**Knowledge and Beliefs of NCAA Basketball Student-Athletes and Coaches on the Use of Frequency Modulation (FM) Systems by Collegiate Players**

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**Abstract**

**Background:** Research shows that noise levels in a collegiate basketball arena exceeds the NIOSH standard of 85 dBA due to the nature of the environment. Student-athletes with hearing difficulties are disadvantaged as the collegiate basketball environment exhibits high noise levels, distance, and reverberation, all of which contribute to ineffective communication. The 2017-18 NCAA Basketball Rules Handbook includes a section supporting accommodations and modifications for student-athletes with disabilities, however, specific disabilities or accommodations are unlisted.

**Purpose:** The purpose of this study was to examine the knowledge and beliefs of student-athletes and coaches on FM system use by collegiate basketball players. This study aimed to address the following questions: 1) Do NCAA basketball student-athletes and coaches differ in knowledge or beliefs of FM system use by collegiate basketball players? 2) Do knowledge or beliefs of FM system use in NCAA basketball differ between men’s and women’s collegiate basketball?

**Research Design**: This is a quantitative study.

**Study Sample**: Two hundred and fifteen individuals completed the survey. Eighty were coaching staff members and 37 were active players of NCAA women’s basketball. Sixty-eight were coaching staff members and 30 were active players of NCAA men’s basketball.

**Data Collection and Analysis**: Data were collected via an electronic survey on PsychData. Participants answered demographic questions, as well knowledge-based, scenario-based, and rule-based questions primarily related to the use of an FM system in in NCAA basketball. An ANOVA, post-hoc analysis using a Bonferroni correction, and independent samples T-test were performed.

**Results**: The scenario-based questions revealed that men’s players were the least accepting of an FM system. Coaches reported greater agreement than players that an FM system would not fundamentally alter the nature of the game.**Conclusions:** More than 75% of participants incorrectly identified the purpose of an FM system. Coaches were more supportive than student-athletes in using an FM system for a player with hearing loss. However, results of the knowledge-based questions suggest that awareness and education of hearing loss and FM systems is critical for all members affiliated with NCAA basketball should a player request this accommodation.

**Keywords:** FM system, NCAA, NIOSH, OSHA

**Abbreviations:** Frequency modulation system = FM system; NCAA = National Collegiate Athletic Association; NIOSH = National Institute for Occupational Safety and Health; OSHA = Occupational Safety and Health Administration

**Background:**

The NCAA Board of Governors, which is the highest governing body, is a group of volunteers from member institutions that oversee each division. This body consists of presidents and chancellors from each division to discuss important issues. The primary responsibility of the NCAA Board of Governors is upholding and advancing the association’s core values of fairness, safety, and equal opportunity for all student-athletes (Hyland, 2017; Levinson, 2017). The NCAA focuses on providing student-athletes a quality education while allowing them to play a sport that is fair in competition, and employs safety and sportsmanship. The national office also enforces rules, advises and supports member institutions during rule-making processes, and oversees the distribution of money to member institutions. Finally, one of the four NCAA core values is making sure student-athletes from all backgrounds have an opportunity to participate in a sport including those with disabilities.

Studies have suggested that college basketball arenas are capable of exceeding the National Institute for Occupational Safety and Health (NIOSH) recommended standard of 85 dBA (England & Larsen, 2014; Morris, Atieh, & Keller, 2013). In an environment such as a basketball arena or gymnasium, noise levels generated by avid spectators, bands, cheerleaders, student sections, and public address systems present a difficult listening environment especially for players with hearing loss. Hearing in noise is a common difficulty for individuals with hearing loss, and elevated noise levels in a basketball game make it far more challenging for these players to understand their coach and teammates, thus creating communication barriers (Cox and Gilmore, 1990; Gatehouse, 1999; Walden et al., 2009).The combination of excessive noise levels, varying distances, and reverberation in college basketball arenas and gymnasiums present a far more vulnerable listening environment for players with hearing loss. Specific communication strategies (e.g., reducing speaker-listener distance, clear speech, optimizing visual communication) and current features (e.g., directional microphones, digital noise reduction) are largely unfeasible to overcome the background noise, distance, and reverberation in basketball games.

In order to overcome these barriers, an FM system can provide greater enhancement in speech recognition providing a player with hearing difficulties the opportunity to effectively communicate with his or her coach and teammates during warm ups, game time, time outs, as well as in the locker room. Unlike directional microphones and digital noise reduction, FM systems have shown to improve speech recognition in noise by as much as 10 to 20 dB SPL over the unaided listening condition (Crandell & Smaldino, 2001). The noise levels, varying distances in reference to the speaker, and reverberation can be alleviated by an FM system because the player will hear his or her coach at a much closer distance than they may actually appear. Finally, FM system features in hearing aids (e.g., FM + Mic, FM only) and the mixing ratio of cochlear implants can be modified so the player can hear his or her immediate environment and coach simultaneously.

An FM system will provide players with hearing difficulties greater auditory access allowing them to be more involved and aware of his or her coach’s spoken messages. With the inclusion of an FM system, a player with hearing difficulties is given greater auditory access to his or her coach’s requests for upcoming plays to execute. During timeouts, pep bands are often playing generating noise levels loud enough to disrupt speech recognition. Therefore, a coach wearing an FM system in combination with visual cues will allow a player with hearing difficulties to better understand what is being said. Lastly, use of an FM system in the locker room before the game, during halftime, and after the game will allow the player with hearing difficulties to hear his or her coach with reduced listening effort and fatigue. In sum, an FM system can provide far more benefits than communication strategies, directional microphones, and digital noise reduction.

Therefore, this study was completed to examine the knowledge and beliefs of student-athletes and coaches on FM system use by collegiate basketball players. It sought to answer the following questions:

1. Do NCAA basketball student-athletes and coaches differ in knowledge or beliefs of FM system use by collegiate basketball players?
2. Do knowledge or beliefs of FM system use in NCAA basketball differ between men’s and women’s collegiate basketball?

The results from this study held implications for the use of FM systems as an accommodation for student-athletes with disabilities in NCAA basketball. Furthermore, educating student-athletes and coaches on communication barriers faced by players with hearing difficulties in basketball as well as the benefits of FM systems may lead to greater acceptance of FM system usage in NCAA basketball.

**Method:**

Approval for this study was granted by the University of South Dakota Institutional Review Board. Informed consent was obtained for all participants, who were required to be at least 18 years of age. Participation in this study was voluntary.

Advertisement for participation in this study was conducted primarily through electronic mail.  A standard letter was developed and sent to the director of basketball programs (cc’d to coaching staff) of each NCAA member institution. Emails to directors of basketball programs included an explanation of the study, a link to PsychData to complete the survey, and a request to share the email to coaching staff and student-athletes. Participants used personal devices to complete the survey. Through PsychData, participants began the study with a consent form, which led to the survey.

Randomization of teams was used to contact directors of basketball programs of NCAA member institutions that have men’s and women’s basketball programs. Coaching staff were included in the email if addresses were available on the institution’s webpage roster. The e-mail also requested to forward the study to the team’s student-athletes. A list of current NCAA basketball institutions was provided by the official NCAA website. All NCAA basketball institutions belong to a designated conference; thus, numbers were assigned to each conference as a method of random sampling. A number generator was used to acquire a randomized list of conferences within all three divisions. All basketball programs within the selected conferences were invited via e-mail to participate in this study.

**Participants:**

Of the coaching staff participants, 68 individuals (45.95%) identified as being affiliated with men’s basketball, while 80 (54.05%) were affiliated with women’s basketball. Most participants identified being a coaching staff member on a Division I team (47.3%). Of the various coaching positions identified in this survey, the most common responses were assistant coach (n=64), head coach (n=35), and director of basketball operations (n=22). In terms of number of total years coaching in NCAA basketball, 52 participants identified 0-3 and 10+ years apiece.

Of the student-athlete participants, 30 individuals identified as current players of NCAA men’s basketball, while 37 individuals identified with women’s basketball. For men’s programs, 13 (43.3%) identified playing in Division I. For women’s programs, 21 (57%) identified playing in Division III. For year in college, most participants identified being freshmen (35.82%), while only two participants identified being graduate students.

**Data Collection and Analyses:**

Measurements were obtained through PsychData. Participants were asked demographic questions, knowledge-based questions, scenario-based questions, and rule-based questions.  The first section included a demographics questionnaire in the form of multiple choice written by the investigator. The questions for a student-athlete and coaching staff member included age, gender, affiliation with NCAA basketball (i.e., student-athlete, coaching staff), and Division (i.e., I, II, or III). An additional question was tailored to student-athletes addressing current year in college (i.e., freshman, sophomore, junior, senior, graduate student). Additional questions for coaching staff included coaching position (i.e., head coach, associate head coach, assistant coach, other: specify), and total number of years coaching NCAA basketball. The purpose of this questionnaire was to identify any major intervening variables to be considered during data analyses.

The second part of the survey queried participants’ knowledge related to hearing, FM systems, and noise levels in NCAA basketball. These questions were addressed to determine if there was a relationship between knowledge and beliefs on the use of FM systems. Following the knowledge-based questions, participants were provided four scenarios (i.e., practice, locker room, timeout, during the game) in which an FM system would be used by a basketball player. These questions were set up in the form of a Likert scale to allow participants to provide their belief on the appropriateness of the situation. Following this section, participants were asked three rule-based questions in the form of a Likert scale as well. These questions allowed participants to provide their beliefs regarding the use of an FM system in accordance to the NCAA governed rules.

Data were analyzed using the Statistical Package Social Science (SPSS) version 23.0 statistical analysis software package. There were two main effects for this study: the effect of NCAA basketball program (i.e., men’s or women’s basketball program), and the effect of role in collegiate basketball (i.e., student-athlete or coach) on knowledge and beliefs of FM system use in NCAA basketball. There were four independent variables: men’s basketball coaches, women’s basketball coaches, men’s basketball student-athletes, and women’s basketball student-athletes. The dependent variables assessed were knowledge and beliefs of FM system use by collegiate basketball players. These effects were analyzed using an ANOVA to determine if there were differences. If any main effects were found, a post hoc analysis was conducted using a Bonferroni correction to determine the differences. An independent samples T-test was utilized to compare coaches and student-athletes, as well as men’s basketball and women’s basketball programs. An alpha level of .05 was utilized for this study.

**Results:**

Results from the current study were analyzed using an ANOVA to compare all four participant groups, a post hoc analysis with a Bonferroni correction to determine where the differences existed between groups. An independent samples T-test to compare men’s basketball and women’s basketball, as well as coaches and players. Results revealed statistical significance in all three sections (i.e. knowledge question two, knowledge question three, scenario-based question regarding timeout, scenario-based question regarding locker room, and rule-based question regarding fundamentals of the game). Data for comparing between Divisions (i.e., I, II, III) and total years coaching did not indicate statistical significance. Overall, women’s basketball participants were more knowledgeable than men’s basketball participants. Coaches were more accepting than players on the use of an FM system, while men’s players were the least accepting of this accommodation.

Question 1 asked “The following variables are factors that contribute to a difficult listening environment EXCEPT” with the correct answer being d) hearing aids. The following participants correctly answered this question: 15 out of 30 (50%) men’s basketball players, 24 out of 37 (65%) women’s basketball players, 48 out of 68 (71%) men’s basketball coaches, and 51 out of 80 (64%) women’s basketball coaches. When comparing between groups, no statistical significance was noted (p<0.05). However, when considering percent correct, men’s players were the least knowledgeable, and no group had a mean score above 75%.  See Figure 1.

Question 2 asked “What is the purpose of a frequency modulation (FM) system?” with the correct answer being a) the goal of an FM system is to reduce the negative consequences of noise, distance, and reverberation on speech perception by placing a microphone close to the talker’s mouth and transmitting the signal to a receiver worn by an individual. The following participants correctly answered this question: 8 out of 30 (27%) men’s players, 21 out of 37 (56%) women’s players, 49 out of 68 (72%) men’s basketball coaches, and 47 out of 80 (59%) women’s basketball coaches. A post hoc analysis using a Bonferroni correction revealed a difference between men’s players and men’s coaches (p=0.000), and men’s players and women’s coaches (p=0.012).  The difference between men’s players and women’s players was not statistically significant (p=0.066). A T-test comparing coaches and players revealed that players provided more incorrect responses [t(213)=-3.020)]. In sum, men’s players collectively provided more incorrect responses. Like question 1, no group had a mean score above 75%.

Question 3 asked “Research studies have identified the following regarding NCAA basketball arenas/gyms” with the following answer choices: a) NCAA basketball arenas/gyms create a quiet environment and studies have shown that high noise levels do not exist in games, b) factors such as the announcers on the public announcement (PA) system, pep bands, and screaming fans contribute to the high noise levels at an NCAA basketball game, c) NCAA basketball arenas/gyms create a more difficult listening environment due to the presence of background noise, distance, and reverberation, d) B & C. The correct answer was choice d.  The following participants correctly answered this question: 19 out of 30 (63%) men’s players, 33 out of 37 (89%) women’s players, 62 out of 68 (91%) men’s basketball coaches, and 76 out of 80 (95%) women’s basketball coaches. A post hoc analysis using a Bonferroni correction revealed a significant difference between men’s players and women’s players (p=0.004), men’s basketball coaches (p=0.000), and women’s basketball coaches (p=0.000). In other words, men’s players were less knowledgeable. A T-test comparing men’s basketball and women’s basketball participants indicated that men’s program participants were more likely incorrect [t(213)=2.415, p=0.017)]. An additional T-test comparing coaches and players revealed that players provided more incorrect responses [t(213)=-3.384)]. Overall, the high mean scores for women’s players, men’s basketball coaches, and women’s basketball coaches are unsurprising due to the nature of the question.

Following the completion of the knowledge-based questions, participants were asked four scenario-based questions. These questions asked the participant to rate the appropriateness of using an FM system in four common scenarios within basketball: practice, timeout, locker room, and in the game (See Figure 2).  Participants rate appropriateness given the following choices: 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, and 5=strongly agree. For analytical purposes, choices 1 and 2 were merged and coded as “disagree”, and choices 4 and 5 were merged and coded as “agree”. Also, two of the four scenario-based questions (i.e., time, in the game) were phrased with the term “not appropriate”, but the data were flipped to be interpreted as appropriateness rather than inappropriateness.

Participants were asked to rate the appropriateness of using an FM system in practice. The following number of participants agreed that it is appropriate to use an FM system during practice: 20 out of 30 men’s players, 29 out of 37 women’s players, 62 out 68 men’s basketball coaches, and 70 out of 80 women’s basketball coaches. A post hoc analysis using a Bonferroni correct revealed that men’s players differed from men’s basketball coaches (p=0.001) and women’s basketball coaches (p=0.001), but not women’s players (p=0.338).  While all four groups had participants most commonly agree that it is appropriate to use an FM system in practice, men’s players were least likely to consider this rating. A T-test comparing coaches and players revealed that coaches were more accepting of using an FM system in practice [t(213)=3.929].

Participants were asked to rate the appropriateness of using an FM system during a timeout.  The following number of participants agreed that it is appropriate to use an FM system during a timeout: 18 out of 30 men’s players, 21 out of 37 women’s players, 42 out 68 men’s basketball coaches, and 54 out of 80 women’s basketball coaches. No statistical significance was noted between groups or between coaches and players. While all four groups had participants most commonly agree that it is appropriate to use an FM system during a timeout, men’s players were least likely to consider this rating.

Participants were asked to rate the appropriateness of using an FM system in the locker room. The following number of participants agreed that it is appropriate to use an FM system in the locker room: 17 out of 30 men’s players, 28 out of 37 women’s players, 60 out of 68 men’s basketball coaches, and 66 out of 80 women’s basketball coaches. A post hoc analysis using a Bonferroni correction revealed a difference in rating between men’s players and women’s players (p=0.044), men’s basketball coaches (p=0.000), and women’s basketball coaches (p=0.001). A T-test comparing coaches and players revealed that coaches were more accepting of using an FM system in the locker room [t(213)=3.383].

Participants were asked to rate the appropriateness of using an FM system in the game. The following number of participants agreed that it is appropriate to use an FM system in the game: 12 out of 30 men’s players, 20 out of 37 women’s players, 27 out 68 men’s basketball coaches, and 42 out of 80 women’s basketball coaches. No statistical significance was noted between groups or between coaches and players. In comparison to the previous three questions, this scenario had the lowest number of participants, in all groups, who agreed that it is appropriate to use an FM system during a game.

Following the completion of the scenario-based questions, participants were asked three rule-based questions derived from the 2017-18 NCAA Rules and Interpretations Handbook (Hyland 2017; Levinson 2017) (See Figure 3). These questions asked the participant to provide their opinion on whether they believed an FM system complied with these rules. Participants rated their response given the following choices: 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, and 5=strongly agree. For analytical purposes, choices 1 and 2 were merged and coded as “disagree”, and choices 4 and 5 were merged and coded as “agree”. Also, the second rule-based question was phrased suggesting inappropriateness, but the data were flipped to be interpreted on a scale of agreeability.

Participants were asked to rate their belief as to whether using an FM system would compromise the safety of, or increase the risk of injury to, any other basketball student-athlete. The following number of participants agreed that an FM system would not compromise safety or increase the risk of injury to another athlete: 14 out of 30 men’s players, 22 out of 37 women’s players, 49 out 68 men’s basketball coaches, and 51 out of 80 women’s basketball coaches. No statistical significance was noted between groups or between coaches and players.  While all four groups had participants most commonly agree that using an FM system is safe, some participants did not report this. This may suggest unfamiliarity of the device.

Participants were asked to rate their belief as to whether using an FM system would change an essential element that would fundamentally alter the nature of the game. The following number of participants agreed that an FM system would not alter the nature of the game: 8 out of 30 men’s players, 14 out of 37 women’s players, 38 out 68 men’s basketball coaches, and 45 out of 80 women’s basketball coaches. A post hoc analysis using a Bonferroni correction revealed that men’s players differed than women’s coaches (p=0.033) in that men’s players disagreed more.  In other words, men’s players generally indicated to a greater degree that using an FM system would fundamentally alter the nature of the game. A T-test comparing coaches and players revealed that coaches agreed more that it would not fundamentally alter the nature of the game [T(213)=2.356].

Participants were asked to rate their belief as to whether using an FM system would provide the accommodated player an unfair advantage over other competitors. The following number of participants agreed that an FM system would not provide an unfair advantage: 14 out of 30 men’s players, 13 out of 37 women’s players, 40 out 68 men’s basketball coaches, and 36 out of 80 women’s basketball coaches. No statistical significance was noted between groups or between coaches and players. However, when looking at all 215 participants, 52 individuals disagreed with the statement and 60 individuals were neutral. In comparison to the other rule-based questions, this question yielded the highest rate of disagreement collectively.

**Conclusions:**

While a high number of the participants were aware of the high noise levels in college basketball, less than 75% of participants in all four groups did not correctly identify the purpose of an FM system. However, prior to answering the questions related to their beliefs in using an FM system in basketball, they were provided the purpose of an FM system. Overall, coaches were more supportive than student-athletes in a student with a hearing loss using an FM system. However, results of the knowledge questions suggest that awareness and education of hearing loss and FM systems is critical for all members affiliated with NCAA basketball.

It should be noted that a recent publication addressed accommodations for athletes at the collegiate level (Rauterkus, Palmer, Toole, Levine, & Jorgensen, 2017). *Time Out! I Didn’t Hear You*, College Edition, was written by audiologists and audiology students and is a comprehensive guide that supports the use of accommodations for student-athletes with hearing loss. The use of a remote microphone, similar concept to an FM system, is suggested in this guide if “normal hearing players can hear the coach” (pp. 62). This statement may create a debate due to the nature of the game. However, players with hearing loss should at least be guaranteed this accommodation in the following situations: during a timeout, in the locker room, and during practice as competition is not in play.

This study should be replicated with a target audience of licensed audiologists and audiology doctoral students. With a stronger knowledge base related to the hearing mechanism, difficulties associated with hearing loss, and the purpose of hearing assistive technology such as an FM system, it is likely that there would be greater support from this population in terms of using an FM system for basketball players with hearing loss. This potential data in combination with the current study’s results could be presented to NCAA compliance officers responsible for reviewing accommodation requests made by student-athletes.

**References**

Crandell C, & Smaldino, J. (2001) Improving classroom acoustics: Utilizing hearing-assistive technology and communication strategies in the educational setting. *Volta Rev*, 101, 47–62.

Cox, R.M., & Gilmore, C. (1990). Development of the profile of hearing aid performance (PHAP). *J Speech Hear Res, 33*(2), 343-357.

England, B., & Larsen J.B. (2014). Noise levels among spectators at an intercollegiate sporting event. *American Journal of Audiology, 23*(1), 71-78. doi:10.1044/1059-0889(2013/12-0071)

Gatehouse, S. (1999). Glasgow hearing aid benefit profile: Derivation and validation of a client-centered outcome measure for hearing aid services. *J Am Acad Audiol, 10,* 80-103.

Hyland, A. (2017). *Men’s Basketball: 2017-18 Rules.* D. Calandro (Ed.). Retrieved from https://www.ncaapublications.com/p-4517-2017-18-ncaa-mens-basketball-rules-and-interpretations.aspx

Levinson, J. (2017). *Women’s Basketball: 2017-18 Rules.* R. Seewald (Ed.). Retrieved from https://www.ncaapublications.com/p-4518-2017-18-and-2018-19-ncaa-womens-basketball-rules-and-interpretations.aspx

Morris, G.A., Atieh, B.H., & Keller, R.J. (2013). Noise Exposures: Assessing an NCAA basketball arena on game day. *Professional Safety, 58*(8), 35-37.

Rauterkus, G., Palmer, C.V., Toole, K., Levin, B., & Jorgensen, L.E. (2017). *Time out! I Didn’t Hear You. Retrieved from https://pitt.app.box.com/v/TimeOut*

Walden, T.C., Walden, B.E., Summers, V., & Grant, K.W. (2009). A naturalistic approach to assessing hearing aid candidacy and motivating hearing aid use. *J Am Acad Audiol, 20*(10), 607-620.

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*Figure 1*. Percent correct for each question plotted as a function of participant group.



*Figure 2*. Percent of response plotted as a function of participant group. Participants were asked to rate appropriateness of using an FM system during practice, during a timeout, in the locker room, and in the game. MP = men’s players, WP = women’s players, MC = men’s coaches, WC = women’s coaches.



*Figure 3*. Percent of response plotted as a function of participant group. Participants were asked if using an FM system follows the three rules listed by the NCAA (see following paragraph for specific rules). MP = men’s players, WP = women’s players, MC = men’s coaches, WC = women’s coaches.