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A Learner-Centered Technique and Clinical Reasoning, Reflection, and Case Presentation Attributes in Athletic Training Students

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Context: Providing opportunities to develop clinical decision-making skills, including clinical reasoning, is an important aspect of clinical education. The learner-centered technique of summarizing the history and findings, narrowing the differential, analyzing the differential, probing the instructor about uncertainties, plan management, and selecting an issue for self-directed study (SNAPPS) is used in medicine to express clinical reasoning.

Objective: To investigate the effects of SNAPPS on the clinical reasoning, reflection, and 4 case presentation attributes (length, conciseness, case summary, and expression of clinical reasoning) in athletic training students.

Design: Randomized controlled clinical trial.

Setting: Three undergraduate programs accredited by the Commission on Accreditation of Athletic Training Education.

Patients or Other Participants: We randomly assigned 38 athletic training students (17 men, 21 women; age = 21.53 ± 1.18 years, grade point average = 3.25 ± 0.31) who had completed at least 1 year of clinical education and all orthopaedic evaluation coursework to the SNAPPS group or the usual and customary group using a stratification scheme.

Intervention(s): The SNAPPS group completed four 45-minute clinical reasoning and case presentation learning modules led by an investigator to learn the SNAPPS technique, whereas the usual and customary group received no formal instruction. Both groups audio recorded all injury evaluations performed over a 2-week period.

Main Outcome Measures: Participants completed the Diagnostic Thinking Inventory and Reflection in Learning Scale twice. Case presentations were analyzed for 4 attributes: length, conciseness, case summary, and expression of clinical reasoning.

Results: Case presentations were longer ($t_{18.806} = -5.862$, $P < .001$) but were more concise ($t_{32} = 11.297$, $P < .001$) for the SNAPPS group than for the usual and customary group. The SNAPPS group performed better on both the case summary subscale ($t_{32} = 2.857$, $P = .007$) and the clinical reasoning subscale ($t_{25.773} = -14.162$, $P < .001$) than the other group. We found a time effect for Diagnostic Thinking Inventory scores ($F_{1,34} = 6.230$, $P = .02$) but observed no group effects ($F_{1,34} = 0.698$, $P = .41$) or time-by-group interaction ($F_{1,34} = 1.050$, $P = .31$). The Reflection in Learning Scale scores analysis revealed no group-by-time interaction ($F_{1,34} = 1.470$, $P = .23$) and no group ($F_{1,34} = 3.751$, $P = .06$) or time ($F_{1,34} = 0.835$, $P = .37$) effects.

Conclusions: The SNAPPS is an effective and feasible clinical education technique for case presentations. This learner-centered technique provides the opportunity for the expression of clinical reasoning skills.

Key Words: learning styles, metacognition, clinical education

Key Points

- The expression of clinical reasoning and uncertainties is possible in the athletic training environment with the learner-centered technique of summarizing the history and findings, narrowing the differential, analyzing the differential, probing the instructor about uncertainties, plan management, and selecting an issue for self-directed study (SNAPPS).
- The SNAPPS group summarized necessary case attributes during case presentations better than the usual and customary group.
- The SNAPPS group could provide a differential diagnosis and complete an analysis of the differential better than the usual and customary group.
- The case presentations took longer to complete, were more detailed, and were more concise for the SNAPPS group than for the usual and customary group.

The clinical education experience is one of the most beneficial aspects of an athletic training student's entry-level professional development.[1] It is often when athletic training students can apply knowledge and make clinical decisions related to patient care. Clinical decision making requires deliberate, conscious discrimination and intuitive judgment.[2] It is a complicated process by which a student must respond to an ill-structured problem in a dynamic context that includes clinician-patient feedback loops, a diverse knowledge base, and a growing body of evidence.[3] Researchers[2,4,5] in other allied health fields have demonstrated that students tend to process

Step 1: Summarize the history and physical examination findings briefly.
Step 2: Narrow the differential diagnoses.
Step 3: Analyze the differential diagnoses.
Step 4: Probe the clinical instructor with questions and express case uncertainties.
Step 5: Plan management for patient case.
Step 6: Select a case related problem for self-directed learning.

Figure 1. SNAPPS mnemonic.

irrelevant information and focus primarily on knowledge acquisition while not indicating the diagnostic reasoning behind decisions. Thus, having experts model and provide feedback about clinical decision-making procedures is paramount to clinical education.

Athletic training clinical education requires students to use clinical reasoning, which is an attribute of clinical decision making, to make appropriate decisions.[6] Clinical reasoning is a cognitive and procedural process that has 3 core dimensions: knowledge, cognition, and metacognition.[3] Cognition is the use of higher-level thinking skills, whereas metacognition is a form of reflective self-awareness in which a student is instructed to think about thinking.[3] Metacognition, which is the act of connecting knowledge and cognition, is a much more elusive facet of reasoning. The development and assessment of clinical reasoning skills have become focuses of education programs in several disciplines, including medicine,[4,7,8] nursing,[9,10] occupational therapy,[6,11,12] and physical therapy.[13] However, few researchers have investigated clinical reasoning during the athletic training clinical education process. Because athletic training students are confronted with novel and sometimes complex cases during clinical experiences, providing students with opportunities to reflect, convey clinical uncertainties, and articulate a reasoning procedure is important to promote learning and to ensure appropriate patient care.

In addition to factual knowledge, clinical education should teach reasoning skills, including cognitive and metacognitive processes, to help students develop clinical decision-making skills. Several clinical reasoning techniques, including case studies,[6] journaling,[9] problem-based learning,[12] peer coaching,[13] and role play,[8] have been used to evaluate the expression of clinical reasoning in allied health and medical students. However, each technique has limitations. Some require instructor training to facilitate the technique; in addition, none are evaluated in real patient contacts, and they are used strictly in didactic settings. Using these types of techniques in athletic training clinical education may be problematic because of the fast-paced environment and the multitude of primary daily responsibilities of clinical instructors (CIs). For these reasons, using clinical reasoning teaching methods that are effective and efficient for athletic training CIs is important.

One way clinical reasoning techniques can be effective and efficient is to shift the focus of the educational encounter from the instructor to the learner. This paradigm shift from instructor-centered to learner-centered education has been discussed at length in the higher education, medical education, and adult learning education literature.[14–16] In an instructor-centered paradigm, the instructor serves as the conveyor of knowledge, and the student is a passive recipient.[15] However, in the learner-centered paradigm, the student becomes more autonomous within the interaction, and learning becomes the responsibility of both participants.[17] The shift of responsibility onto the student in the learning encounter has been demonstrated as one way to facilitate learning in adults.[18] Although students are autonomous in a learner-centered encounter, providing the student with appropriate techniques to guide their autonomy is beneficial. The learner-centered technique of summarizing the history and findings, narrowing the differential, analyzing the differential, probing the instructor about uncertainties, plan management, and selecting an issue for self-directed study (SNAPPS) has been used in medical education for students to present patient cases (Figure 1). The SNAPPS technique is effective for communicating patient findings and expressing clinical reasoning in a time-efficient manner while allowing the CI to remain fully engaged in patient care.[4,19] Therefore, the purpose of our study was to investigate the effects of the SNAPPS technique on clinical reasoning, reflection, and 4 case presentation attributes (length, conciseness, case summary, and expression of clinical reasoning) in athletic training students.

METHODS

Participants

Thirty-eight students (17 men, 21 women; age = 21.53 ± 1.18 years, grade point average = 3.25 ± 0.31) from 3 undergraduate programs accredited by the Commission on Accreditation of Athletic Training Education (CAATE) volunteered to participate (Figure 2). We included students who had completed the orthopaedic evaluation course sequence required by each athletic training education program and at least 1 year of clinical education opportunities. All orthopaedic evaluation courses included formal instruction in assessment of the head and spine, lower extremity, and upper extremity. In addition, the courses or laboratories used a hypothetico-deductive reasoning strategy for teaching or testing injury-evaluation skills. We excluded any student who was not assigned to a clinical education rotation with freedom to regularly perform initial musculoskeletal injury evaluations. The decision to exclude a participant was made in consultation with the clinical coordinator of each institution when we were advised that the student's role at a clinical education site, such as a nontraditional site, limited exposures to direct patient contact for initial injury evaluations.

All participants provided written informed consent, and the study was approved by the institutional review boards of all participating institutions.

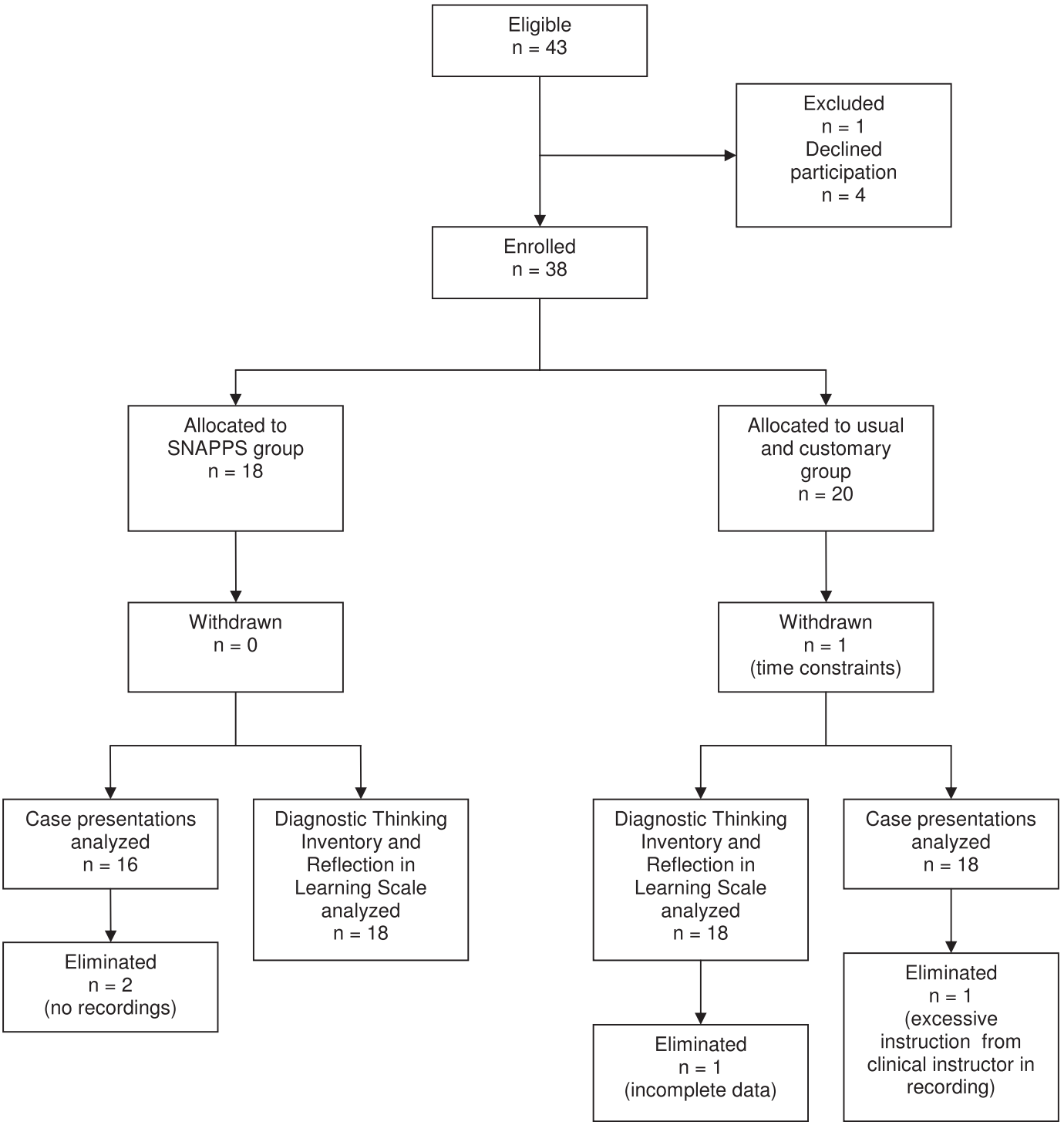

Figure 2. Participant flowchart. Abbreviation: SNAPPS, summarize the history and findings, narrow the differential, analyze the differential, probe the instructor about uncertainties, plan management, and select an issue for self-directed study.

Randomization

We used a 2-group, randomized controlled trial. We assigned participants to the SNAPPS group or the usual and customary group with a stratification scheme based on 3 variables: (1) number of students supervised by each CI, (2) CI's years of experience, and (3) type of clinical opportunity. We assigned participants who reported to the same CI into the same group to avoid cross-contamination between groups. We classified the CIs into 2 groups ($<$10 years of experience, $>$10 years of experience; no CI had 10 years of experience) to control for the role of experience in the quality of interactions between the participants and CIs. Clinical opportunities were subdivided into collision and noncontact sports and were used as a form of stratification to ensure that participants in each group were likely to encounter comparable injury rates for injury evaluation and presentations. To randomize students, we first identified and listed all CIs who supervised multiple students. We

Case Scenario Week 1: 16 YO male basketball player lands on an opponent's foot with his R foot during a rebound at practice. c/o a "pop" on his R ankle. Pt. reports no PMHx to involved extremity. You did not observe the injury and the pt. is not certain of the MOI.

Physical Exam: PWB possible with 6/10 pain. Edema on anterolateral aspect of R A immediately postinjury. AROM: DF 5 degrees with 6/10 pain, plantar flexion 20 degrees with 8/10 pain. Inversion limited with 6/10 pain, eversion limited with 6/10 pain. Pt. reports point tenderness G2 on anterior margin of lateral malleolus and ATFL; neg. point tenderness over CFL, medial malleolus or deltoid ligament. pos. anterior drawer for laxity and pain, pos. compression test, neg. inversion talar tilt for laxity with 2/10 pain; neg. Kleiger's, neg. posterior drawer.

Possible Dx (Hypotheses)	Hx/Observation (Key S/S)	Key Contributing Factors	Important Physical Examination Results	Other Info. Needed to Make Dx

List the most likely diagnoses in order then justify/reason why by listing and/or explaining both the key features that support your decisions and those features that do not fit.

1. _____
Reasoning:
2. _____
Reasoning:
3. _____
Reasoning:

Figure 3. Differential diagnosis schematic. Abbreviations: YO, year old; R, right; c/o, complains of; Pt., patient; PMHx, previous medical history; MOI, mechanism of injury; PWB, partial weight bearing; A′, ankle; AROM, active range of motion; DF, dorsiflexion; G2, Grade 2; ATFL, anterior talofibular ligament; CFL, calcaneofibular ligament; pos., positive; neg., negative; Dx, diagnosis; Hx, history; S/S, signs and symptoms; Info., information.

used a coin toss to assign the CI's students to either the SNAPPS or the usual and customary group. We used the same procedure for the list that was generated for students assigned to CIs with less than 10 years of experience, followed by students assigned to CIs who worked with a collision sport. Five CIs met several of the stratification criteria, but after the CI's students were randomized, they were eliminated from subsequent randomization lists. Finally, the remaining students who had not been assigned were listed and assigned using a coin toss.

Procedures

SNAPPS Group. Students assigned to the SNAPPS group participated in 4 clinical reasoning learning modules led by the authors from their respective institutions. Participants met on consecutive Mondays for 45-minute sessions throughout the 4-week study and 1 exit session during the fifth week. In the first session, we oriented the participants to the concept of clinical reasoning, taught the SNAPPS technique, procured clinical reasoning baseline data using the Diagnostic Thinking Inventory (DTI) and Reflection in Learning Scale (RLS), and gave an overview of the study procedures. We used a voice-over PowerPoint (version 2003; Microsoft Corporation, Redmond, WA) presentation and video demonstration produced by the lead author (S.H.) in the first session to ensure consistency across all sites. At the conclusion of the PowerPoint presentation, we gave the students a sample orthopaedic case so they could use the reasoning technique and SNAPPS presentation style. One author (J.M.D.) designed each of the cases, which used a differential diagnosis schematic that is demonstrated in the literature as an exercise in clinical reasoning (Figure 3).[20] After individual work on the case, we instructed the participants to present the case using the SNAPPS technique. The participants were given a laminated index card containing the SNAPPS technique outline and were instructed to use the card for the remainder of the sessions and at their clinical sites for all orthopaedic injury case presentations over the next several weeks. In the remaining sessions, the participants worked through an orthopaedic case; presented the case using the SNAPPS technique; and discussed their perceptions of the SNAPPS technique, including any problems they were encountering.

Table 1. Outcome Descriptions

Variable	Operational Definition	Scoring
Outcomes		
Basic patient attributes	Assessed 4 distinct components: (1) chief concern, (2) mechanism of injury, (3) injury history, and (4) signs and symptoms of the condition	0–4 points
Completeness of the physical examination	Assessed 5 distinct components: (1) observation, (2) palpation, (3) range of motion, (4) strength testing/manual muscle testing, and (5) special tests	0–5 points
Differential diagnosis	Provided a differential diagnosis	1 point
Justification	Described evidence that supports why each diagnosis is included in differential	1 point
Compare and contrast	Provided distinct comparisons between 2 or more differentials	1 point
Obtaining clarification	Initiated questions about uncertainties and areas needing clarification	1 point
Discussing patient management	Initiated patient management discussion	1 point
Identifying self-directed learning	Identified a topic for self-directed learning	1 point
Subscale		
Case summary	Sum of basic patient attributes and completeness of the physical examination	9 points
Clinical reasoning	Sum of differential diagnosis, justification, compare and contrast, obtaining clarification, discussing patient management, and identifying self-directed learning	6 points
Length		
Presentation length	Length of case presentation from start to end	Minutes
Conciseness	Case summary subscale length divided by the total presentation time	Minutes

During the first 2 weeks of the study, we instructed participants to familiarize themselves with the SNAPPS technique by practicing the technique during all case presentations completed at their clinical education sites. We also gave the participants audio recorders with identification codes and instructed them to practice using the audio recorders to record the case presentations. At the third session (beginning of week 3 of the study), we reminded the participants to take the recorders to their clinical sites to record all orthopaedic case presentations made to their respective CIs while using the SNAPPS technique for the next 2 weeks. During the exit session, we collected poststudy data on the DTI and RLS and conducted a focus group centering on the students' perceptions of their experiences.

Usual and Customary Group. Participants assigned to the usual and customary group participated in 15-minute orientation and exit sessions at their respective sites**.** The orientation session was held on the Monday before the beginning of the 4-week study. In this session, we oriented the participants to procedures of the study and collected baseline DTI and RLS scores. We used a separate voice-over PowerPoint presentation produced by the lead author to describe the procedures of the study to ensure consistency across all sites. Students in this group were not trained in any method for case presentations. They were advised to present cases as they were taught in their respective orthopaedic evaluation classes and were allowed to use the method with which they were most comfortable. We gave participants audio recorders with identification codes and instructed them to practice using the audio recorders to record the case presentations. Before the start of week 3, we reminded the participants to take the recorders to their clinical sites to record all orthopaedic case presentations made to their respective CI during the next 2 weeks. The exit session occurred at the conclusion of the 4-week study. We used the exit session to collect poststudy data on the DTI and RLS and conducted a focus group centering on the students' perceptions of their experiences.

SNAPPS Group CIs. Before the start of the 4-week study, we oriented each CI of the participants assigned to the SNAPPS group to the concept of clinical reasoning and the SNAPPS technique through a voice-over PowerPoint presentation and video created by the lead researcher**.** We gave each CI the same laminated index cards as the participants in the SNAPPS group and informed the CIs that the participants should use this procedure for all orthopaedic case presentations over the next 4 weeks. Before the start of week 3, the CIs received an e-mail indicating the participants would audio record all orthopaedic case presentations using the SNAPPS technique during the next 2 weeks. The CIs were instructed to e-mail or call the respective site leaders with any questions.

Usual and Customary CIs. Each CI of participants assigned to the usual and customary group received an e-mail before the start of the study**.** The e-mail explained the participant's involvement in the study. Before week 3 of the study, the CIs received an e-mail indicating participants would audio record all orthopaedic case presentations during the next 2 weeks. The CIs were instructed to e-mail or call the respective site leaders with any questions.

Outcome Measures

Case Presentations. We instructed all participants to record as many musculoskeletal injury evaluations as possible during a 2-week period, with the target of recording at least 2 evaluations per week to reach a desired minimum of 4 recorded evaluations**.**

We used the final audio-recorded clinical presentation completed in the final week of the study to code for the 8 variables that composed 2 subscales: case summary subscale and clinical reasoning subscale. Descriptions and operational definitions of each of the 8 variables and 2 subscales are presented in Table 1. The case summary subscale comprised 9 distinct attributes of a complete history and physical examination. The clinical reasoning subscale comprised key pieces of clinical reasoning verbalized during a case presentation as described by Wolpaw et al.[4] We coded each of the 8 variables in a

dichotomous yes or no fashion. A *yes* score indicated that the participant verbalized information that met the criteria of the operational definition for each variable. We summed the *yes* scores together to create the subscale score. In addition, we recorded the length of the injury-evaluation presentation and calculated a conciseness score by dividing the time to complete the case summary portion of the case presentation by the total presentation length.

After completing a training session, 2 authors (S.H. and L.I.V.) coded each blinded transcription. Within the training session, the authors coded 10 transcriptions. After discussion and clarification, the authors practiced independently on 10 more transcriptions (intraclass correlation coefficient [2,1] $\alpha = .98$ and .99 for summary subscale and reasoning subscale scores, respectively). The transcriptions used for the training and practice sessions were obtained from recordings made during the first 2 practice weeks and were not used for the final data analysis.

Diagnostic Thinking Inventory. The DTI is a 41-question instrument used to assess clinical reasoning skills in medical education settings.[21] The DTI assesses the clinical reasoning process using the knowledge-driven model of diagnostic thinking, which focuses on the organization and availability of medical knowledge as the major influence in the reasoning process. The DTI measures 2 constructs: flexibility in thinking (n = 21 questions) and evidence for structure in memory (n = 20 questions). Each item contains a stem, 2 accompanying statements at opposite ends of a continuum, and a rating between the statements using a 6-point semantic-differential–type scale. Reliability of the instrument ($\alpha = .83$), flexibility subscale ($\alpha = .72$), and structure subscale ($\alpha = .74$) have been established in medical students.[19]

The language and questions of the DTI were modified by an expert panel of athletic training educators who were from a variety of CAATE-accredited institutions (n = 6). The experts completed an item-content–relevance analysis and provided feedback on the terminology used in the instrument. All experts met 1 of 2 criteria: (1) had published athletic training education-related articles within the 5 years before the study or (2) had served on education-related committees of the National Athletic Trainers' Association. We eliminated questions that did not apply to athletic training. For example, we eliminated the question on the DTI that began with the stem, "When I order laboratory tests." In other cases, terminology was modified slightly for consistency with language commonly used in athletic training. For example, rather than stating, "during the course of an interview," the instrument was modified to state, "during the course of the clinical history." The final instrument that we used in this study comprised 29 questions, with 17 items on the flexibility in thinking subscale and 12 items on the evidence in structure for memory subscale.

Reflection in Learning Scale. The RLS is a 14-item questionnaire that assesses the reflective learning process using a 7-point Likert scale with scores ranging from 14 to 98.[22] We used this scale because reflection is posited to be involved in metacognition. The RLS measures reflection as a cognitive regulation strategy similar to reflection in action advocated by Schön.[23] The reliability (α range = .84–.88, $r = 0.709$) and validity ($R^2 = 0.547$) of the RLS were established by Sobral,[22] who studied medical students.

Statistical Analysis

We analyzed the presentation length, conciseness value, case summary subscale score, and clinical reasoning subscale score using an independent-samples *t* test for mean differences in outcomes between the SNAPPS and usual and customary groups with an a priori α level of .0125 based on a correction for multiple comparisons (.05/4 = .0125). The DTI and RLS scores were analyzed using separate 2 × 2 mixed factorial analyses of variance to test mean differences between groups (SNAPPS, usual and customary) and time (baseline, 4 weeks posttest). The α level was set at .05. All data were analyzed with PASW Statistics (version 18.0; IBM Corporation, Armonk, NY).

RESULTS

Participants were assigned randomly to the SNAPPS group (9 men, 9 women; age = 21.50 ± 1.04 years, grade point average = 3.17 ± 0.29) and the usual and customary group (8 men, 12 women; age = 21.55 ± 1.32 years, grade point average = 3.33 ± 0.31). One participant withdrew from the usual and customary group during the study because of self-reported time constraints. We had 94.7% of the participants complete the DTI and RLS at both administrations and 89% of the participants complete case presentations that could be analyzed. We eliminated 2 participants in the usual and customary group; 1 participant was eliminated from the case presentation analysis because the audio recordings included excessive CI instruction and conversation that interrupted the case presentation, and 1 participant was eliminated from the DTI/RLS analysis because of incomplete data. We removed 2 participants in the SNAPPS group from the case presentation analysis because the participants did not complete any audio recordings.

Case presentations that the SNAPPS group made were longer than those that the usual and customary group made ($t_{18.81} = -5.862$, $P < .001$), but the cases that the SNAPPS group presented were also more concise ($t_{32} = 11.297$, $P < .001$), indicating the added time on the case presentation was spent verbalizing clinical reasoning. The SNAPPS group also performed better on the case summary subscale ($t_{32} = 2.857$, $P = .007$) and clinical reasoning subscale ($t_{25.77} = -14.162$, $P < .001$) than the usual and customary group. The SNAPPS participants provided more details about patient attributes and physical examination procedures and verbalized important indicators of clinical reasoning. The group means and standard deviations for the summary and clinical reasoning subscales and the outcome measures for presentation length and conciseness are provided in Table 2. Frequencies for each clinical reasoning subscale component are presented in Table 3.

Although both groups had similar DTI scores at baseline, the usual and customary group had higher baseline scores on the RLS than the SNAPPS group ($t_{34} = 2.24$, $P = .03$). We found an increase from baseline to posttest DTI scores ($F_{1,34} = 6.230$, $P = .02$). However, we did not observe group effects ($F_{1,34} = 0.698$, $P = .41$) or time-by-group interactions ($F_{1,34} = 1.050$, $P = .31$) (Table 2). When examining RLS scores, we found no group-by-time interaction ($F_{1,34} = 1.470$, $P = .23$) and no group ($F_{1,34} = 3.751$, $P = .06$) or time ($F_{1,34} = 0.835$, $P = .37$) effects.

Table 2. Study Outcomes (Mean ± SD)

Study Outcome	Group	
	SNAPPS (n = 16)	Usual and Customary (n = 18)
Presentation length	4.59 ± 1.81[a]	1.77 ± 0.69
Presentation conciseness	0.38 ± 0.10[a]	0.85 ± 0.13
Case summary score	7.50 ± 1.03[a]	6.28 ± 1.41
Attributes	3.38 ± 0.72	2.67 ± 0.84
Completeness	4.13 ± 0.62	3.61 ± 0.98
Clinical reasoning score	4.38 ± 0.89[a]	0.67 ± 0.59

Abbreviation: SNAPPS, summarize the history and findings, narrow the differential, analyze the differential, probe the instructor about uncertainties, plan management, and select an issue for self-directed study.

[a] Indicates difference ($P < .01$).

Table 3. Frequencies of Clinical Reasoning Subscale

Clinical Reasoning Subscale Component	Group, No. (%)	
	SNAPPS (n = 16)	Usual and Customary (n = 18)
Differential diagnosis	15 (93.8)	0 (0)
Justification	14 (87.5)	3 (16.7)
Compare and contrast	0 (0)	0 (0)
Obtaining clarification	13 (81.3)	0 (0)
Discussing patient management	15 (93.8)	9 (50)
Identifying self-directed learning	13 (81.3)	0 (0)

Abbreviation: SNAPPS, summarize the history and findings, narrow the differential, analyze the differential, probe the instructor about uncertainties, plan management, and select an issue for self-directed study.

Means and standard deviations of baseline and posttest scores for both groups are shown in Table 4.

DISCUSSION

The purpose of our study was to investigate the effect of a learner-centered case presentation technique (SNAPPS) on clinical reasoning, reflection, and 4 case presentation attributes (length, conciseness, case summary, expression of clinical reasoning). One of the primary goals of athletic training clinical education is to develop an effective practitioner during an important, formative period in a student's professional development.[1] Therefore, providing instructional encounters that will offer maximal benefit is imperative. The use of learner-centered teaching strategies is one way to provide maximal benefit. The emergence of the learner-centered paradigm encourages students to become seekers of knowledge and reflects a shift away from the CI serving as the "sage on the stage" to a "guide on the side."[24] This shift is not only beneficial for the students but equally beneficial for the CIs.

The quick tempo of an athletic training clinical education environment can be difficult for students for many reasons, including anxiety about novel patient cases and fear of presenting patient findings to a CI.[25–30] The teaching methods that CIs use should allow for brief, teachable moments between episodes of patient care while helping CIs assess a student's thinking and reasoning abilities.[31] Our results demonstrate that the expression of clinical reasoning and uncertainties is possible in the athletic training environment using the SNAPPS technique. This technique removes the responsibility of the teachable moment from the instructor and places it on the learner while helping the student articulate concise thinking. The learner-centered nature of SNAPPS also aligns well with adult learning principles because it allows athletic training students to take responsibility for learning.[18] The areas in which we collected outcomes (presentation length and conciseness, case summary, and expressing clinical reasoning) have important implications for teaching and learning in the clinical athletic training environment and are discussed.

Summarizing Patient Findings

Similar to the nursing field, having students prepare and articulate case presentations is often a neglected part of athletic training education.[32] Many students are taught the traditional format of history of the injury, observation and inspection, palpation, and special tests to help organize the evaluation process as it is carried out. However, articulating a case presentation after an evaluation is equally important because it creates an opportunity for the student to convey a clear and comprehensive account of a patient's problems and allows the CI to assess the student's level of expertise regarding the evaluation of the patient.[32]

The first step in the SNAPPS technique is to summarize the case attributes, which pertain to the subjective and objective portions of the patient examination and include the patient history (chief concern, mechanism of injury, signs and symptoms, previous history) and results of the physical examination (observation, palpation, special tests). Students in the SNAPPS group summarized necessary case attributes during case presentations better than the usual and customary group. When students do not articulate appropriate subjective and objective information, the CI must take more time to probe students to assess their knowledge and skills. Allowing students to use SNAPPS and have the SNAPPS card enabled them to focus on the important aspects of the case without the potential anxiety associated with the encounter.[25–30] Using the SNAPPS procedure provides a framework to allow students to think more clearly and focus on how the subjective and objective items of information obtained in an evaluation influence each other and assist in the diagnosis of an injury.

Expression of Clinical Reasoning

Medical education research has revealed 2 levels of clinical reasoning: hypothetico-deductive reasoning and case pattern recognition.[33] Hypothetico-deductive reasoning is a form of clinical reasoning characterized by forming a possible hypothesis based on a case presentation that is known as a differential diagnosis.[20] After forming several hypotheses, an individual then attempts to support or refute each hypothesis by performing special tests or identifying key features to solve the problem.[34,35] The ability of individuals to propose a hypothesis is based on experience, so novices may struggle with developing a plan to support or refute a hypothesis if they have little or no experience with a specific case.

Case pattern recognition has been described as an advanced reasoning strategy used by experts or individuals with more experience related to a case. In this form of clinical reasoning, the clinician recognizes key features of a

Table 4. Reflection in Learning Scale and Diagnostic Thinking Inventory (Mean ± SD)

	Baseline		Posttest	
	SNAPPS Group (n = 18)	Usual and Customary Group (n = 18)	SNAPPS Group (n = 18)	Usual and Customary Group (n = 18)
Reflection in Learning Scale	64.61 ± 10.48	71.44 ± 7.63	67.78 ± 9.19	71.00 ± 8.37
Diagnostic Thinking Inventory	113.06 ± 13.09	117.89 ± 8.78	120.50 ± 12.19	121.00 ± 11.43

Abbreviation: SNAPPS, summarize the history and findings, narrow the differential, analyze the differential, probe the instructor about uncertainties, plan management, and select an issue for self-directed study.

case (ie, signs, symptoms) that fit within a known pattern of a specific condition. Specifically, Schmidt et al[36] noted that case pattern recognition is a mental process that relies upon comparing new cases with cases that have been encountered in the past. Each level of clinical reasoning occurs subconsciously most of the time, so individuals may or may not know they are engaging in these techniques. The SNAPPS allows students to express these levels of clinical reasoning, regardless of their stage of development, in a more deliberate, conscious manner.

After the summary of the patient examination, the next 2 steps in the SNAPPS technique are narrowing and analyzing the differential. With these steps, the students demonstrate the clinical reasoning component of the strategy. Students need to understand and express clinical reasoning skills during the clinical education experience.[33] Researchers have shown that many diagnostic errors occur because of failures in cognition rather than a lack of knowledge. Students commonly gather too much information; ignore relevant information; incompletely solicit patient concerns; or place too much emphasis on extraneous information, leading to confirmation bias.[8,37] As adult learners, athletic training students are motivated to learn by the need to solve problems.[14] Prompting students to engage in clinical reasoning through SNAPPS allows them to consider their thought processes more systematically by analyzing their differential diagnoses to solve the problem. In addition, the verbalization of their differential diagnoses and analyses provides an important feedback mechanism by which CIs can correct errors in students' thinking. Our results demonstrated that participants in the SNAPPS group could provide a differential diagnosis and complete an analysis of their differential better than the usual and customary group. Specifically, the SNAPPS group provided on average 3 diagnoses for each presentation. Many participants in the usual and customary group did not present a diagnostic hypothesis or provided only 1 hypothesis. If a student cannot provide a diagnostic hypothesis, then the CI may have difficulty discerning the student's level of diagnostic reasoning. In addition, having students analyze their diagnostic hypothesis helps avoid tunnel vision and diagnostic error.[38]

Meaningful student and CI interactions occur when a student engages in a discussion of evaluations that includes the formation of a differential diagnosis and analysis of the diagnostic possibilities. When a student engages in these types of skills, the CI can ensure that the student is demonstrating more than just technical skills. Moreover, this fosters an educational environment that promotes higher-level thinking skills, such as evaluation and synthesis, that coincide well with the purpose of the clinical integration proficiencies.[37]

Probing the CI

An essential component of the clinical experience is feedback from supervisors.[39] A CI's failure to provide feedback may lead to students' uncertainty about their professional development as clinicians.[39] A unique component of SNAPPS is its built-in mechanism for probing the CI and receiving feedback. In addition, the feedback obtained during SNAPPS has learner-centered meaning because the student is responsible for the initial questioning and the CI is present to listen and provide expert opinion and direction.

The questioning needs to begin with students because researchers[40] have found that experts (ie, CIs) cannot easily predict the errors that novices make. Furthermore, when they obtain the initial feedback from their point of view, students can use the appropriate knowledge and skills to enhance their future performance.[41] Finally, the environment of athletic training may not always allow the CI to provide immediate student questioning because of the other primary responsibilities of a CI to patient care. However, having the student leading the "cognitive dance" will help the CI participate immediately and possibly continue the conversation at a time that is more convenient.

Creating Self-Directed Learning Opportunities

The self-directed component of the SNAPPS technique enhances 3 aspects of student development: (1) student self-regulation through reflection, (2) lifelong learning habits, and (3) intellectual curiosity. Investigators[23] have shown that experts reflect in action rather than reflect on action. This subtle distinction suggests that an expert can reflect on performance while performing a task, whereas a novice tends to think about a set of actions after the performance is complete. Eighty-one percent (14 of 18) of SNAPPS group participants identified a self-directed learning topic, whereas no usual and customary group participant did. This finding is not surprising because many clinicians would not naturally articulate a self-directed learning topic in a case presentation. However, providing an opportunity for the student to reflect on deficiencies and articulate a strategy to address the deficiency is valuable in clinical education. Although the SNAPPS procedure focuses on reflecting on action, this technique may serve as an important gateway to promote the development of clinical reasoning whereby the student can generate new meaning and map new experiences.[10] Through the self-directed learning process within SNAPPS, athletic training students are involved integrally in the learning process. Allowing students the opportunity to research areas of misunderstanding or ambiguous information has been shown to lead to greater motivation and likelihood of overall success in adult learners.[42] In addition, the self-directed learning that occurs through the

use of SNAPPS enables educators to infuse evidence-based practice procedures into the students' self-directed learning by incorporating the 5-step process. This process for answering a clinical question can provide students with the framework to create a clinically relevant question, search for the best evidence, appraise the literature, integrate the information into clinical practice, and appraise the performance of the intervention.[43]

Presentation Length

Presentation length and conciseness were 2 variables calculated during case presentations. The SNAPPS group presentations on average were 2.5 times longer and were far more detailed than those completed by the usual and customary group as evidenced by the groups' case summary scores. The SNAPPS participants verbalized more details about the attributes of the patient history and completeness of the physical examination procedures during the presentation. Interestingly, the greater length of time spent during the case presentation actually was attributed to the time that the SNAPPS participants spent verbalizing their reasoning strategies, probing the CI, discussing the plan for patient management, and selecting a subject for self-directed learning. Although this technique takes longer to complete, it allows the student and CI to recognize what the student knows and does not know. Another important finding was that the SNAPPS group was more concise than the usual and customary group, indicating that the time the latter group spent detailing the history and physical examination procedures was longer yet less comprehensive. When a student does not provide a comprehensive case presentation and leaves out key features, such as history and physical examination findings, the CI might take as long to review a case with a student as a student would take to provide a comprehensive presentation.

As students move through their clinical education experiences, researchers may assume that their evaluations and case presentations will improve. However, some researchers have suggested that the clinical experiences of students may be random with respect to providing opportunities to apply all of their skills.[44] In athletic training, these opportunities may be limited by the type of clinical experience (volume of injuries) or a CI's willingness to allow the student to be an active participant.[45] A foundational technique, such as SNAPPS, may provide systematic learning opportunities during an essential time in the professional development of the aspiring clinician.

LIMITATIONS

Our study had limitations. We used 2 instruments, the DTI and RLS, to measure changes in clinical reasoning and reflection in a pretest-posttest fashion. We did not find a change in scores on either instrument based on group assignment, but we noted an increase in DTI scores over time. We believe that the absence of group differences may be attributed to 1 of 2 causes: (1) insufficient time for change or (2) measurement error. The study spanned a 4-week period, which was enough time to note group differences in clinical presentations but may not have been enough time to note changes in global constructs, such as diagnostic reasoning and reflection strategies. In the future, researchers should allow more time to measure change in these 2 constructs in an experimental study. The second possible cause may be measurement error. Although the DTI and RLS are valid and reliable instruments, they have not been used in the athletic training education setting. In addition, we modified the DTI from its original form to contain language consistent with athletic training education. Although created through an expert content analysis, these changes could have altered the psychometric properties of the instrument. We anecdotally found that some participants had difficulty understanding the clinical reasoning nomenclature used in the DTI. If clinical reasoning strategies and vernacular had been common in the participants' education, this might not have been a problem. Consequently, we suggest that participants be provided an orientation to clinical reasoning nomenclature or receive training with the instruments before use.

CONCLUSIONS

The use of clinical reasoning techniques has been demonstrated in medicine and various allied health professions, but we have found no clinical reasoning experimental research in athletic training. Providing opportunities during the clinical experience for students to develop clinical reasoning skills is an important aspect of their professional development. The integration of the SNAPPS technique can help students effectively and efficiently verbalize higher-level thinking skills and improve technical skills.

The learner-centered nature of SNAPPS is equally beneficial and effective for the athletic training environment. When students take control of their learning, they become more autonomous and conscientious about their experiences. In addition, it allows CIs to focus on their primary responsibilities while maintaining a level of clinical education that is thought provoking and meaningful.

Similar to other allied health professions, athletic training education programs should begin to use the terminology associated with clinical reasoning and techniques to assess the process throughout their programs so faculty, CIs, and students can be more aware of this cognitive process. In particular, SNAPPS can be used successfully during clinical education to allow students to develop concise case presentations and express clinical reasoning skills to facilitate learning and feedback. In the future, researchers should examine the diagnostic accuracy of the student's use of SNAPPS and of the student's and CI's perceptions of the technique to triangulate our findings about the effectiveness of the technique.

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