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A Behavior Analytic Interpretation of Concussion Reporting in Athletes: How the Field of Behavior Analysis Can Help Make Athletes Safer

Frank R. Cicero, PhD*; Joseph S. Russano, MA*; Nyasia M. Sanchez, MA*; Dawn Maffucci, PhD, ATC, LAT†

*College of Education and Human Services and †School of Health and Medical Sciences, Seton Hall University, South Orange, NJ

Concussion resulting from athletic activities is a frequent occurrence in youth, collegiate, and professional sports. The first step in concussion treatment is usually the self-reporting of concussion symptoms by athletes. Unfortunately, over the past decade, concussion nondisclosure has remained a prominent concern in concussion identification. This review begins with a summary of the prominent theories being used to explain the deficit in concussion reporting (ie, lack of concussion knowledge, negative attitudes toward reporting, and socioecological models). Unfortunately, current literature indicates that these theories may not often lead to effective treatments for reporting behavior. We then present an alternative model of concussion reporting, one based on the theories of behavior analysis. The deficit in concussion reporting by athletes may be explained in a comprehensive yet parsimonious way through the behavior analytic principles of differential reinforcement and punishment. We also discuss directions for potential intervention strategies based on behavioral theory.

Key Words: sports, mild traumatic brain injury, reinforcement, punishment

Key Points

- Proper treatment of sport-related concussion relies on the self-reporting of concussion symptoms by athletes.
- Concussion symptoms self-reported by athletes were noted to be lower in frequency than concussion-causing incidents.
- Current prominent theories proposed to account for concerns with self-reporting have not led to consistently effective interventions.
- The principles and procedures of behavior analysis provide a comprehensive and parsimonious theory for the deficits in self-reporting and may offer a framework for effective intervention.

Concussion resulting from athletic activities, commonly referred to as sport-related concussion (SRC), is a frequent occurrence in youth, collegiate, and professional sports.[1] In basic terms, *concussion* refers to a brain injury resulting from a direct hit to the head or body that causes the brain to move quickly back and forth within the skull.[2,3] Concussion can result in a wide range of both short- and long-term health problems. In their investigation of SRC prevalence in youth athletes $\leq$18 years of age, Bryan et al[4] estimated 1.1 to 1.9 million SRCs were occurring annually in the United States in that population. Given that approximately 39% of SRCs occurred in individuals older than 18, these estimates were consistent with previous estimates of SRC between 1.6 and 3.8 million annually in the United States as reported in a 1991 National Health Interview Survey.[4] Risks varied by sport; a recent investigation indicated that football and ice hockey had the highest lifetime SRC diagnosis rates in male sports; gymnastics, soccer, and swimming showed the highest rates in female sports.[5] Although the reported rates seemed high, the overall concern was even more problematic because many incidents of SRC went unreported by athletes and were therefore undiagnosed and potentially untreated.[4] Underreporting makes it difficult to establish true occurrence rates in both youth sports[6] and collegiate sports.[7] We know rates of SRC nondisclosure are high, yet accurate rates are difficult to determine because data are based on athlete self-reporting of past events. Therefore, the results of studies looking at SRC nondisclosure vary. In their investigation of SRC reporting in high school athletes, Register-Mihalik et al[8] found that 41 of 84 (48%) potential concussion episodes went unreported to a coach or medical professional. Kerr et al[9] examined SRC reporting in former collegiate athletes and found that 71 of 214 athletes (33.2%) reported at least 1 SRC nondisclosure in their athletic career. Nondisclosure was highest among former men's football players (68% of the sample), followed by women's soccer (42% of the sample), men's lacrosse (36% of the sample), and men's wrestling (36% of the sample). In their research on university athletes across several sports, Delaney et al[10] observed that more than 78% of 469 athletes interviewed had not sought medical attention when an SRC occurred. In a recent investigation of nondisclosure in high school athletes, Post et al[11] noted that 22.4% of participants

reported not having disclosed possible concussion episodes. Although this percentage seemed relatively low, it represented the behavior of more than 659 student-athletes of their total sample of 2998.[11]

Responding quickly and correctly to an SRC is of utmost importance to prevent further injury or even death.[12] Immediate removal from play after a possible concussion incident is necessary because continued physical activity can result in a longer recovery period, increased risk for repeated concussions, and an overall poorer outcome.[7,13] Further, the majority of SRC symptoms are not noticeable to an outside observer.[14] Symptoms such as difficulty in clear thought, blurry vision, sensitivity to light and noise, and fatigue are only experienced internally by the athlete.[15] Affected athletes must self-recognize the presence of SRC symptoms and immediately report the incident to an appropriate person.[16] Communicating a possible SRC is critical to obtaining a correct diagnosis and implementing effective treatment.[15] Unfortunately, although some progress has been made in the treatment of SRCs, little improvement has been shown in increasing athlete self-reporting.[1]

To protect youth athletes, all 50 states currently have laws in place mandating concussion education for athletes as well as coaches.[12] The Lystedt Law requires the immediate removal from play of youth athletes with suspected SRCs and clearance by a health care professional before return to play.[7] Once again, however, the effect of these laws relies on athletes' self-reporting of SRC symptoms. This leads to 2 important questions. Why don't athletes, including youth-, collegiate-, and professional-level players, report SRC incidents and symptoms when they occur, and how do we increase reporting when needed? Craig et al[17] conducted a systematic review of the barriers to reporting SRC by athletes. Their results indicated that common barriers were not realizing the severity of the injury, not identifying the symptoms as those of concussion, not wanting to be removed from play, and not wanting to let teammates down. A review of the literature reveals that several themes were commonly presented and discussed as explanations of athletes' unwillingness to self-report SRC symptoms: lack of concussion knowledge or education, athletes' attitudes toward concussion and reporting, attitudes of peers and coaches, and influences of the broader sports culture.[15] In this review, we will briefly evaluate the literature across these themes and then present an alternate explanation rooted in the theories of behavior analysis for the lack of reporting. We hope that readers will find benefit and practicality in the theoretical logic of behavioral interpretation and be able to implement concepts of the practice into their treatment protocol with the ultimate goal of improving athlete reporting.

EDUCATIONAL INTERVENTIONS

It logically may be concluded that accurate knowledge of concussion signs and symptoms, in addition to knowledge of the importance of reporting, are necessary and sufficient prerequisites to athlete reporting. Research indicated that athletes often did not recognize the full range of symptoms of concussion[6,18,19] and therefore may have missed their own concussion symptoms.[8] It follows that increasing the knowledge of concussion symptoms would increase identification of those symptoms by athletes. Similarly, increasing knowledge of the importance of reporting on future health would increase reporting of symptoms when they occur. It is no wonder that interventions focused on education about concussion symptoms, associated risks, and the importance of reporting are the most commonly cited interventions for the promotion of SRC reporting.[15]

Traditional concussion education programs often consist of various instructional components, including videos, fact sheets, and presentations by health care professionals.[7] Two examples of structured concussion education programs geared to youth athletes are the Centers for Disease Control and Prevention's "Heads Up: Concussion in Youth Sports Initiative" and the "Sports Legacy Institute's Community Educators (SLICE) Program."[12] As another example, Hickling et al[2] designed a youth concussion education program, the "Youth Concussion Awareness Network (You-CAN)," for promoting concussion education among Canadian high school athletes. The program included the creation of a concussion council, which was a committee of high school students and school staff members tasked with designing and initiating a week-long concussion safety and awareness campaign. The emphasis on having peer leaders provide the education in combination with school staff resulted in increased intent of school athletes to report SRC.[2]

The question arises, however, of whether these education-based programs resulted in an improvement in the rates of concussion reporting among athletes. In their systematic review of SRC-reporting literature, Craig et al[17] concluded that educational programs were effective in increasing SRC knowledge but had few effects on reporting behavior. For example, after participating in the SLICE program, student-athletes showed an increase of 34% in concussion-related-knowledge quiz scores.[20] Yet knowledge does not directly translate into reporting behavior.[8] Therefore it is incorrect to assume that because athletes showed an increase in their concussion-related knowledge, they would automatically show an increased rate of concussion reporting. Research in the broader field of injury prevention in sports also demonstrated opposition to this assumption that increased knowledge would increase reporting rates.[14] In a study of 231 Gaelic Games athletes, Leahy et al[13] found that 64% of participants continued to play in games while experiencing symptoms of SRC. Regarding concussion-related knowledge, almost 30% of participants did not report a suspected SRC despite their recognition of the signs, symptoms, and consequences.[13] In general, research on concussion-related education programs indicated that they were not overly effective in increasing SRC reporting by athletes when implemented in isolation.[16,21] In summary, programs designed solely to increase concussion-related knowledge seemed to be necessary but were not sufficient interventions to improve SRC reporting by athletes.

ATTITUDES ON REPORTING AND INTENTIONS TO REPORT

Merely providing education about concussion signs, symptoms, and consequences is a 1-dimensional intervention that does not take into account individual attitudes about SRC reporting.[15] The theory of planned behavior

postulates that athlete reporting of SRC symptoms is influenced by a combination of knowledge, attitudes, subjective norms, and perceived behavioral control.[13] An athlete's beliefs about the consequences of a behavior make up his or her attitudes regarding that behavior.[22] An athlete's beliefs regarding others' expectations of a behavior comprise the subjective norms concerning that behavior.[22] Finally, an athlete's beliefs about the ability to perform a behavior define perceived control of that behavior.[22] A related theory is the integrated behavioral model. Similar to the theory of planned behavior, the integrated behavioral model predicts behavioral intention through a combination of a person's perceived norms, attitudes, and personal efficacy.[23] Regarding SRC reporting by athletes, the theory would postulate that an athlete would be more likely to report symptoms of SRC if it was believed that others would report symptoms as well. Intention to report would also increase if an athlete believed that key stakeholders (ie, teammates, coaches, fans) approved of the behavior of reporting SRC symptoms and would expect an athlete to do so when symptoms were experienced. Finally, the intent to report was hypothesized to increase when a person felt a sense of self-efficacy to behave.[23] Despite the attractiveness of these theories, attitudes and expectations might not have much influence on SRC reporting. In their study of the reporting intentions of 40 high school football players, Carpenter et al[22] found that self-efficacy for reporting was the only attribute that correlated with intention to report. Subjective norms and attitudes about reporting had no correlation with intention. A significant concern with much of the research on the effects of attitudes on SRC reporting was that intention to report was used as a dependent variable in place of actual reporting behavior. In these models, the intention was interpreted as self-instruction for an action and was seen as a reflection of a person's motivation for that action. Behavioral intention was said to directly precede and predict action.[14] The difficulty was that research did not consistently support this association. Register-Mihalik et al[8] determined that reporting behavior could not be reliably predicted by reports of intention, and Kroshus et al[24] stated that the intention to report could only account for a small fraction of the variability in actual reporting behavior. Using the intention to report SRCs as a measure of the effects of attitudes on actual reporting behavior seems flawed and misleading.

SOCIOECOLOGICAL MODELS

The most comprehensive theories accounting for deficits in SRC reporting by athletes are the socioecological models. These models postulate that concussion reporting is influenced on multiple levels by many factors, both internal and external to the individual.[15] The individual athlete is seen as 1 factor within the context of relationships, community influences, and society at large.[1] One example of these models is the Brofenbrenner socioecological model. This model

> posits that human behavior is a function of synergistic and reciprocal influences between the individual and the settings in which he or she operates (microsystem), the interaction among those settings (mesosystem), the environments that indirectly affect the settings (exosystem), and cultural ideologies (macrosystem).[25]

Most interventions for increasing SRC reporting only focused on changing variables at the individual level (ie, educational programs), ignoring influences at broader levels, and many were unsuccessful in achieving behavior change.[25] Through interviews with stakeholders from 4 National Collegiate Athletic Association (NCAA) Division I collegiate football programs, Lininger et al[25] noted that nearly all interventions designed to increase SRC reporting within those programs focused solely on individual-level factors. According to the authors, the interventions were largely unsuccessful.[25] Being more entrenched in society, factors at the exosystem level (ie, policies of institutions, historical influences) and the macrosystem level (ie, cultural norms, concepts of masculinity) were more difficult to control; however, they are likely to heavily influence actual reporting behavior.[25]

Another socioecological model is the vested interest theory. Similar to the Brofenbrenner socioecological model, the vested interest theory postulates that behavior is influenced on multiple levels from within the individual to the society at large. The focus of the model is on the influences of perceived risk and cultural narratives.[15] The perception of risk is purported to be crucial to the intention to report, and the perception forms through interpersonal communications among key stakeholders in the sports world (ie, coaches, athletic trainers [ATs], teammates, fans) and social influences through ingrained cultural narratives.[15] In their research, Corman et al[15] observed that athletes reported being least influenced by the health risks of SRCs because the risks were perceived as uncertain and in the distant future. Additionally, more immediate influences, such as narratives of success on the field, respect for toughness, perceived pressure by teammates to not report, and perceived coaches' reactions, were seen as encouraging the decision not to report.

Although these socioecological theories seem comprehensive, their reliance on multitiered social constructs seems to make them complex, theoretical, and potentially impractical for the development of treatments for actual behavior change on the playing field. We are not suggesting that the socioecological models are incorrect in their assumptions of social-environmental influences over behavior. Certainly, the environment influences behavior, and, in that respect, the socioecological models should be aligned with effective treatment. It is, however, the framing of these models in high-level constructs rather than in basic behavioral principles that likely makes them less practical as interventions. Taken together, the educational, attitude-based, and socioecological models of SRC reporting interventions have not, as yet, resulted in a solution for the problem of nonreporting by youth, collegiate, or professional athletes.

OBJECTIVE

The purpose of our review is to provide an alternate explanation for the reluctance of athletes to report SRC symptoms. Our explanation is based on the theories and principles of behavior analysis, which provides a conceptually simple paradigm for explaining behavior. We hope that by framing SRC reporting through a behavior analytic

Table. Basic Principles of Behavior Analysis

Principle or Procedure	Definition	Example Specific to SRC Reporting	What Happens to SRC Reporting Behavior If Applied?
Operant behavior	"Behavior that is selected, maintained, and brought under stimulus control as a function of its consequences" (p. 796) [26]	SRC reporting is considered operant behavior because whether or not an athlete decides to report is determined by what he or she thinks will happen as a result of reporting and whether that result is preferred or not preferred	SRC reporting will increase if followed by reinforcement and decrease if followed by punishment.
Positive reinforcement	"A response followed immediately by the presentation of a stimulus change that results in similar responses occurring more often" (p. 797) [26]	An athlete reporting SRC symptoms and immediately receiving praise and social validation or support from peers and coaches, in addition to access to necessary treatment	SRC reporting will increase.
Negative reinforcement	"A contingency in which the occurrence of a response is followed immediately by the termination, reduction, postponement, or avoidance of a stimulus, and which leads to an increase in the future occurrence of similar responses" (p. 796) [26]	If a coach witnesses an athlete sustain a probable SRC and is about to call over the athletic trainer for an assessment, the athlete may deny any symptoms of SRC to avoid the athletic trainer and thereby remain in the game	Denial of SRC symptoms will increase.
Positive punishment	"A response followed immediately by the presentation of a stimulus that decreases the future frequency of the behavior" (p. 797) [26]	An athlete reporting SRC symptoms, which results in unpreferred peer or coach (or both) interactions, such as teasing and blaming for a game loss	SRC reporting will decrease.
Negative punishment	"A response behavior followed immediately by the removal of a stimulus (or a decrease in the intensity of the stimulus) that results in similar responses occurring less often" (p. 796) [26]	Being withheld from play or participation in team activities immediately after having reported SRC symptoms	SRC reporting will decrease.
Extinction	"The discontinuing of a reinforcement of a previously reinforced behavior (ie, responses no longer produce reinforcement); the primary effect is a decrease in the frequency of the behavior until it reaches a pre-reinforced level or ultimately ceases to occur" (p. 792) [26]	When an athlete reports the presence of concussion symptoms but does not receive praise or support from peers and coaches for reporting it and the concussion never resulted in serious health concerns anyway	SRC reporting will decrease.
Behavioral skills training (BST)	An evidence-based practice used to teach skills through the systematic use of instructions, modeling, rehearsal, and feedback[30]	Role-playing situations in which SRC reporting is desired by providing models, feedback with reinforcement, and repeated opportunities to practice	SRC reporting will increase.

Abbreviation: SRC, sport-related concussion.

lens, the environmental variables accounting for the problem will be revealed. This will then allow for the development of more effective interventions.

Behavior Analytic Theory

As summarized in comprehensive texts such as Cooper et al[26] and Vargas,[27] behavior analysis is a discipline with its roots in the field of behavioral psychology. In its most basic definition, *behavior analysis* is the study of learning and behavior. It accounts for why people engage in the actions that they do and under what circumstances those actions can be expected to occur. It allows us to assess the functions of behavior and the environmental variables that drive it. In this way, behavior analysis provides the foundation for the development of interventions to shape appropriate behavior. Because it relies on a core set of behavioral principles (ie, reinforcement, punishment, extinction), it is a conceptually simple science that accounts for a wide variety of human behavior.[28] A sampling of these core behavioral principles is listed and defined in the Table.

Recent evidence has already supported the use of behavior analytic principles and procedures with behaviors similar to SRC reporting. Domeniconi et al[29] investigated the effects of reinforcement contingencies on truthful versus untruthful responses concerning reading performance in teenagers. By systematically reinforcing accurate correspondence between participants' and experimenters' ratings of reading accuracy, regardless of whether the responses were correct or incorrect, an increase in truthful self-reporting and a decrease in untruthful reporting were achieved as compared with baseline.[29] Behavioral skills training, consisting of modeling, practice with feedback, and contingent reinforcement for correct responding, increased spontaneous reporting by children in situations involving the presence of firearms in the environment[30] and behaviors associated with child abduction lures.[31]

Intention and Education Versus Action

One subject that should be addressed in the SRC-reporting literature is the overreliance on "intention to report" as the target-dependent measure in some studies.[17] Although the theory of planned behavior postulates that a person's stated intentions can be used to predict future behavior,[14] we know from decades of behavior analytic research that what people say they will do shows little correspondence with what they will actually do in a given circumstance.[32] Verbal behavior is not equal to action.[26] In a synthesis of 10 separately published meta-analyses investigating the discrepancies between stated intention and behavior, Sheeran[33] found that stated intention accounted for only a 28% chance that the person would respond in the future across various target behaviors and contexts. Specifically discussing SRC reporting, Register-Mihalik et al[8] concluded that reporting intention may not be a reliable indicator of reporting behavior. Environmental stimuli were likely to play a role in reporting behavior despite the stated intention.[14] It is here that behavior analysis can have an effect. Behavior analysis maintains a focus on the shaping of operant behavior. *Operant behaviors* are those behaviors that are controlled by their consequences. All intentional behaviors (eg, eating, speaking, walking, problem-solving, lying) are considered to be operant and thereby created and maintained by the principles of learning.[26] The act of reporting is operant behavior and cannot be assumed to occur or not occur based on stated intention. If we truly want to assess and improve SRC reporting by athletes, we need to abandon the study of intention as a dependent variable and instead focus on the direct observation of actual SRC reporting in real-life situations.

Similar to the topic of the intention not equating to action is the topic of education not equating to action. Behavioral research indicates that having knowledge of what is expected in a given situation is not a good predictor of how a person will behave when actually in that situation.[34] The environmental variables in a situation, in combination with a person's behavioral history with similar situations, are responsible for the actions that will occur.[34] This lack of correlation between knowledge and behavior was shown across several dependent measures in a series of studies by Ajzen et al.[35] In 1 study, the authors investigated the prediction of alcohol consumption in college students by assessing their knowledge of the consequences of alcohol and found no correlation between the variables. Knowledge of alcohol did not discourage reported intentions to drink or actual drinking behavior when in situations with access to alcohol.[35] This exemplifies the problem with education-only interventions in SRC reporting. As was shown by Leahy et al,[13] Milroy et al,[23] and Register-Mihalik et al,[8] for example, concussion-related knowledge was a piece of the puzzle but not a sufficient variable to increase actual reporting. Having accurate knowledge about a situation did not predict decision-making. A better determinant of action was the information that was held about the potential outcomes of various decisions when in different situations.[35] Relying on education-only programs as a sufficient intervention was therefore not empirically supported. With their reliance on direct behavior shaping through the manipulation of environmental contingencies, the principles of behavior analysis are a perfect adjunct to education programs for the treatment of SRC-reporting deficits in athletes. In other words, combine an SRC education program with a behavioral system designed to reward athlete reporting implemented in actual sporting environments during games and practices.

Punishment for Reporting

Although other variables are also factors, we hypothesized that the primary behavioral contingency preventing SRC reporting was the principle of punishment for responding. In its most basic definition, *punishment* refers to the reduction of future behavior when an instance of behavior is followed by an unpreferred consequence.[26] Punishment can either be *positive*, meaning something aversive is presented upon a behavior (ie, scolding a child), or *negative*, meaning something pleasant is removed upon a behavior (ie, taking away computer time).[26] Both types of punishment are effective in decreasing behavior and can be applied to the topic of SRC reporting. Behavior-consequence contingencies associated with SRC reporting can be readily mapped out. In both youth and NCAA sports in the United States, players must be immediately removed from play after reporting SRC symptoms.[12] Removal from play has unpreferred consequences for both the reporting player and the team as a whole and is one of the most common reasons cited by athletes for not reporting.[17] Removal from play can lead to a discontinuation of immediate enjoyment of the activity, actual or perceived damage to reputations of star athletes, potential loss of current or future games for the team, teasing from peers, lectures from coaches, not playing in future games, and potential loss of scholarships or recruitment opportunities, to list just a few possible consequences. All of these outcomes stemmed from being punished for the response that immediately preceded them, which was the reporting of concussion symptoms. In their study of SRC reporting in NCAA athletes, Milroy et al[23] found that athletes who expected unpleasant consequences from reporting and the potential for few pleasant consequences showed low intent to report. The contingency was countertherapeutic. To avoid punishment, it was in the best interest of athletes to not report. This is the exact opposite of the contingency that would lead to an increase in reporting.

Delayed and Intermittent Consequences

It might seem logical to believe that an athlete would be willing to experience mild short-term punishment (as described earlier) by reporting SRC symptoms to avoid future, serious long-term health consequences of unreported concussions. However, this is not always the case. Research in behavior analysis has consistently shown that a person's behavior was more affected by short-term consequences than by long-term consequences, despite the magnitude of the long-term consequence.[36] For example, Baum[36] presented a behavioral model to account for maintaining cigarette-smoking behavior. His model postulated that individuals continued to smoke to obtain short-term, immediate reinforcers, such as the temporary pleasurable effects of nicotine and social attention, while ignoring the more serious and permanent long-term health effects that are delayed. Based on this model, positive effects on smoking reduction and cessation occurred through the

planned manipulation of immediate rewards for smoking reduction, while reliance on health effects (a long-term consequence) did not show a behavioral change.[37,38] Regarding SRC reporting, Corman et al[15] found that athletes perceived the consequences of serious head injuries as being too far in the future to encourage reporting behavior. Instead, a lack of reporting was driven more by the immediate rewards of not reporting.

Another property of punishment that changed its effect on behavior was the consistency of its implementation. Basic and applied literature in behavior analysis indicated that punishment was more effective in changing behavior when it was delivered on a continuous schedule (after every occurrence of a target response) than on an intermittent schedule (after some occurrences of a target response but not every one).[26,27] People were likely to refrain from engaging in a behavior when there was certainty about it leading to an unpreferred outcome. However, when the outcome was uncertain, people were more likely to take chances. Unfortunately for the behavior of SRC reporting, the contingencies for short-term punishment were much more consistent and certain than the long-term contingencies of not reporting. With the laws dictating that athletes who reported SRC symptoms be immediately removed from play and not allowed to return to play until medical clearance was obtained, the certainty that SRC reporting behavior would result in an immediate unpreferred consequence was 100% for most athletes. Moreover, long-term, serious health problems resulting from nonreporting were not definite outcomes from any single SRC episode. Therefore, in terms of the effects of punishment on behavior, a behavior that was followed by punishment on a continuous schedule (ie, SRC reporting) was more likely to decrease than a behavior followed by punishment on an intermittent schedule (ie, playing through the injury). This relationship between certain and uncertain consequences of behavior applied in at least 1 study specifically focusing on SRC nondisclosure.[15]

Reinforcement for Not Reporting

Reinforcement is perhaps the most basic and primary principle in behavior analysis. The principle states that a behavior will increase in some future dimension if it is followed by a preferred outcome; in the absence of reinforcement, a behavior will no longer increase and may even decrease in the future.[26] As we have already discussed, the target behavior of SRC reporting is consistently followed by immediate unpreferred consequences. Alternatively, the absence of reporting is followed by immediate preferred outcomes, such as continuing to play in games or practices, helping the team win a game, participating in after-sport activities, and continued peer camaraderie. The outcome of this contingency is obvious. Reporting will never increase in frequency if the absence of reporting results in reinforcement.

BEHAVIORAL INTERVENTIONS

After a review of the current literature on SRC reporting, it was apparent that educational, attitude-based, and socioecological theories were prominent explanations for the lack of reporting in athletes. Unfortunately, these strategies have not resulted in consistently effective intervention strategies.[14,21,25] The behavioral model, as presented in this review, has the advantage of being founded on basic behavioral principles that are empirically supported specifically for the promotion of behavior change (refer to Table). Although we are not proposing that the other theories and models are incorrect, we are suggesting that their reliance on hypothetical constructs, indirect dependent variables, and broad sociological models makes them impractical to test and intervention results difficult to measure. The behavioral principles of reinforcement and punishment, when shaped into correct contingencies, may offer a more direct and applicable model for intervention.

Although potentially difficult to put into practice, the concept of a behavioral intervention to increase SRC reporting by athletes is conceptually simple: design and initiate behavior-consequence contingencies such that the act of reporting is reinforced more than its absence and the absence of reporting is punished more than the act of reporting. If set up as described, SRC reporting as a behavior will potentially increase under those conditions in which it was reinforced. We need to emphasize the reinforcement of reporting in the short term, rather than focusing on the knowledge of long-term consequences.

The presence of an immediate preferred consequence for reporting will increase reporting more than the promise of ensuring future health, but what could be the preferred consequence for an athlete directly after reporting? This presents a challenge. For good reason, laws dictate that players be removed from play after reporting. Despite a valid rationale for the law, punishment was built into the system. Reporting was met with contingent punishment, thereby decreasing its future likelihood of occurrence. The punishment contingency cannot be removed; however, a work-around might be found by increasing the rewards associated with reporting. How such a program would work and what those rewards could be would be up to the individual financial means, culture, and possibilities of the school, program, or team. Each athletic program would need to develop reinforcers based on the individual sport or even the individual athlete. Because the reinforcement needs to be strong enough to overcome the hesitation to report, trying to generalize potential reinforcers here would not be fruitful. Although it is tempting to present examples, this level of motivation needs to come from within, and as such, is highly individualized. It would be up to the specific organization to determine what is appealing and practical enough to encourage SRC reporting. The goal is that if access to rewarding opportunities is potentially more rewarding than the temporary removal from play is punishing, the athletes will likely increase reporting behavior to access the rewards despite having to also receive punishment. Another benefit of a program based on the principle of reinforcement is to decrease the aura of the "punisher." Athletic trainers often fall into this undesirable role as a result of their medical position. If the punishing aspect of SRC reporting is decreased, then the punisher persona will likely decrease as well. The difference between reinforcement and punishment for reporting can be further moderated by reducing the magnitude of the punishment. Once again, the punishment of being removed from play cannot be avoided to ensure responsible injury management and abide by laws that are in place to protect athlete health; yet the consequences of removal potentially

can be modified to lessen the aversive effect of reporting. For example, even during the athlete's removal from play for a period of time, coaches and other stakeholders can ensure that the athlete continues to be included in all athletic social events and remains part of the team's identity and, to the extent possible, that activities such as observations by scouts are rescheduled as needed.

By understanding the reinforcing and punishing contingencies at play in individual situations, stakeholders such as coaches, ATs, team administrators, and parents can make individualized decisions that promote SRC reporting by athletes. Implementing these strategies will require the shaping of stakeholder behavior. As with athletes, what is required is a change in behavior of the stakeholder, not in attitude or intention. It would be logical to start with stakeholder education about the principles of behavior analysis and how SRC reporting is affected. This can be added to a preexisting education program designed to increase stakeholder knowledge of concussion signs, symptoms, and prevention. However, as previously discussed, knowledge is a necessary variable, but it is not sufficient when it comes to changing behavior. Behavior will only change in the desired direction when the contingencies of a given situation support new behavior over old. Therefore, stakeholder behavior that promotes honest SRC reporting (ie, asking athletes how they feel after a head bump, orally rewarding an athlete for reporting in front of teammates following reporting with some tangible reinforcer such as discussed earlier, refraining from any request to have athletes play through symptoms) must result in reinforcement for the stakeholder. As are athletes, coaches are often met with punishment when an athlete reports symptoms of SRC. For example, star athletes may have to be removed from play, resulting in game losses, the potential tarnishing of a coach's reputation, missed opportunities for the coach's promotion, or even nonrenewal of coaching contracts. To increase coaching behavior that promotes SRC reporting by athletes, punishment of the coach for athlete reporting should be removed or at least the magnitude of the punishment be reduced so that the power of newly initiated contingent reinforcers (commendations from supervisors and administrators, increased funding for the team, opportunities for specialized training for the team, etc) will be increased by comparison.

CONCLUSIONS

Although many investigators have examined the potential reasons for an athlete's unwillingness to report SRC symptoms, we believe that the principles and procedures of behavior analysis provide the most theoretically sound and parsimonious explanation, including a framework for the development of intervention strategies rooted in evidence-based practice. This framework can have important implications for the practice of athletic training regarding work done before and during games and practices. With an emphasis on prevention, detection, and immediate treatment of sport-related injuries, ATs could benefit greatly from having an understanding of how the behaviors of athletes are affected by people and actions in the environment. Athletic trainers are often present at the sidelines during athletic events and are relied on to identify possible SRCs, including stepping in to provide assessment and immediate care as needed when a possible SRC is identified. The role of the AT is significantly hampered when athletes do not disclose symptoms of SRC, putting both the health of the athlete and the career of the AT at risk. We presented this work to introduce ATs to a behavioral way of conceptualizing SRC reporting so that we can begin developing and researching effective behavioral strategies to encourage SRC reporting in athletes. To enhance the effectiveness of current intervention practices, ATs can work with athletes and other stakeholders to encourage behavioral contingencies that will increase the likelihood of SRC reporting (ie, directly rewarding SRC reporting in athletes while also rewarding any behaviors of coaches that encourage reporting), in combination with removing or lessening the punishment consequences for SRC reporting, to the extent that is possible given laws, regulations, and good practice. The practical details of treatment will need to be individualized to each athletic environment and situation and are outside the scope of this review, which was to provide a basic theoretical interpretation of SRC nondisclosure based on the principles of behavior analysis. The specifics of how ATs begin using these principles in practice across various sports organizations will, we hope, be the focus of future research.

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Address correspondence to Frank R. Cicero, PhD, College of Education and Human Services, Seton Hall University, 400 South Orange Avenue, South Orange, NJ 07079. Address email to Frank.Cicero@shu.edu.