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RESEARCH METHODS

A Simple Field-Based Tool to Assess Concussion Symptom Reporting Behavior

Heidi A. Wayment, PhD,[1] Debbie I. Craig, PhD, LAT, ATC,[2] Ann H. Huffman, PhD,[1,3] Monica R. Lininger, PhD, LAT, ATC[2]

Introduction: Prevention and treatment of sport-related concussions is an important public health issue and has led to increased research on concussion symptom reporting behavior. To date, there is neither a common understanding of what constitutes concussion symptom reporting behavior nor measures that capture key features of concussion symptom reporting behavior. Concussion symptom reporting behavior can be initiated by an athlete, an athletic trainer, coach, or teammate and can occur in competition, practice, or days after symptoms appear. Follow-up diagnostics range from asking athletes initial questions about their symptoms to conducting rapid standardized sideline assessments to conducting full comprehensive concussion screens. Currently, for athletes who are not formally diagnosed with concussion, no information about concussion symptom reporting behavior sources, screening methods, or context is collected.

Methods: Pilot data were collected from four National Collegiate Athletic Association Division I football programs. Athletic trainers recorded data about key concussion symptom reporting behavior features during the 2016 and 2017 football seasons. The 2016 data were analyzed in Spring 2017 and the reporting form was adapted for the Fall 2017 season. Two programs completed records during the 2017 season. These records were analyzed in Spring 2018.

Results: Concussion symptom reporting behavior is most often initiated by athletes in practice contexts, followed by athletic trainers in game contexts. The 2017 data revealed that, regardless of source, 45% of initial screens received a comprehensive screen and about 25% of comprehensive screens originated by athlete or athletic trainer concussion symptom reporting behavior resulted in concussion diagnosis. Results led to development of a brief concussion symptom reporting behavior recording tool that can be used in practice, game, and athletic training room settings.

Conclusions: The smartphone-supported Concussion Symptom Reporting Tool provides a rapid and easy way to record concussion symptom reporting behavior as well as estimate program-specific data for stakeholders interested in understanding concussion symptom reporting behavior.

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INTRODUCTION

Sport-related concussions (SRCs) are a significant public health problem.[1] Football players are exposed to SRC risk nearly each time they practice or play football. Using 3 years of data from the National Collegiate Athletic Association (NCAA) Injury Surveillance Program,[2] Kerr and associates[3] estimated that the probability of any active NCAA football player becoming concussed in a football season is 5% (95% CI=4.9, 5.8), or roughly one in 20 active players in any given season. This estimate is likely a lower-bound estimate given that the Injury Surveillance Program data included

From the [1]Department of Psychological Sciences, Northern Arizona University, Flagstaff, Arizona; [2]Department of Physical Therapy and Athletic Training, Northern Arizona University, Flagstaff, Arizona; and [3]W.A. Franke College of Business, Northern Arizona University, Flagstaff, Arizona

Address correspondence to: Heidi A. Wayment, PhD, Department of Psychological Sciences, Northern Arizona University, Box 15106, Flagstaff AZ 86011. E-mail: heidi.wayment@nau.edu.

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only those SRCs that were reported to or identified by sports medicine professionals.

WHAT IS CONCUSSION SYMPTOM REPORTING BEHAVIOR?

Concussion symptom reporting behavior (CSRB) is defined as any behavior by which an athlete's potential SRC or concussion-related symptoms become known to an athletic program's medical personnel for evaluation. In an athletic program, CSRB can be performed by several individuals, including medical professionals (e.g., team physicians, athletic trainers [ATs], other medical healthcare professionals); coaching staff; or the athletes themselves. CSRB is routinely performed by athletic program health professionals during practice and game situations. A classic example is when an AT directly observes a player taking a direct hit, with or without clear on-field signs of SRC (e.g., loss of consciousness, tonic posturing, balance disturbance). Because most SRCs occur without loss of consciousness or clear neurologic signs, it is not possible to rule out SRC when observing an injury event. Although medical and applied guidelines have been established for helping medically trained professionals to recognize potential SRC symptoms in these situations,[1] healthcare professionals rely on athletes coming forward and honestly expressing potential concussion symptoms to initiate recommended forms of concussion and evaluation care.[1] Accordingly, recent calls for "changing the culture of concussion reporting" have focused on encouraging athletes to engage in CSRB. Yet, recent research has shown that more than half of all collegiate football players do not report suspected SRCs or concussion-related symptoms.[4–7] Further, athletes are known to be unaware of,[1,8–10] or even hide,[11–15] their SRC symptoms. In addition to the athletes themselves, other stakeholders are also encouraged to engage in CSRB. For example, coaches are receiving training to recognize symptoms and pass on that information to a program health official. Increasingly, players are encouraged to tell an AT if they believe one of their teammates may have an SRC. Thus, for any potential SRC, there are many individuals who could be the source of a CSRB.

IMPORTANCE OF DOCUMENTING CONCUSSION SYMPTOM REPORTING BEHAVIOR

Regardless of the initial source of CSRB, once aware of a potential head injury, athletic program health professionals follow specific diagnostic steps. The Berlin Consensus statement on concussions recommends that, for any suspected SRC, ATs perform an initial rapid sideline assessment[1] (e.g., abbreviated SCAT or SAC) and, if warranted, follow-up with a full SRC assessment to ascertain whether an SRC can be diagnosed.[1] Currently, there are no published data on how often this recommendation is followed and the extent to which rapid sideline evaluations might also reasonably include initial questions. Typically, the only data collected about CSRB and follow-up diagnostics by sports health professionals are about diagnosed SRC injuries, or if cleared, as non-concussive injuries (e.g., dehydration, whiplash). A recent review[16] found that programs collected several metrics for confirmed diagnosed SRCs: clinical assessment of the SRC (including symptoms) as well as the context where the injury occurred (practice, game). Yet, to understand the culture of concussion symptom reporting, all forms of CSRB and their follow-up care are important to document. First, such information helps to better measure the impact of educational programs designed to increase symptom reporting. Second, the care that healthcare professionals provide to athletes who report potential concussion symptoms should be documented.

Third, understanding the source and timing of symptom reporting provides important information to university stakeholders about program compliance with concussion assessment policies. There are three broad types of information that would be useful to meet this goal: (1) sources of CSRB; (2) the context of CSRB; and (3) the types of assessment and progression of follow-up care. CSRB sources are classified as direct and indirect. Direct CSRB are those directly observed by medical professionals and indirect CSRB are when other individuals relay potential injury information to them (e.g., student athlete, teammate, other AT). CSRB contexts are practice and games (during or after) and time of year (in season, off season). The types of follow-up care include initial questions, sideline assessment, full assessment, and assessment outcome. For the purposes of this paper, an initial evaluation is defined as a situation when an AT or healthcare professional asks an athlete preliminary questions about potential concussion symptoms, which could be followed by the sideline use of the Sports Concussion Assessment Tool[17] or Standardized Assessment of Concussion.[18] A full assessment is defined as a situation when an athlete is removed from the arena to a quiet place for an AT, team physician, or other certified healthcare professional to perform multiple, thorough concussion evaluation processes in accordance with their institution's policy.

HOW TO MEASURE CONCUSSION SYMPTOM REPORTING BEHAVIOR AND FOLLOW-UP CARE

Existing measures typically used to assess CSRB have limited utility for athletic program health professionals

to assess the frequency of this important health behavior. The most common methods for assessing CSRB are self-report Likert scales that ask student athletes to estimate how often they have or have not reported symptoms in the past (e.g., *never* to *very often*) or estimate their likelihood for reporting SRC symptoms in the future (*not at all likely* to *very likely*). Although such measures may be useful for model testing on predictors of reporting intentions, such measures tell researchers little about the actual number of student athletes that come forward to report possible SRC symptoms. Further, retrospective questions are subject to recall bias; prospective questions are subject to demand characteristics. This paper recommends that in order to understand the sources, contexts, and follow-up care of CSRB, a simple and easy-to-use CSRB recording tool is essential. For example, the authors of this study have evidence that ATs are very interested in documenting this information, but the collection of this information is not mandated and there is no efficient tool to assist in this effort.[19]

In the next section, the development of a CSRB reporting tool is described. First is a description of pilot data results collected during the 2016 and 2017 football seasons. The goal was to develop a recording method that was simple and brief because of the numerous demands placed on athletic program health professionals as well as the understanding that sport health professionals care for athletes in non-standardized settings, such as sports fields and swimming pools, and it is nearly impossible to document every encounter with an athlete. Next, a brief smartphone-supported checklist (Concussion Symptom Reporting Tool [CSR-Tool]) is presented and described, including its advantages over existing methods of measuring CSRB. This tool can be used by athletic program health professionals in the field to quickly and easily document the source and follow-up care of CSRB. Finally, an illustration is provided describing how data collected with this tool could benefit ongoing efforts to increase important concussion-related health outcomes in student athletes.

CAPTURING KEY CONCUSSION SYMPTOM REPORTING BEHAVIOR FEATURES: 2016 AND 2017 PILOT DATA

The data described in this section are part of a larger study examining the culture of concussion reporting, which had university IRB approval as well as from the participating universities. The overall project utilized a novel approach to understanding the "culture of concussion reporting"—a modified community-based participatory research and mixed-method paradigm that included a cultural analysis (D Craig, Northern Arizona University, unpublished observations, 2018). This in-depth and multi-phased process led to the initial procedures by which athletic program health care providers could collect more detailed CSRB information. During the 2016 football season, ATs from four NCAA Division I football programs were asked to record on a weekly basis, for every full assessment SRC evaluation, (1) who reported; (2) the context; and (3) the outcome (returned to play or diagnosed as an SRC). ATs were asked to enter this information in an Excel spreadsheet provided to them. Table 1 presents these data aggregated over the four programs. Two thirds (66%) of all full-screen evaluations resulted in a concussion diagnosis (44 of 66 recorded full assessments). Sixty-two percent of the full assessments came from practice settings, and nearly two thirds (61%) of full assessments originated with athlete CSRB. Nearly all indirect CSRB (80%) were in practice settings; most of the direct reports were in game settings (57%). Full assessments initiated by AT CSRB were more likely to result in a concussion diagnosis regardless

Table 1. Summary of Reporting Data from Four National Collegiate Athletic Association Football Programs for the 2016 Football Season

	CSRB source			
Variable	Athlete	Teammate	Athletic trainer /Coach	Total
Totals				
Full assessments	40	2	24	66
SRCs	24	1	19	44
Subtotals				
Game reports	7	0	18	25
Game SRCs	3	0	14	17
Practice reports	33	2	6	41
Practice SRCs	21	1	5	27

CSRB, concussion symptom reporting behavior; SRCs, sport-related concussions.

of setting (practice: 83%, game: 78%), compared with athlete-initiated CSRB (practice: 64%, game: 43%).

Although this initial attempt to record CSRB was successful in understanding the number of direct and indirect reports that were serious enough to warrant a full SRC assessment, ATs were given the form after the season had commenced and were asked to complete the Excel form only when a full SRC assessment had been made. The reporting form captured no information about the number of student athletes, regardless of reporting source, who received an initial assessment with or without a follow-up screen. The form was revised prior to the 2017 football season such that ATs were asked to complete the report any day that there were football players who received an initial assessment for a potential SRC. Two of the original four football programs were willing and able to collect these data (Table 2 provides explanation). During the 2017 season, a total of 126 initial evaluations of athletes were made, and 57 received a full SRC assessment. Of those receiving a full SRC assessment, 23 were eventually diagnosed with an SRC and 34 were returned to play following a non-diagnosis. Cumulatively, of the 126 initial assessments conducted on athletes, 56 were initiated by an AT, 31 were initiated by the student athlete, seven were initiated by a teammate, 11 were initiated or observed by a coach, and the source of 21 initial assessments was not recorded. Of the 23 diagnosed SRCs, 35% (n=8) were the result of indirect observation (eight reported by the athlete) and 65% (n=15) were the result of direct observation by AT or coach. Table 2 provides a summary of the information obtained in 2017. On average, there were more full assessments conducted in 2017 (28.5 per program) than in 2016 (16.5 per program). The average number of diagnosed SRC were about the same in 2017 (11.5 per program) as in 2016 (11 per program). In 2016, with four participating programs, about half of all diagnosed SRCs involved student-athlete CSRB, whereas in 2017, with just two participating programs, 35% of all diagnosed SRCs involved student-related CSRB. In both years, the remaining diagnosed SRCs were a result of AT CSRB.

CONCUSSION SYMPTOM REPORTING TOOL: A SMARTPHONE-ENABLED CONCUSSION SYMPTOM REPORTING BEHAVIOR ASSESSMENT TOOL

The 2016 and 2017 reporting tools were limited in that there was no way to verify when data were entered into the Excel spreadsheet, data were subject to recall bias, and if there was more than one report a day, information about context and outcome could not be tied to each individual report. Thus, results from the 2016 and 2017 pilot data led to the development of a simple smartphone-based reporting tool called the CSR-Tool that can be used in practice, game, and athletic training room settings.[2] As depicted in Figure 1, the tool uses six simple questions with no identifying information. The questions are delivered one at a time with an easy-to-use touch screen entry system. When Internet is available, the data are automatically sent to a database that can be easily tabulated using Excel or other data analytic software. It is estimated that for any given report, a healthcare professional (e.g., AT) could enter the relevant information in about 10 seconds, with date and time information automatically recorded.

ADVANTAGES OF CONCUSSION SYMPTOM REPORTING TOOL TO MEASURE CONCUSSION SYMPTOM REPORTING BEHAVIOR

The CSR-Tool provides several advantages over current assessment metrics for clinical practice and research. First, in contrast to self-report measures that ask athletes

Table 2. Reporting Data From Two[a] National Collegiate Athletic Association Football Programs for the 2017 Football Season

Variable	Practice	Game	Total	Non–head related concerns, *n*	Initial screen, *n*	Full screen, *n*	Diagnosed concussions, *n*
Indirect reports							
Player	30	1	31	2	31	20	8
Coach	10	1	11	1	11	3	1
Teammate	5	2	7	0	7	3	0
Other/unknown	0	0	21	0	21	0	0
Direct report							
Athletic trainer	25	31	56	4	56	31	14
Totals	70	35	126	7	126	57	23

[a]The third program utilized a different method to guage concussion-related reporting behavior; the fourth did not participate in 2017.

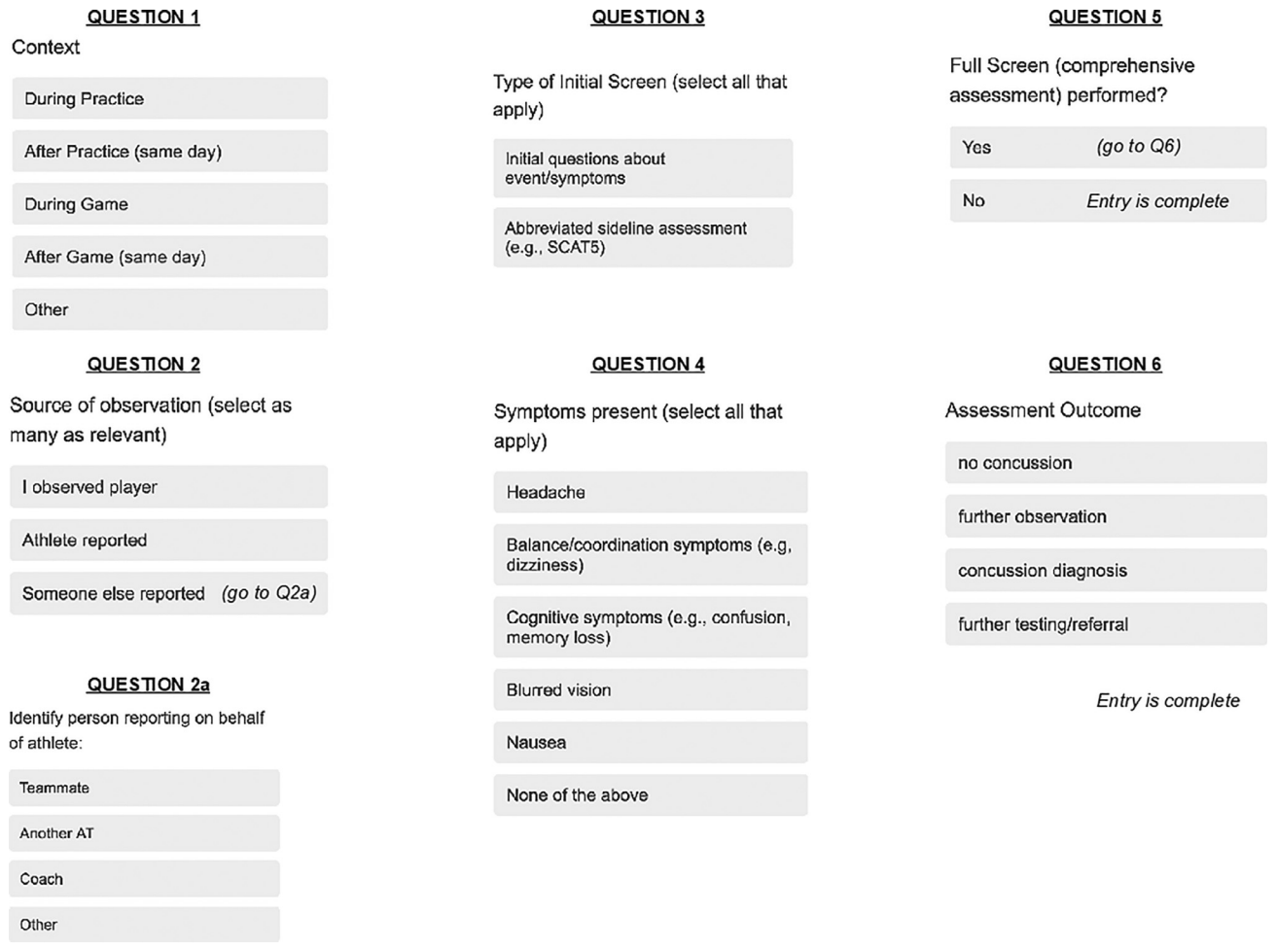

Figure 1. CSR-tool questions as they appear on smartphones.

to estimate past CSRB or future intentions to engage in CSRB, the CSR-Tool allows a health care professional to record data quickly and in proximity to a CSRB event, which should reduce recall bias. Second, in comparison to documenting only those athletes who have been diagnosed with SRC, the CSR-Tool records information about the number of athletes who receive an initial assessment but do not have an SRC, and the extent to which brief sideline assessments occur, in line with the Berlin consensus statement.[1] Thus, the CSR-Tool could assist programs in their documentation of best practices regarding concussion safety efforts. A third advantage of the CSR-Tool is that more accurate information about CSRB source, context, and follow-up care could provide programs with useful content for their educational interventions that can specifically address student athletes' perceived barriers to symptom reporting. For example, one of the strongest barriers to CSRB is that athletes fear that reporting will lead to their removal from play.[8]

If ATs or other healthcare providers were able to use the CSR-Tool in a systematic way over the course of a season, the data could be used to generate a conservative range of estimates regarding the likelihood that concussion reporting behavior leads to a diagnosed concussion.[3] Figure 2 illustrates how the data collected in 2017 yields such probability estimates using an Excel-based calculator (Appendix, available online). For example, the 2017 data showed an average of four to five student athletes/incidents initially evaluated each week. This number seems fairly low if one considers how many student athletes each week could be expected to have symptoms worthy of an initial assessment. If 80 athletes on a football team are exposed to SRC risk just once a week, then conducting initial assessments on five players per week is only 6% of what could be expected. If the number of initial evaluations associated with athlete CSRB tripled (from five to 15 a week or 225 initial assessments), the probability that an initial evaluation from an athlete CSRB would be diagnosed as an SRC would be reduced to 4%. If student athletes knew that there was a very small chance of actually being diagnosed with an SRC, perhaps the number of athlete CSRB would increase.

DATA INPUT

INDIRECT REPORTS TO AT	Number	Received Initial Screen	Received Full Screen	Diagnosed with Concussion
Athlete self-report	31.00	31.00	20.00	8.00
Peer report	7.00	7.00	3.00	0.00
Coach report	11.00	11.00	3.00	1.00
Other report	21.00	21.00	0.00	0.00
DIRECT OBSERVATION	**Number**	**Received Initial Screen**	**Received Full Screen**	**Diagnosed with Concussion**
Athletic Trainer	56	56	31	14

RESULTS

By Source of Reporting

	P Initial Screen | Report	P Full Screen|Initial Screen	P Concussion | Full Screen	P Concussion | Report
Athlete self-report	1.000	0.645	0.400	0.258
Peer report	1.000	0.429	0.000	0.000
Coach report	1.000	0.273	0.333	0.091
Direct observation by AT	1.000	0.554	0.452	0.250

	Total				
TOTAL INDIRECT	70	**1.000**	**0.371**	**0.346**	**0.129**
TOTAL INDIRECT & DIRECT	126	**1.000**	**0.452**	**0.404**	**0.183**

Figure 2. Probabilities derived from 2017 pilot data.

Note: Probabilities calculated from 2017 pilot data. The probability that a player was directly observed by an AT=0.250. Indirect reports: the probability that a player who initially self-reported would be diagnosed with a concussion=0.258; 0.091 if a coach reported the injury.

Probability estimates of concussion diagnosis would likely vary widely between athletic programs or sports, depending on a number of factors, such as number of healthcare providers or spotters available to help during practices or games, as well as subjective factors, such as the level of support for SRC reporting or program norms regarding interactions between athletes and healthcare providers. Taken together, although it is difficult to estimate the number of athletes that should be initially evaluated each week, the information gathered with the CSR-Tool could help encourage athletes to be more proactive in concussion-related health behavior. With more athletes coming forward, there is also the real possibility of more SRCs being detected. Finally, the CSR-Tool has the potential to improve stakeholders' understanding of whether SRC prevention efforts are effective in increasing student athlete and peer self-reports. This information, perhaps in concert with other methods to estimate hidden and hard-to-reach samples,[15,17] will greatly improve stakeholders' ability to understand the extent to which players, peers, and coaches are heeding the call to report possible symptoms and whether educational interventions designed to improve student-athletes' health behavior are having a positive impact.

LIMITATIONS OF MEASURING CONCUSSION SYMPTOM REPORTING BEHAVIOR WITH THE CONCUSSION SYMPTOM REPORTING TOOL

Would the type of estimate described above dissuade an athlete from reporting potential symptoms if there is a 96% chance that his symptoms are not concussion-related and he does not want to stop playing? If CSRB did increase, would it overload medical providers, particularly as a smaller and smaller percentage of such reports would yield true concussion diagnoses? At least at this early stage of implementing programmatic efforts to increase concussion safety, the potential benefits of having a clearer understanding of CSRB outweigh possible negative consequences of these data. For example, it would be extremely important for program stakeholders to be able to present probabilistic data to athletes and coaches in ways that frame these numbers in a positive light while also acknowledging the potential risks. If increased resources are needed to meet an increased demand, justification may be aided by more accurate CSRB data.

Relatedly, although the data collected with the CSR-Tool are collected closer in time and place to CSRB, programs that use the CSR-Tool reporting tool should be careful to consider the accuracy and reliability of the reports and work with ATs and other health care providers to establish shared norms about how to use the tool in their program. With a more accurate understanding of program-specific CSRB over time, and improved program-specific norms regarding the acceptability of CSRB, a balance of reporting/assessment can be achieved. Further, the athletes with potential concussions will be screened (true positives) whereas the number of false positives will be reduced so as not to exacerbate the workload of athletic health professionals.

CONCLUSIONS

SRCs continue to be a public health threat.[1] Unlike many sports injuries that are physically evident, the identification

of a potential SRC begins with CSRB, whether by the athlete, a teammate, a health professional, or coach. As important as this reporting process is for the well-being and safety of the athlete, there is no standardized reporting tool that provides key information concerning the source, care, and context of CSRB that minimizes the types of recall biases that are present in athletes' estimates of past and future CSRB. This paper introduces a simple and straightforward measurement tool that not only can help programs assess the detection and care completed by trained health professionals but also record the number of student athletes seeking help for any type of symptom, regardless of the SRC outcome—which is arguably a first step in endorsing a culture of concussion reporting. Second, this tool can provide stakeholders with useful estimates that describe the likelihood of diagnosis depending on the method of reporting and help estimate the number of student athletes that should be coming forward. This type of CSRB information could be useful in determining the success of educational efforts to increase CSRB initiated by student athletes.

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SUPPLEMENTAL MATERIAL

Supplemental materials associated with this article can be found in the online version at https://doi.org/10.1016/j.amepre.2018.10.007.

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