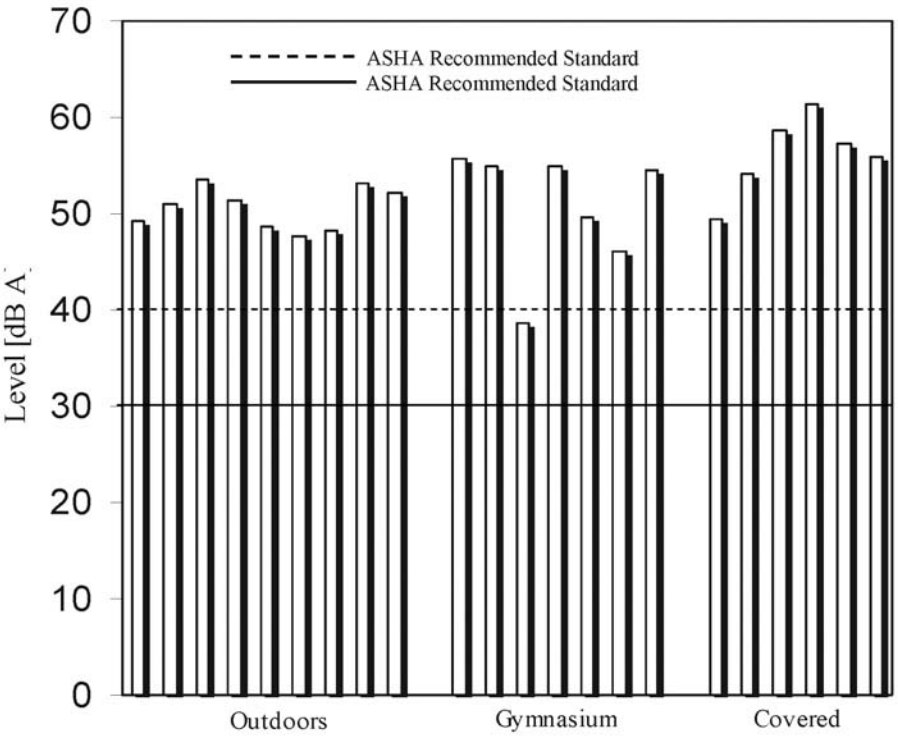

Figure 1. Background Noise Levels in Unoccupied Outdoor, Gymnasium, and Covered Physical Education Settings in dB(A) and ASHA and ASNI Recommended Standards.

standards for acoustics in educational settings. Only 1 of the 22 physical education settings studied had background noise levels at or below 40 dB (A). The one gymnasium that met the allowable noise levels was built within the past ten years and had carpeting on the floor and was the only setting with any type of acoustic treatment. Overall, there was a wide range of background noise levels, ranging from 38.6 to 61.3 dB (A). These results indicate that the physical education settings investigated here exhibit ambient noise levels at 10 to 15 dB higher than recommended levels. These findings are similar to acoustical conditions measured in classrooms in prior studies (Crandell & Smaldino; 1994; Knecht et al., 2002).

In light of the acoustics standards and prior research, these results are discouraging if not alarming. This finding also suggests that the background noise in physical education settings is likely detrimental to student learning. Poor physical education acoustics have been a long-standing problem in schools. In part, this is probably due to the complexity of the factors involved and the issues underlying these factors. Unfortunately, organizations like ANSI and ASHA which

Blue Angel Elementary School Covered Activity Area, Pensacola, FL

Blue Angel Elementary School Gymnasium, Pensacola, FL

are leaders in research and establishing acoustic policy have overlooked the issues related to noise in physical education. Physical education has established national standards (NASPE, 2004), best known practices (COPEC, 2000), and is recognized as a subject area that is vital to the development of the whole child. To label the primary educational functions of physical educators as "informal" is devaluing the fitness, health and well-being of our students and enhancing the acoustical issues in physical education. In the future, ANSI, ASHA and the Council of Educational Facility Planners International (CEFPI) need to seek cross-discipline research that includes physical education teachers. This type of collaboration would hopefully start the process needed to better understand methodologies and philosophies of all groups with the goal of improving acoustics in physical education settings.

The noise levels measured in the present study are limited due to the number of school settings used and only reflect physical education classrooms in the southeastern United States. Data on signal-to-noise ratios, reverberation times, and noise produced during activity time are needed to further understand the complexity of the noise issues in physical education settings. Future efforts to examine the effects of sound field amplification feedback in the area of physical education may provide added insight into effective teaching strategies.

There does not seem to be a simple way to identify or treat all the problems of poor physical education acoustics. However, these findings indicate an immediate need for administrators to support future research and determine the most appropriate, cost-effective procedures to reduce noise in existing physical education settings. As school districts enter into future school construction projects, a combination of several strategies seems necessary to meet the recommended guidelines set by ASHA and ANSI. Audiologists, speech-language pathologists, and physical education teachers can collaborate to make school administrators aware of the common problems and current and upcoming standards. Unfortunately, it appears that discussion among such disciplines prior to building construction is rare (Elliot, 1982). Since guidelines for this collaboration do not exist, it is appropriate to first consider the complementary roles of audiologists and acoustic consultants by examining a tailored description of physical education teachers and their students. This collaborative approach would be ideal to allow new schools to meet the recommended guidelines so that all students, including physical education students, can hear and learn at their maximum potential. ■

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REFERENCES

American National Standards Institute. 2002. *Acoustical performance criteria, design requirements, and guidelines for schools* (ANSI S12.60-2002). New York: ANSI.

American Speech-Language-Hearing Association. 1995. *Position statement and guidelines for acoustics in educational settings.* ASHA 37, no. suppl. 14: 15–20.

Berg, F., J. Blair, and P. Benson. 1996. Classroom acoustics: The problem, impact, and solution. *Language, Speech and Hearing Services in Schools 27,* 16–20.

Boothroyd, A. 2006. Characteristics of listening environments: Benefits of binaural hearing and implications for bilateral management. *International Journal of Audiology 45,* 12–19.

Council on Physical Education for Children (COPEC). 2000. *Appropriate practices for elementary school physical education.* Reston, VA: NASPE Publications.

Crandell, C. 1993. Noise effects on the speech recognition of children with minimal hearing loss. *Ear and Hearing 7,* 210–17.

Crandell, C., and F. Bess. 1987. Developmental changes in speech recognition in noise and reverberation. *American Speech-Language-Hearing Association 29,* 170.

Crandell, C., and J.J. Smaldino. 1994. An update of classroom acoustics for children with hearing impairment. *The Volta Review 96,* 291–306.

Crandell, C., and J.J. Smaldino. 2000. Classroom acoustics for children with normal hearing and with hearing impairment. *Language, Speech, and Hearing Services in Schools 31,* 362–70.

Crandell, C., J.J. Smaldino, and C. Flexer. 2005. Sound-field applications: *Applications to speech perception and classroom acoustics, 2nd ed.* New York: Thomson.

Elliott, L. 1982. Effects of noise on perception of speech by children and certain handicapped individuals. *Sound and Vibration 71,* 9–14.

Flexer, C., J. Millin, and L. Brown. 1990. Children with developmental disabilities: The effect of sound field amplification on word identification. *Language, Speech and Hearing Services in Schools 21,* 177–82.

Jiang, T. 1997. Can noise levels at school gymnasia cause hearing loss: A case study of a physical education teacher. *Paper presented at the Noise-Con 97 Meeting,* 15–17 June, in State College.

Johnson, C.E. 2000. Children's phoneme identification in reverberation and noise. *Journal of Speech, Language, and Hearing Research 43,* 144–57.

Knecht, H.A., P.B. Nelson, G.M. Whitelaw, and L.L. Feth. 2002. Background noise levels and reverberation times in unoccupied classrooms predictions and measurements. *American Journal of Audiology 11,* 65–71.

Massie, R., D. Theodoros, B. McPherson, and J.J. Smaldino. 2004. Sound-field amplification: Enhancing the classroom listening environment for aboriginal and torres strait islander children. *The Australian Journal of Indigenous Education 33,* 47–53.

McSporran, E., Y. Butterworth, and V.J. Rowson. 1997. Sound field amplification and listening behavior in the classroom centre for audiology, education of the deaf and speech pathology. *British Educational Research Journal 23,* (1), 81–96.

National Association for Sport and Physical Education. 2004. Moving into the future: *National standards for physical education.* Reston, VA: National Association for Sport and Physical Education.

Ryan, S. 2009. Can your students hear you? *Florida Journal of Health, Physical Education, Recreation, Dance, & Driver Education 47,* (1), 25–6.

Ryan, S. 2010. Seven ways to improve sound in physical education settings. *Strategies, 23* (5), 27-30.

Ryan, S., and B. Yerg. 2001. The effects of crossgroup feedback on off-task behavior in a physical education setting. *Journal of Teaching Physical Education, 20,* 172–88.

Sanders, D. 1965. Noise conditions in normal school classrooms. *Exceptional Child 31,* 344–53.

Smaldino, J.J., and C. Flexer. 1991. Improving listening in the classroom. *Paper presented at the 1991 Academy of Rehabilitative Audiology Annual Meeting, 7*–10 June, in Breckenridge, CO.