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ORIGINAL RESEARCH

Exploration of Factors Perceived to Influence Development of Diagnostic Reasoning in Athletic Trainers and Athletic Training Students

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Context: Diagnostic reasoning is acknowledged as a vital skill for medical practice, but research regarding this core aspect of medical cognition as it pertains to athletic training contexts is scarce. To compare athletic training–specific clinical reasoning skills with those of other health care practitioners, educators need to better understand how athletic trainers (ATs) think, what helps them think better, and what may hinder their thinking skills as related to diagnostic reasoning challenges in the clinical context.

Objective: To conduct a preliminary investigation into ATs' and undergraduate athletic training students' perceptions about their diagnostic reasoning processes. Secondarily, to identify and compare activities or practices that may influence individual diagnostic reasoning abilities.

Design: Qualitative research.

Setting: Online interviews.

Patients or Other Participants: Twenty-three participants (11 ATs, 12 senior-level athletic training students) were convenience sampled from a pool of participants used in a separate, multifaceted diagnostic reasoning study.

Main Outcome Measure(s): Participants were interviewed in an online format to determine their diagnostic processing ability and perceived factors that enhance and hinder diagnostic reasoning. Data were analyzed using a general inductive approach.

Results: Analysis determined ATs and athletic training students used similar reasoning processes to previously reported expert- and novice-level reasoning abilities, respectively. Professional socialization and metacognitive activities were found to enhance individual diagnostic reasoning abilities in both groups. Lack of professional socialization and time in ATs and limited experiences and educational settings in athletic training students were thought to detract from diagnostic reasoning development.

Conclusions: Use of diagnostic reasoning and factors perceived to influence ATs' and athletic training students' ability found within our study correspond with previously reported theories and mimic the current understanding of expert and novice abilities respectively. Understanding factors that influence diagnostic reasoning ability is crucial for developing effective pedagogical and curricular strategies in athletic training education.

Key Words: Clinical decision making, diagnostic judgment, clinical reasoning

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KEY POINTS

- Athletic trainers' and athletic training students' understanding of diagnostic reasoning ability corresponds with that in similar health care fields.
- Athletic trainers typically use a nonanalytic diagnostic approach, whereas athletic training students use a more analytic approach.
- Factors that positively and negatively influence diagnostic reasoning development in athletic training are similar to those found in other health care fields.

INTRODUCTION

Medical cognition, or the workings of the medical mind, includes myriad cognitive and metacognitive capacities that medical educators strive to instill and develop in their students.[1] Further, all medical practitioners possess and display a version of medical cognition in various manners and strengths.[1] Included under the umbrella of medical cognition is *clinical reasoning*, a facet of critical thinking in which medical practitioners use multifaceted and nuanced thought processes to make appropriate clinical decisions.[2] Depending upon the context, clinical reasoning can further be delineated into 2 interrelated modes of clinically applied thinking: diagnostic reasoning and therapeutic reasoning.[3] To this end, clinical reasoning was first described in the athletic training literature by Geisler and Lazenby as "the cognitive processes, decision making, problem solving, or focused thinking used in the evaluation and management of a patient."[4(p56)] Diagnostic reasoning, the focus of this investigation, is required when making a diagnostic decision on a patient presentation, and is essential for all allied health care professionals, including athletic trainers (ATs). To date, the inner processes and clinical utility of diagnostic reasoning have been only marginally investigated in athletic training education or clinical practice.[1,2,4–9] Athletic trainers must make accurate diagnostic decisions or impressions before implementing safe and effective plans of care, and diagnostic reasoning is a core concept of the clinician expertise component of evidence-based practice. Recently, a modicum of studies and presentations have been made available in various outlets,[3,8] but there is still much work on the topic to be carried out by educators and clinicians alike.

Many authorities agree that diagnostic reasoning is founded upon a fluid and interconnected balance of several different types of knowing, of case-based exemplars or schemas, and of the biomedical mechanisms that govern function and dysfunction of the human body.[10] Structurally, it is generally agreed that personal expertise and context will dictate precisely how a particular physician will diagnostically solve problems on a case-by-case basis, but over time it can be seen that reflective and effective physicians use a hybridization of hypothetico-deductive reasoning (HDR) and case pattern recognition (CPR) to solve unique and familiar problems, respectively.[1,5] Hypothetico-deductive reasoning is a more focused and analytic approach to diagnosis making, encompassing greater data collection and experimentation in order to prioritize and test the many relationships among accrued signs and symptoms, all towards the purpose of determining a potential diagnosis.[4,11,12] Hypothetico-deductive reasoning is typically a disorganized, time-intensive process practiced by and expected as the norm by less-experienced clinicians who have not yet encountered the necessary patient experiences to develop a highly organized and easily accessible memory structure.[13]

At the other end of the spectrum, CPR is a more streamlined, densely organized, and rich subconscious or nonanalytic ability that experienced clinicians use to translate patient information into meaningful presentations. Case pattern recognition is a more efficient, nonanalytic reasoning process that produces lower diagnostic error because of the reliance on more organized memory structures and the ability to balance and prioritize multiple potential diagnoses simultaneously.[1,14] Interestingly, expert diagnostic reasoners have also been shown to possess increased flexibility in their thinking because of an ability to revert to HDR as a chief cognitive strategy when confronted with novel cases.[4,12]

The development of diagnostic reasoning ability and the cognitive transition from novice to expert clinician remains a focus of investigation in the medical education literature. However, the multifaceted mental processes involved in establishing and defining expertise complicate the ability to objectify this inherently qualitative trait of the mind.[15] In athletic training literature, there are even greater gaps between what we know and don't know about clinical expertise, as there currently are only 2 reports focusing on expertise in athletic training, both published by Gardin et al.[16,17] Given this significant gap in understanding, studies capable of exposing the presence and nature of diagnostic reasoning in athletic training, as well as those designed to ascertain how it can be developed or stunted, are warranted.

The purpose of our study was to conduct a preliminary investigation into ATs' and undergraduate athletic training students' perceptions about their diagnostic reasoning processes and experiences. Secondarily, we wished to identify and compare activities or practices that may enhance or hinder individuals' diagnostic reasoning abilities. We hypothesize ATs and athletic training students will have a basic understanding of clinical reasoning concepts, but will differ considerably in their perceptions of activities to hinder or bolster clinical reasoning ability. It is our hope that these findings will provide early and constructive insight on the current state of diagnostic reasoning abilities within the field in order to promote future investigations into strategies, mechanisms, and behaviors for fostering diagnostic reasoning abilities in athletic training students and clinicians.

METHODS

Participant Selection

All AT and athletic training student participants were originally recruited for a larger, multifaceted diagnostic reasoning study involving an objective measurement of diagnostic thinking. Athletic trainers were recruited by sending a participation e-mail to a randomized list of names and e-mail addresses obtained from the National Athletic Trainers' Association. Athletic training students were recruited through e-mails sent to random and purposefully sampled athletic training program directors, asking them to forward the participation e-mail to each senior-level athletic training student in their program. Additionally, senior-level athletic training students were recruited in person at the 2015 Southeast Athletic Trainers' Association Athletic Training Student Symposium to participate in the study. The results of the larger study are not presented in this paper. Originally, 103 randomly sampled professional and student participants completed the Diagnostic Thinking Inventory for Athletic Training (DTI-AT)[18] at a site and time of their choosing. Participants were contacted by e-mail within 6 hours after completion of the DTI-AT and asked to participate in an online interview, using either Skype (Microsoft, Redmond, WA) or Apple FaceTime (Cupertino, CA). If a participant agreed to the interview, it was scheduled to take place within 48 hours after completion of the DTI-AT. The purpose of scheduling interviews within close proximity to DTI-AT completion was to allow for clinical reasoning processes to be fresh in the participants' minds, potentially leading to more accurate reflections of clinical reasoning experiences. Because data analysis occurred simultaneously with data collection, interviews were conducted until data saturation occurred, at which point we ceased contacting participants. Thirty participants were contacted and 23 were interviewed (11 ATs, 12 athletic training students). Participants consisted of 14 women (61%) and 9 men (39%) with the following education levels: 12 with a high school diploma (52%), 3 with a bachelor's degree (13%), 7 with a master's degree (30%), and 1 with a doctoral degree (5%).

Inclusion criteria stated each AT had to be currently practicing or educating, and each athletic training student had to be over the age of 18, in the senior year of an athletic training program curriculum, and considered a full-time student in an undergraduate professional education program. Exclusion criteria included professional graduate program students and any AT who had maintained certification status but was not currently working in a clinical or educational capacity within 6 months of the study.

Instrumentation

Experts in qualitative research design who were familiar with diagnostic reasoning theory constructed the interview template used for data collection. The interview questions and procedures were piloted by using senior athletic training students from the investigators' institutions; they were interviewed and queried in a follow-up dialogue to ensure that all questions were clearly understood. Pilot data from the interview were analyzed using a general inductive approach and critical-friend analysis, and it was determined that the information gathered coincided with the interview purpose.[19] Based on feedback in the pilot process, no major question revisions were deemed necessary, but examples of potential query items to enhance or hinder diagnostic reasoning were added to provide context for the participants. The interview questions were as follows:

1. When confronted with a diagnostic opportunity, please tell me how you reason through your evaluation process. In other words, please describe your thought process when making a clinical decision.
2. Please explain some personal activities you have engaged in over time you feel have helped to develop your diagnostic reasoning ability.
3. Please explain some professional activities (clinical experiences and professional development for students) you have engaged in over time you feel have helped to develop your diagnostic reasoning ability.
4. What are some issues in your personal life that act as barriers to your diagnostic reasoning development?
5. What are some issues in your professional life (clinical experiences and professional development for students) that act as barriers to your diagnostic reasoning development?

All interviews were conducted through Skype or Apple FaceTime, with the exception of 1 participant who was interviewed over the phone because of technical issues that could not be rectified. Before participating, participants were required to read and sign an electronic or paper copy of the informed-consent document. All interviews were digitally recorded and both the interviews and transcriptions were stored on a password-protected hard drive. The principal investigator and 1 other individual not associated with the study transcribed all interview data. Once accurate transcription was ensured, pseudonyms were provided for the participants to ensure confidentiality and digital copies of the interviews were deleted. This study was approved through institutional review board before data collection initiation.

Data Analysis

We used a general inductive approach to analyze the interviews with the intent of determining participants' understanding of their diagnostic reasoning processes as a whole, as well as which personal and professional activities they perceived to enhance or hinder their diagnostic reasoning ability.[19] The general inductive approach uses an analysis methodology similar to grounded theory, but is more appropriate for condensing extensive data and providing links between themes rather than for developing one specific theory,[19] an approach documented as viable for analyzing qualitative data.[20,21] Data were analyzed separately for the AT and athletic training student participant groups in order to assess differences in perceptions between groups. The transcribed interviews were first analyzed by the principal investigator independently in order to identify and label specific segments of words or phrases from each response. The overlapping information was then compared and combined to form subcategories based on our stated research objectives, and associated participant quotes were assigned to the subcategories.[19] The subcategories were extrapolated into larger themes once saturation was determined using the constant-comparative approach.[19] Saturation was considered reached by the principal investigator during the formation of subcategories when new information that might lead to the

formation of a new subcategory or theme was no longer apparent. After finalization of themes and subthemes, a coding consistency check was performed by having an independent researcher who has published experimental clinical reasoning articles demonstrating expertise with diagnostic reasoning theory assess the coded data to help reduce potential research bias, challenge coding assumptions, refine operational terminology, establish connections between the data analyzed and other research findings, and confirm data saturation.[19] A literature consistency check was then performed by having the 4 coauthors compare the exposed themes with research in other fields and provide feedback for clarity between themes and associated participant quotes.[19] Independent analysis, coding consistency check, and coauthor literature consistency check techniques were considered sufficient to ensure trustworthiness of the data collected. Of the 5 interview questions, the first was designed to evaluate participants' understanding of their own diagnostic reasoning thought process, questions 2 and 3 were intended to weigh practices perceived to enhance their diagnostic reasoning, and questions 4 and 5 were specifically designed to reveal any practices perceived to act as barriers to diagnostic reasoning development; therefore, the themes and subthemes were separated into these 3 categories.

RESULTS

Coding and analysis of the interviews revealed the following 3 themes and 8 subthemes for certified participants. Additionally, 3 themes and 11 subthemes were determined for athletic training student participants. The themes and subthemes along with the number of coded references can be found in the Figure. Tables 1 through 3 provide a comparison of ATs' and athletic training students' themes and subthemes, along with quotes to support data trustworthiness. Table 1 addresses thought process during diagnosis, Table 2 addresses perceived enhancers of clinical reasoning development, and Table 3 addresses perceived barriers to clinical reasoning development.

DISCUSSION

Comparing ATs' and Athletic Training Students' Thought Processes

The purpose of our study was to conduct a preliminary investigation into ATs' and undergraduate athletic training students' perceptions about their diagnostic reasoning processes and experiences. Secondarily, we aimed to identify and compare activities or practices that may enhance or hinder individual diagnostic reasoning abilities. The first interview question was designed to determine participants' understanding of their cognitive processes during a diagnostic encounter. The interviews occurred within 48 hours after each participant completed the recently validated DTI-AT by Kicklighter et al,[18] in which participants encounter a common orthopaedic diagnostic scenario and then are asked to reflect on their diagnostic reasoning over 41 questions, or cues.[18] Our intent was for this metacognitive activity to provide participants with a reference point from which to address our first question with more introspection and personal analysis. Given that our respondents were then able to make specific comments about their didactic and clinical experiences, to provide specific examples, and to articulate many of the foundational underpinnings of metacognition, reflection, and reasoning found in both practice and the literature, we are confident that our goals were met and that operationally, our methods were effective for addressing our research questions.

To have a standard reference for comparison, it is necessary to determine if the processes presented within our results coincide with established theory of experts and novice diagnostic reasoning processes found in other health care fields. Recent research by Gardin and Mensch[16] in athletic training has begun to demarcate expert diagnostic reasoning through experimental and qualitative research.[17] However, the complex nature of diagnostic reasoning expertise requires further research before we are able to truly label an individual as an expert or novice, especially in athletic training contexts, as the topic has largely been ignored to date. For the purpose of this study, the terms *expert* and *novice* are used based on professional versus student experience, respectively, and therefore used to compare our findings of participants' perceptions with established characteristics found in current diagnostic reasoning research. As the authors, we are not attempting to firmly objectify or define the specific characteristics of experts or nonexperts in athletic training. Given this limitation, it is well reported in the medical literature that experts take a minimum of 10 years of deliberate practice, and in doing so develop, display, or possess, on some level or another, more expert diagnostic reasoning (CPR) abilities, an authentic commitment to lifelong learning, and a habit for meaningful and structured reflection and metacognition.[15] Though we did not set out to define expertise in athletic training, it is clear from the information we collected that these thematic characteristics of medical expertise are indeed operational in some format, and on some level in athletic training. Much more research needs to be carried out on the idea of expertise in athletic training, research designed to address such questions as, for example, "What is expertise in athletic training?", "What is an expert AT?", and "How is expertise developed or built?".

In our study, the AT participants demonstrated some of the known characteristics of expert-level diagnostic reasoning by describing how they quickly and accurately form and test a working diagnosis via very complex and interrelated mechanisms. Consistent with findings from medical literature, experienced ATs in our study reflected more expert behaviors such as recognizing key features and unique features that don't fit,[4] forming plausible yet small differential diagnosis lists, relying on bioscientific knowledge, reflecting on past case experiences, and subconsciously using semantic axes to decipher and connect patient-provided information into appropriate medical contexts and clinical meanings. *Semantic axes* are defined as cognitive connections between various presenting signs or symptoms and actual diagnoses that exist in a clinician's experienced and organized mind.[22] This neurological scaffolding helps more expert clinicians prioritize and recognize existing relationships among previously learned information or "key features" to recall known clinical case patterns.[22,23] Our results demonstrate that expert-level, subconscious cognitive reasoning in ATs occurs during the history and observation portions, which is consistent with prior findings that have reported that 80% to 90% of diagnoses are formulated early in the subjective portion of the evaluative process.[24,25]

Figure. Athletic trainer (AT) and athletic training student (ATS) interview themes and subthemes. (Parentheses indicate the number of coded references.)

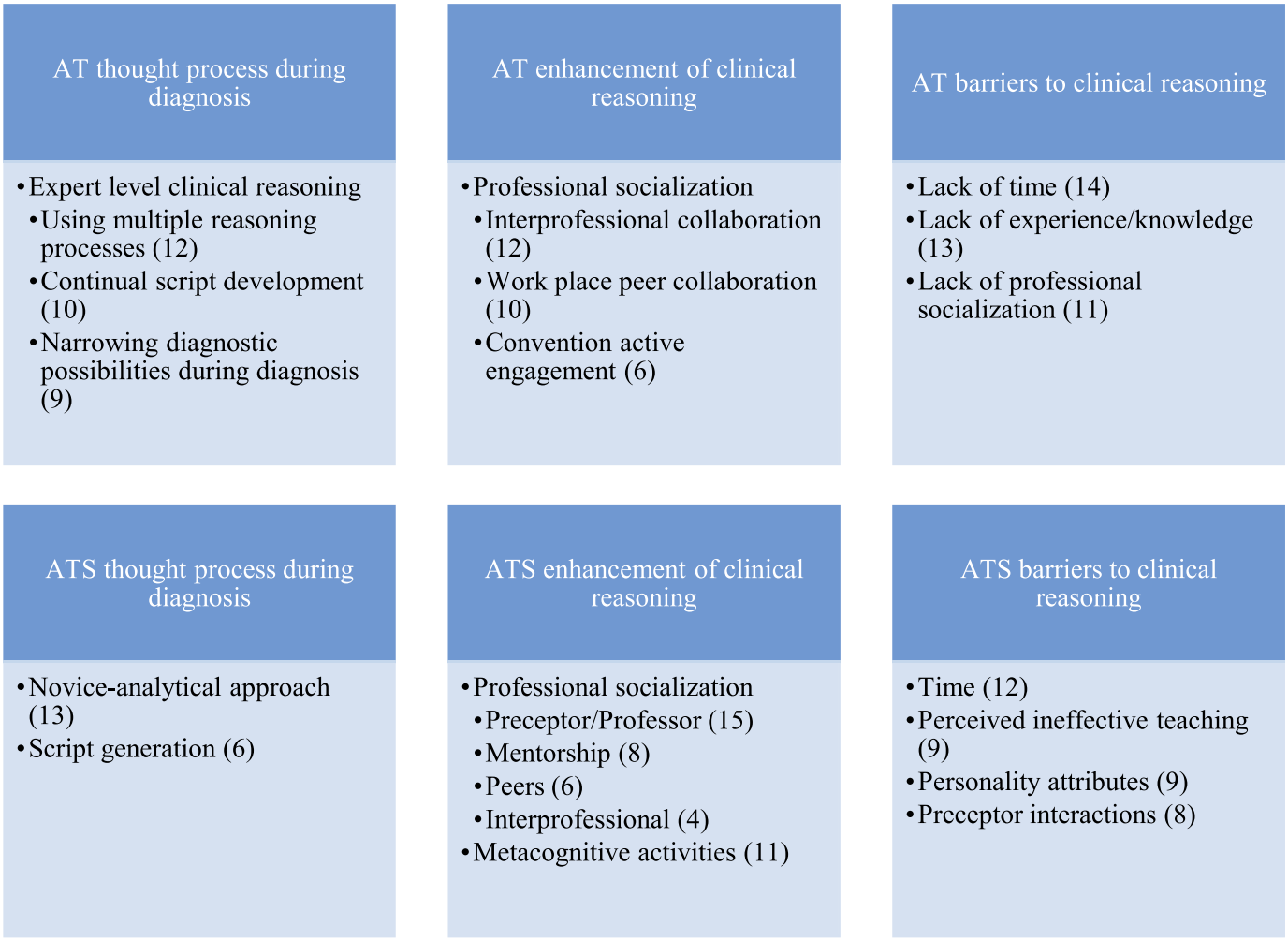

Table 1. Comparison of Athletic Trainers' and Athletic Training Students' Thought Process During Diagnosis

Athletic Trainers	Athletic Training Students
Expert-level diagnostic reasoning	Novice-analytic approach
Subtheme 1: Using multiple reasoning processes	Cedrick: "I go through the entire history and I analyze everything, every detail."
Christi: "If, for some reason, what they are saying and the tests don't add up, then I continue to ask questions to get to the bottom of it."	Amy: "I think of every possible injury that could be in that portion of the body."
Carolyn: "I have to make sure I understand what it is they're describing and sometimes have to ask, 'What do you mean by that?'"	Burgeoning script generation
Subtheme 2: Continual script development	Dayna: "I think of what could be associated with it, and then I rely on patient information."
Dennis: "It's just like putting a puzzle together. . .we get to a point where we can see the picture without having every piece there."	Justin: "You know in our evaluation classes they teach us, history, observation, palpation, special tests, but the more you're able to integrate those things, to be able to incorporate those things together, at the same time, will help you get a better diagnosis."
Ty: "I create a differential diagnosis in my head."	
Subtheme 3: Narrowing diagnostic possibilities during diagnosis	
Nathan: "During the history I can get exactly an idea of what's going on before I start to do anything."	
Carlee: "Depending on where their location is and their mechanism, I'm starting to get ideas in my head of what their eventual diagnosis could be."	

Table 2. Comparison of Athletic Trainers' and Athletic Training Students' Perceptions of Perceived Enhancers of Diagnostic Reasoning Development

Athletic Trainers	Athletic Training Students
Professional socialization	Professional socialization
Subtheme 1: Interprofessional collaboration	Subtheme 1: Preceptor/professor interactions
Havie: "Following up with the doctor and asking, 'Was there something I should have done differently, or could the injury have been something different?'"	Justin: "Having someone there who will actually push you and then they talk you through things you actually do well, things you do bad, and just that one-on-one feedback."
Carolyn: "I've gone out and contacted chiropractors, massage therapists, and one occupational therapist and we get together every week and have a roundtable discussion."	Julie: "My professor would give me case studies, which would be good to see, be given an actual scenario, not just trying to learn the tests and what you have to do during the evaluation, but actually having a scenario."
Subtheme 2: Workplace peer collaboration	Subtheme 2: Mentorship
Trey: "Just being able to sit down with an older athletic trainer and ask 'Why did you do this?'. . .just picking their brain. . .I like to ask a lot of questions."	Andrew: "My mentor will sometimes give me scenarios, and she'll [say] 'OK, give me 4 differential diagnoses and breakdown pinpoint questions that you would relate to that.'"
Dennis: "I think number 1 is mingling with peers, having discussions. It may be reviewing 'Hey I just had such and such. . .' just bouncing it off a peer."	Dayna: "I go to a mentor, who is actually a GA [graduate assistant] student, who is with me right now."
Subtheme 3: Convention active engagement	Subtheme 3: Peer interactions
Havie: "It's really at the conferences where I'm hearing from others points of view."	Leah: "My classmates talk to each other about it and see if we can come to, like a consensus."
Dennis: "Getting together with peers, engaging with speakers. . .you pick up so many ideas, and so many new thoughts, maybe even a new skill."	Amy: "[We like to] bounce ideas off of each other."
	Subtheme 4: Interprofessional interactions
	Danielle: "[Interprofessional lectures] have been very helpful just to refresh my mind and just get me thinking about other injuries."
	Ryan: "We have professionals that will come in and do clinics or symposiums. Our MDs [medical doctors] come in and do oscillations and palpations regarding cardiovascular issues."
	Metacognitive activities
	Amy: "I draw flow charts to try and see what symptoms go with what."
	Cedrick: "I like to reflect or journal at the end of every day in order to see what I could have done better or maybe if I missed out on something."

Additionally, our diagnostic reasoning findings align with those reported by Cappelletti et al[26] in their systematic review of the nursing literature regarding expert thinking. Cappelletti and colleagues[26] demonstrated experts convey preestablished, organized memory structures along with a flexibility of cognitive strategies when encountering more difficult clinical situations, which is similar to Norman's[2] contemporary dual processing theory for diagnostic reasoning. Dual processing posits that although experts primarily use nonanalytic CPR-based approaches to diagnostic reasoning in familiar cases, they must also think flexibly by using HDR in the presence of unusual information or atypical cases in order to avoid overlooking important signs and symptoms and making a diagnostic error.[5,27] These findings coincide with Gardin and Mensch's[16] findings that athletic training experts use more than 1 type of thought process when making diagnostic decisions, depending upon the context.

Responses to our first line of student questioning indicate our athletic training students use a more extensive, analytic, diagnostic methodology consisting of excessive data collection, limited script development, and a lack of confidence in the eventual diagnosis. This analytic HDR processing is appropriate for and expected of novices, and should thus be encouraged in all student novices as the preferred mode of thinking for initial clinical encounters, as less-experienced clinicians require safety in and find comfort with greater structure and comprehensiveness. However, it must also be cautioned that an exclusive use of HDR is associated with increased diagnostic error because of the limited ability of the novice mind to process and prioritize relationships among the large amounts of data (signs and symptoms, exam findings, etc) effectively. In other words, cognitive overload can inhibit the ability of the investigating mind to filter appropriate from inappropriate information, and it can overtax the short-term memory capacity of even the brightest and best students. Because of its necessity and students' propensity to organize and understand accumulated data with new cases, HDR is an expected and necessary entry-level cognitive process for professional students, and thus should be mastered before progressing to more advanced CPR approaches. As knowledge acquisition and experience with clinical cases mount,

Table 3. Comparison of Athletic Trainers' and Athletic Training Students' Perceptions of Perceived Barriers to Diagnostic Reasoning Development

Athletic Trainers	Athletic Training Students
Lack of time	Lack of time
Havie: "Am I going to spend 15 minutes looking up an injury I don't know much about, or take care of my baby, cook dinner, those kind of things?"	Andrew: "I have to do this [clinical] rotation and you're tired from the rotation, but to go home, to pick up a book and study, to eat something, and then try to get at least a good night's rest."
Ty: "If you have a small staff, you may not have the time to commit to a full evaluation."	Danielle: "We have clinical rotations that usually lasts 3 months at a time and then we switch to another rotation, so we usually don't get a break, so I do feel time managing is extremely important."
Lack of experience/knowledge	Perceived ineffective teaching
Christi: "Because I work in a high school setting, I don't get that broad spectrum of injuries like a clinic would have."	Ryan: "Having just a bunch of really unnecessary information thrown your way or in a format that just doesn't make sense."
Haven: "I know I can get some people started, but there is a better person than me to evaluate that."	Justin: "I've had a professor say, 'I've never used this test, I'm not going to teach it to you.'"
Lack of professional socialization	Julie: "I would say one of my professors [hinders my reasoning development] because he kind of pushed on us what his thoughts were in evaluating, and kind of how certain injuries can occur like it's the only way they can occur."
Carlee: "I received a head athletic trainer position straight out of grad school. . .I would have preferred to be 'Aaron Rodgers learning from Brett Favre' so that I could learn and then one day be as good as Favre."	Personality attributes
Ty: "I used to trust my instinct a little too much and didn't seek advice."	Breanne: "I didn't take the initiative. . .my preceptor lets me do anything, and I was like 'No, I'm not ready.'"
	Danielle: "But it is just all day every day, so it's hard to umm. . .stay motivated."
	Preceptor interactions
	Andrew: "I do feel like sometimes at my athletic training facility at school, when I was there I wish they would allow more hands on."
	Ryan: "With a really bad preceptor, you can either have a poor experience or you can learn incorrect knowledge."
	Justin: "I have been exposed to couple of different people who I try and ask questions, and I try to engage in about injuries and different athletes who have conditions and their communication style resorts to maybe 1 or 2 sentences and then that's kind of it. So. . . it doesn't quite lead to a lot of discussion."

CPR strategies can and do evolve organically, but there is also a personal and experiential context to consider, as each student will waver or float between HDR and CPR mechanisms depending on his or her relative knowledge, experiential encounters, and metacognitive acumen.[4] Nevertheless, it is indeed interesting to note that the level and type of diagnostic reasoning reported by our undergraduate athletic training participants is similar to and consistent with that found in first-year medical students, despite the obvious differences in age and educational background.[28–30]

Regardless of what type of reasoning a particular student or practitioner employs or describes, the potential factors perceived to enhance or hinder diagnostic reasoning must be assessed in order to better appreciate diagnostic reasoning ability and to determine the validity of participant perceptions.[31] Therefore, it was prudent for us to explore the perceptions our participants had regarding potential factors or experiences that influenced their diagnostic reasoning abilities in order to help future investigations address them in isolation and context.

Collective Perceived Enhancers of Diagnostic Reasoning

In both groups, the most important factor perceived to impact current state of diagnostic reasoning was professional socialization. This collaborative and interactive dynamic appears to provide students and young clinicians with multiple perspectives for thinking, possibly leading to increased structure of memory through continual feedback, script development and reformation, and better cognitive organization. We also found that diversifying one's initial skill set, using mentors for feedback and challenge, and active participation in professional conferences are other ways to increase thinking and knowing perspectives. Although this was not directly stated by our participants, previous research has demonstrated that professional socialization is considered a form of metacognition, given the fact

that alternative perspectives require reflection and analysis of current abilities and understanding, possibly refining and enhancing diagnostic abilities and thinking processes.[26,32] Our findings are further validated when compared with the findings of Gardin and Mensch[16] that varied experiences combined with consistent internal and external feedback are self-regulatory metacognitive activities considered to enhance diagnostic reasoning development.[17] For our student participants, educational and professional socialization need to incorporate structured, autonomous, varied patient encounters emphasizing the transfer and integration of previous and relevant bioscientific knowledge, as well as use of effective and meaningful semantic axes in order for script or case pattern development, and these activities and challenges clearly need to occur in classroom and clinic alike.[4,6,33]

Using physicians and interns, Durning et al[32] provided a qualitative analysis similar to that of our study in order to determine what activities may develop and maintain diagnostic reasoning in different stages of a physician's career. Durning et al[32] similarly determined specific undergraduate and graduate teaching strategies (both didactic and clinical), patient encounters, teaching others, having a mentor, and self-directed learning to be the most important factors for developing and maintaining diagnostic reasoning abilities. These findings align with our ATs' and athletic training students' findings regarding the importance of specific educational strategies and professional socialization in the development of clinical competence and professional transition.[34,35] It was interesting to note, however, that neither the AT population in our study nor the physicians used by Durning et al[32] expressly determined reflective or metacognitive activities as being perceived to enhance diagnostic reasoning, despite the considerable research stating otherwise.[26,33,36,37] Most current research in diagnostic reasoning development states that metacognitive activities are imperative because they help to refine judgments, prioritize relationships among signs and symptoms, and force individuals to evaluate the cognitive processes used during a diagnosis.[36] Interestingly, our results indicate that student respondents favored self-directed learning as a metacognitive strategy rather than the traditional sense of reflection, a finding that aligns with current research into the development of diagnostic reasoning.[33,36,38]

In fact, our athletic training student population seemed to possess a deeper grasp of at least some of the concepts considered to enhance and hinder diagnostic reasoning than did our professional participants.[13,39] This curious finding may be at least partially attributable to the notion that current athletic training students are being more formally exposed to diagnostic reasoning development strategies in their didactic and clinical experiences, and perhaps even have more thinking-focused clinical education experiences compared with practicing ATs, who may have finished their formal education some time ago. To that end, recent exposure to diagnostic reasoning–related theory, application, and research at athletic training education conferences and journals, and advances in required educational standards, including the Commission on Accreditation of Athletic Training Education competency requirement for diagnostic reasoning–based education and formalized preceptor training, may suggest that the future AT population should be engaging in more structured metacognitive activities to enhance all facets of diagnostic reasoning.

Collective Perceived Barriers to Diagnostic Reasoning

Cappelletti et al[26] determined that social factors associated with work and education environments play large roles in either enhancing or hindering diagnostic reasoning development. Lack of or ineffective professional and educational socialization and perceived or real time constraints were 2 of the largest barriers to diagnostic reasoning development in both groups of our current study. In our AT population, a lack of professional collaboration and debriefing was perceived to limit the ability to gain multiple diagnostic perspectives, which may in turn limit future script development and refinement, self-reflection, and even future memory organization. Additionally, time constraints may force individuals to rush through diagnostic challenges, potentially overlooking important details and limiting the flexibility of thinking (not to mention dangerous and inaccurate outcomes). These issues are certainly not specific to athletic training, and have previously been noted as meaningful barriers to diagnostic reasoning in other health care fields.[26,40–43] On another level, however, this finding is somewhat counterintuitive to some aspects of diagnostic reasoning theory, because expert-level diagnostic reasoning ability ultimately requires less time to more accurately diagnose an illness or injury. Therefore, perceived time constraints should, in fact and in the minds of capable clinicians, actually promote the use of CPR by forcing individuals to refine their cognitive strategies, leading to more efficient diagnoses. Or alternatively, perhaps assessment of other metrics of clinical expertise would reveal that more expert thinkers actually operate better under tighter time constraints. Combined with ineffective professional transfer and perceived job pressures due to lack of resources and staffing, it is perhaps understandable that less-experienced clinicians would consider time as a barrier to diagnostic reasoning despite the logical application of diagnostic reasoning theory, which states otherwise.

As expected, the barriers that our students perceived were consistent with studies across other health care fields and focused mainly on a lack of time, educational frustration, and various personality attributes. The perception that there is too little time to think is very similar to that of their professional counterparts, with students feeling as though their schedule, personal life/family commitments, or lack of good time management skills prevents them from studying further to improve their diagnostic reasoning ability. However, this logic can be viewed as faulty, because research has shown that the gaining of knowledge does not directly lead to increased diagnostic reasoning as much as understanding and use of specific cognitive processes.[40,44] Time constraints are unavoidable in any allied health care education because of the dense structure of course sequencing and intense clinical rotation requirements; therefore, it is imperative that educational experiences be designed to lead students towards a less time-intensive, more nonanalytic approach to thinking by using specific diagnostic reasoning pedagogy, ultimately enhancing students' and professionals' ability.

Perceived ineffective preceptor and professor interaction was a large and, to be candid, disturbing theme of this study, and

has been well documented as a barrier not only to diagnostic reasoning, but to clinical education in general.[45–51] This barrier can stem from clinical supervision from less-experienced preceptors who have not yet developed expert diagnostic reasoning,[51] increased preceptor role strain,[52] and lack of formal clinical instruction strategies.[46] Just recently, Geisler[53] published a concise, evidence-informed piece for developing diagnostic reasoning abilities in students and young clinicians alike, and, interestingly enough, the piece both harmonizes with and summarizes the findings of this investigation as it highlights the various clinical and didactic approaches that help develop CPR skills for diagnostic challenges. Along with this preceptor frustration, a professor not instructing in a way that is perceived to enhance diagnostic skills was seen as a large barrier. However, it is unclear whether the instruction is truly ineffective or just perceived as ineffective because of conflicts in learning and teaching styles. Regardless, it is imperative that more research into clinical and didactic education methods intended to enhance diagnostic reasoning now be validated using current qualitative methods such as the DTI-AT in order for more effective educational interventions to be documented.[31] In a thorough review recently published in *Medical Education*, Schmidt and Mamede[54] outlines a 3-stage model for teaching diagnostic reasoning in both the classroom and the clinic. Stage 1 entails detailed causal knowledge of disease and illness through pathophysiological and pathomechanical principles (which, of course, are first founded upon other basic sciences like anatomy and physiology); stage 2 uses pathophysiological knowledge encapsulated into diagnostic labels by introducing the transfer and applicability of information learned in stage 1 (and prior); and stage 3 is founded upon the development and learning of rudimentary illness/injury scripts, whereby key features and cues are used to foster recognition of typical case patterns.[54] Interlaced with this, of course, would be an intentional curriculum designed to reflect a parallel, interrelated, reflective, evidence-informed, and deliberate practice-based clinical education component.[54]

Lastly, common and challenging athletic training student personality traits such as lack of initiative, low confidence, and poor motivation to engage in more diagnostic opportunities were thought to hinder diagnostic reasoning advancement. Although these have been recognized in previous athletic training and other health care studies as common traits among students,[55,56] providing more effective and efficient diagnostic reasoning–based education should increase confidence and initiative in students as they progress through a well-structured AT curriculum and gain meaningful experiences from their intentional clinical education program.[54] Most experts agree that using specific methods to enhance diagnostic reasoning may increase students' confidence by increasing their ability to easily and correctly solve diagnosis, rehabilitation, or treatment problems, leading to increased self-efficacy and positive reinforcement.[4,5,12,33,53]

LIMITATIONS

There were several limitations to this study that should provide both caution and thought. This study intentionally analyzed senior-level undergraduate athletic training students in their final semester of coursework, and therefore the scores are not reflective of the ability of general athletic training students or of professional graduate-level–degree students. Additionally, the interview was piloted only on an athletic training student sample, and although it can be assumed an AT would be able to understand questions piloted to athletic training students, it cannot be stated conclusively that AT participants would respond differently. Similarly, the varied interview platforms (Skype, Apple FaceTime, phone call) may have resulted in differences in answers between phone and visual conversations; however, all are considered acceptable one-on-one interview techniques, and therefore the impacts should be minimal. Specific demographic information of the interview participants providing their level of diagnostic experience was originally gathered as a part of a much larger study, and could not be specifically paired to the interview participants because of confidentiality issues. This information would have enhanced the presentation of our results. Finally, the varied athletic training student solicitation and participation methods were due to initially low participation rates, and it is not known if this was due to lack of interest in students or program directors.

CONCLUSIONS

We have highlighted various factors perceived to enhance and hinder diagnostic reasoning development, all of which have been similarly found in other health care studies.[1,26] The development of effective strategies for augmenting diagnostic reasoning skills in both student and professional populations is fundamental to the progress of athletic training and the proliferation of meaningful evidence-based practice in the field, especially in light of the required transition to a professional master's degree for all entry-level practitioners. Additionally, developing diagnostic reasoning–based continuing education for the professional AT population might assist in further developing expert-level diagnostic reasoning by reiterating important strategies considered necessary in reasoning development. Further, other aspects of clinical expertise and expertise building in athletic training need to be defined, measured, and analyzed, and tools designed to do so need to be developed in order to better understand the various differences between true expert thinkers and novices in our field.

Both certified ATs' and athletic training students' perceptions of their diagnostic reasoning processes parallel those of current allied health care students and professionals and are consistent with reported diagnostic reasoning theories and development.[1,4,12,32] Understanding ATs' and athletic training students' perceptions helps illuminate some potential factors that might enhance or hinder diagnostic reasoning development, and is fundamental to the development of educational and professional policies and practices geared towards expert-level reasoning abilities. Although research into diagnostic reasoning is not as developed in athletic training as in other health care professions, it is encouraging that our results align well with reported abilities and theoretical constructs of diagnostic reasoning from other health care professions. Given these findings, we might cautiously surmise that strategies found in other health care fields to enhance diagnostic reasoning hold the potential to do likewise in athletic training, and therefore can be examined with creative research projects. Further research using quantitative inventories such as the DTI-AT[18] or script concordance tests or mixed methods will be necessary to determine if the enhancers and barriers to diagnostic reasoning development found here

have any real effect on diagnostic reasoning development in order for more specific, validated pedagogical tools to be developed.

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