

Validation of the Quantitative Diagnostic Thinking Inventory for Athletic Training: A Pilot Study

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Context: The cognitive process of making a clinical decision lies somewhere on a continuum between novices using hypothetico-deductive reasoning and experts relying more on case pattern recognition. Although several methods exist for measuring facets of clinical reasoning in specific situations, none have been experimentally applied, as of yet, to the profession of athletic training. The Diagnostic Thinking Inventory (DTI) has been used with medical doctors and medical students to determine their level of clinical reasoning as it applies to diagnosis making.

Objective: To validate the DTI for Athletic Training (DTI-AT) and associated interview questions for use in the field of athletic training.

Design: Mixed methodology.

Setting: Online inventory and Skype-based interviews.

Patients or Other Participants: Convenience sample of 25 senior-level athletic training students.

Main Outcome Measure(s): Participants completed an online version of the DTI-AT which rated clinical reasoning tendencies on a 6-point Likert-type scale. Quantitative analysis consisted of determining means and ranges of scores along with reliability of total scores and subset scores. Randomly selected participants were interviewed online in order to provide validity of interview questions that were used to determine personal and professional activities that are either thought to enhance or hinder clinical reasoning. A secondary purpose was to solicit specific feedback that may enhance our understanding of the modified DTI.

Results: A strong reliability was found for total DTI ($r(41) = 0.846$) and an acceptable reliability for flexibility in thinking ($r(21) = 0.731$) and structure of memory ($r(20) = 0.771$).

Conclusions: The modifications of the DTI-AT demonstrated strong reliability and face validity. The DTI-AT may be an effective tool for determining clinical reasoning of athletic training students.

Key Words: Clinical reasoning, education, athletic training students

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INTRODUCTION

Several studies have noted that a common deficiency of entry-level health care professionals is the inability to effectively reason during a difficult clinical situation.¹⁻⁴ Although it is accepted in allied health care education that the development of clinical reasoning is necessary, the concepts surrounding the development of clinical reasoning have been ambiguous and confusing.⁵⁻⁹ Clinical reasoning has most recently been defined in the athletic training literature as “the cognitive processes, decision making, problem solving, or focused thinking used in the evaluation and management of a patient.”^{10(p56)} However, despite consistency in definition, there remains considerable variation in the operational definition and processes of clinical reasoning. Clinical reasoning is a multifaceted concept founded upon a domain- and context-specific version of critical thinking. In order to be used effectively, clinical reasoning requires an accurate and organized collection of data from patient encounters, while incorporating clinical experience to make the best clinical decision.^{5,11-13} Due to many nuances associated with how clinical reasoning is defined, operationalized, measured, and valued, methods capable of determining how to best promote, teach, and evaluate its presence have been difficult.^{5,14,15}

Most experts currently agree the cognitive process of making a clinical decision lies somewhere on a continuum between a method chiefly used by novices as hypothetico-deductive reasoning (HDR) and a more sophisticated method used by experts known as case pattern recognition (CPR).^{10,11,16} Hypothetico-deductive reasoning, or analytic reasoning, is a more purposeful and conscious process that involves gathering large amounts of data in order to determine several plausible hypotheses for a diagnosis and then confirming or eliminating potential conclusions based on thorough experimentation.^{10,11,16} Case pattern recognition is considered to be less analytical, instead working on a subconscious level and operating in the minds of more experienced clinicians who are better able to recognize and relate the various data pieces that are presented in the patient encounter. Case pattern recognition relies on the ability of the clinician to efficiently and expertly store and access his or her knowledge and experiences so that the clinical relationships between specific bioscientific knowledge (anatomy, physiology, pathoetiology, epidemiology, biomechanics, etc) and typical signs and symptoms (or key features) can be used and recognized to formulate known case patterns (or illness/injury scripts or schemas), all while being flexible to the potential diagnostic alternatives.^{8-11,16} Case pattern recognition is considered a more efficient and timelier method of cognitively organizing data, thus typically leading to quicker and more accurate diagnoses.^{8-11,16,17} However, in the presence of unique or misleading information in an unfamiliar case, an expert clinician may resort to using HDR as his or her chief strategy in order to eliminate the increased number of potential hypotheses in play because of the unique features and findings presented.^{8-11,16,17}

Until recently, there have been few valid tools reported in the literature for measuring clinical reasoning ability.¹⁸ Furthermore, the few measuring tools in existence are either case specific or so varied in methodology it is often difficult to conclude whether one tool is more effective than another in measuring clinical reasoning across allied health care fields.^{18,19} Due to this relative lack of valid measuring instruments, it has been difficult to effectively or critically evaluate the many pedagogies suggested for developing expert clinical reasoning.²⁰ In order to determine an individual's cognitive process when making a clinical decision, Bordage et al¹⁷ developed and validated the Diagnostic Thinking Inventory (DTI) for general medicine students and practitioners. This tool contains 41 items using a Likert-type scale which rates each answer as being more indicative of HDR or CPR.¹⁷ Of the 41 inventory items, 20 were designed to measure *structure of memory*, and 21 were designed to measure *flexibility in thinking*. According to Bordage et al,¹⁷ structure of memory refers to the availability and ready access of stored and organized knowledge during the diagnostic process and is largely dependent upon the accumulation of reflective experience. Flexibility in thinking refers to a clinician's ability to use multiple methods of investigation and analysis while allowing for alternative diagnostic possibilities in light of key features that may conflict with previous knowledge or in the absence of any key features to guide the diagnosis.¹⁷

For example, if a female volleyball athlete presents with profound knee pain after awkwardly landing from a jump, a more experienced clinician with a very structured memory will subconsciously and quickly recognize a familiar case pattern founded upon his or her structured knowledge that has connected the demographics, sport, mechanism of injury, and initial presentation into a known and previously experienced pattern. With this sophisticated knowledge scheme, the experienced clinician knows the likelihood of a young, female jumping athlete sustaining a noncontact knee injury upon landing. Additionally, this clinician uses what Lemieux and Bordage²¹ terms *semantic axes* by automatically converting “my knee went in” to *valgus collapse*, and “I heard a ‘pop’” to *significant tissue damage or failure*. Quickly and seamlessly, an experienced clinician with a structured and elaborated memory will recall the case-specific key features of previously experienced knee injuries and his or her biomedical knowledge base with this type of presentation, and will automatically prioritize the relationships between them to narrow potential diagnostic possibilities, more simply known as forming and recalling of a case pattern presentation or injury script.¹⁴ Very quickly and rather automatically, the experienced clinician will be thinking the athlete has ruptured his/her anterior cruciate ligament, and thus his or her subsequent injury evaluation will be streamlined and organized toward that diagnosis. Therefore, more expert-level clinicians will score higher in structure of memory and flexibility in thinking on the DTI, indicating a proclivity towards a CPR style of clinical reasoning.¹⁷

However, if the same patient scenario is presented to a less experienced clinician who primarily uses the more analytic diagnostic processes of HDR to problem solve, he or she will typically display a longer, less organized, and more deliberate evaluation, over thinking the data being collected before moving to subsequent steps in order to ensure thoroughness and accuracy. The novice clinician will have a less organized memory structure due to more limited diagnostic experiences, limiting his or her ability to form injury scripts. Additionally, the novice will display less flexibility in thinking by ignoring contributing or unusual signs because they do not fit with his or her preconceived diagnosis. Therefore, the novice will be limited in ability to determine the relevance and meaning of the collected case data and expand his or her diagnostic possibilities.^{8,11,12,16} According to Bordage et al,¹⁷ novices will score lower in items that indicate structure of memory and flexibility in thinking on the DTI, which may be indicative of HDR.

In recent years, several authors have used the DTI to measure the clinical reasoning abilities of practicing physicians and medical students alike.^{22–25} The DTI has been shown to be a reliable tool with strong content validity for determining the level of cognitive flexibility and memory structure that expert physicians and medical students use in their clinical practice. However, to date, the DTI has only been administered to medical students and physicians and thus needs to be expanded to other health care fields.

Currently, there are few published articles on clinical reasoning within athletic training and, to our knowledge, no publications concerning the experimental measurement of clinical reasoning specific to athletic training.^{10,26–29} The use of the DTI for Athletic Training (DTI-AT) in athletic training holds promise for allowing athletic trainers to assess their own clinical reasoning abilities, for educators to assess the clinical reasoning abilities of their athletic training students, and for educational researchers to determine if specific pedagogies are effective and valid. Therefore, employing the DTI-AT has the potential to significantly impact both the practice and educational processes of athletic training by assessing and strengthening clinical reasoning abilities and may even lead to improved patient outcomes and advancement of the profession.

The purposes of the pilot study were 3-fold: (1) to validate context-specific alterations of the DTI that were needed to construct the DTI-AT, (2) to provide validity to the opening scenario used with the DTI-AT, and (3) to ensure there were no technical issues associated with the new, online format of DTI-AT testing. Additionally, we conducted a qualitative follow up of 5 interview questions to investigate which factors might be enhancing or hindering clinical reasoning development, followed with several additional questions to ensure questions used in the follow-up interview and verbiage and content of the DTI-AT were appropriate and understood by the participants.

METHODS

Instrumentation

The instrument was adapted from Bordage et al,¹⁷ who developed and provided the DTI to first-year medical

students, third-year medical students, and various categories of expert-level physicians with greater than 3 years' experience. A total of 270 subjects participated, and a cumulative inventory reliability of 0.84 was calculated. The reliability of questions specific to memory structure was reported as 0.74, with a 0.72 reliability for questions measuring flexibility in thinking. Furthermore, discrimination indices were performed on all DTI questions and found to be acceptable for all questions, adding to the construct validity of the inventory. Fisher's protected least significant difference post hoc analysis demonstrated all medical doctor groups scored significantly higher than first- and third-year medical students in total DTI and both subset scores ($P = .0001$). Additionally, the registrar physicians (senior-level clinical instructors) demonstrated significantly higher ($P = .0001$) scores in all scoring categories than senior house officers (junior doctors in first year of residency).

Permission to use and alter the DTI was provided through e-mail by primary author Bordage and subsequently by John Wiley and Sons, publisher. Once permission was obtained, the primary author along with a committee composed of a clinical reasoning expert and 2 education researchers altered specific questions within the DTI to reflect athletic training practice. The alterations of specific questions can be found in the Figure. The alterations did not adjust the ratio of questions used to measure flexibility in thinking (21) and memory structure (20). Additionally, through the suggestion of Bordage during e-mail communication, the authors provided an introductory scenario to be used with the DTI-AT providing a reference point for the participants to more specifically answer the questions (see the Figure). Content validity for this introductory scenario and the DTI-AT was determined through peer debriefing prior to data collection and member checking with the participants following the data collection.

Upon revision of the DTI, the online version of the inventory was built using the Remark survey software³⁰ provided through the institution of the primary researcher. The Remark software allowed the inventory to be designed to mimic the original design of the DTI as accurately as possible. Once the online version of the DTI-AT was designed, a link was sent to each member of the committee to review for possible grammatical, spelling, or content errors. Additionally, each committee member completed the inventory to determine any technical issues associated with the software and downloading of the data. Once the online version of the DTI-AT was completed, the pilot study participants were contacted to participate in the study.

Participants

Convenience sampling consisted of recruiting 25 senior-level students from 2 undergraduate Commission on Accreditation of Athletic Training Education accredited athletic training programs. Of the 25 participants recruited, 13 completed the inventory, and 3 participants from 1 institution were randomly selected to engage in the Skype-based interview. These institutions were chosen due to their association with members of the study committee. Every senior athletic training student was over the age of 18 and therefore had the right to disclose his or her personal contact information according to the Family Educational Rights and Privacy Act.

Figure. Diagnostic Thinking Inventory for Athletic Training with opening scenario and alterations of questions 19, 21, and 39. The alterations of the questions are in parentheses below the original question.

A 19-year-old volleyball player presents with right shoulder pain that has been present over about 2 weeks. Patient denies any previous history of right shoulder injury or trauma and is unable to specify a specific mechanism of injury. She primarily notices a mild, sharp pain when serving, blocking, and spiking that progressively worsens as practice progresses and is uncomfortable at night.

1. When the patient presents symptoms,

I think of the symptoms in the precise words used by the patient

I think of the symptoms in more abstract terms than the expressions actually used (eg, '4-day duration' becomes 'acute'; 'two-hands' becomes bilateral)

2. In considering each diagnosis,

I try to evaluate their relative importance

I try to give them equal importance or weighting

3. In thinking of diagnostic possibilities,

I think of diagnostic possibilities early on in the case

First I collect the clinical information and then I think about it

4. When I am interviewing a patient,

I often seem to get one idea stuck in my mind about what might be wrong

I usually find it easy to explore various possible diagnosis

5. Throughout the interview,

If I follow the patient's line of thought, I tend to lose my own thread

I can still keep my own ideas clear even if I follow the patient's line of thought

6. When it comes to making up my mind about a diagnosis,

I do not mind postponing my diagnostic decisions about a case

I feel obliged to go for one diagnosis or another even if I am not very certain

7. Once the patient has clearly presented his symptoms and signs,

I think about them in my mind in the patient's own words

I translate them in my mind into medical terms (eg, 'numbness' becomes 'paraesthesia' or 'paralysis')

8. In relation to the routine history,

I often feel that I did not sufficiently cover the routine history

I usually cover the routine history to my satisfaction

The committee members were not involved in the data collection or analysis.

Procedures

Committee members associated with the participating institutions provided institution e-mail addresses of all senior-level athletic training students to the primary investigator. The athletic training student participants were contacted by the

primary investigator through a solicitation e-mail. No incentives or disincentives were provided by the committee members at each institution to any student choosing to participate or not participate in the pilot study. Students were given 1 week to agree to participate in the study by returning the signed informed consent document. All students who responded within 1 week were selected to participate in the study and were provided an online link and password to access the DTI-AT. Three participants from 1 institution were

Figure. Continued

9. **As the patient tells his story and the case unfolds,**
I often find it difficult to remember what has been said *I can usually keep track in my mind of what has been said*
10. **During the course of the interview, I find that,**
Some key pieces of information seem to leap out at me *It is often difficult to know which items of information to latch on to*
11. **When I cannot make sense of the patient's symptoms,**
I move on and gather new information to trigger new ideas *I ask the patient to define those symptoms more clearly*
12. **In considering diagnostic possibilities,**
I often come up with unlikely diagnoses *I am usually in the right area*
13. **While I am collecting information about a patient,**
The various items of information usually seem to group themselves together in my mind *I often have difficulty seeing how the pieces of information relate to each other*
14. **When the diagnosis becomes known and I realise that I have missed it initially,**
It is often because I knew the disease but failed to think about it *It is often because I did not know enough about the disease*
15. **During the clinical interview,**
I cannot bring myself to dismiss some information as irrelevant *I am quite happy to dismiss some information as irrelevant*
16. **When I cannot make sense of the patient's symptoms and signs,**
I move on to get new information and a new perspective *I look at them from a different perspective before moving on*
17. **When I consider a number of possible diagnoses,**
The diagnoses tend to be related to one another *The diagnoses tend to be scattered*
18. **When a possible diagnosis comes to my mind,**
I usually find myself anticipating possible abnormal signs and symptoms that go with that diagnosis *Quite often, it does not help me to decide what to ask the patient next*

randomly selected using a random number generator to participate in the interview. Each pilot study participant completed the DTI-AT on a computer at the location of his or her choosing. Upon completion of the DTI-AT, each participant sent an e-mail to the primary investigator indicating completion of the inventory in order to schedule

the interview. Scores from the DTI-AT were saved into Microsoft Excel (Redmond, WA) and then copied directly into SPSS (version 18.0; SPSS Inc, Chicago, IL)³¹ for analysis. Interview participants were contacted immediately upon receipt of the e-mail, and an interview was scheduled within 48 hours of completing the DTI-AT. Participants were free to

Figure. Continued

19. **When I know very little about a particular type of disease,**
(When I know very little about the particular injury or condition,)
- I can still usually come up with a diagnosis* *I have great difficulty in reaching a diagnosis*
20. **In considering the patient's signs and symptoms,**
- I think about each in absolute terms as stated by the patient* *I think of them in terms of possible opposites (eg, progressive vs. sudden; unilateral vs. bilateral; spastic vs. flaccid)*
21. **When I know a lot about a particular type of disease and have to make a diagnosis,**
(When I know a lot about a particular type of injury or condition and have to make a diagnosis,)
- I find it relatively easy to pin down a diagnosis* *I often seem to be all over the place and have difficulty pinning down a diagnosis*
22. **As the history progresses and I already have some ideas about the possible diagnosis(es),**
- New information often makes me have more ideas* *New information does not often make me have more ideas*
23. **When I am taking a history, I find that,**
- I can get new ideas just by going over the existing information in my mind* *I need to have new information to make me have a new idea about the case*
24. **When patients use imprecise or ambiguous expressions,**
- I let them go on to maintain the flow of the interview* *I make them clarify precisely what they mean before going on*
25. **After an interview with a patient,**
- I rarely think of other things that I should have asked in relation to the patient's disorder* *I often think of other things that I should have asked in relation to the patient's disorder*
26. **When a piece of information comes along and makes me think of a possible diagnosis,**
- It often makes me go back to previous information to see if things fit together or not* *It rarely makes me review the information that I have gathered previously*

not answer questions they did not wish to answer. See Table 1 for interview transcript. The interviews were digitally recorded and transcribed with the data being stored on a secure server. Interview data was analyzed by the primary researcher and an additional content expert.

This study was approved through the Institutional Review Board of Rocky Mountain University of Health Professions. Additionally, institutional review board exemption was

provided by both participating institutions to use their students in the study; however, only 1 institution's review board provided permission to interview their students.

Data Analysis

Quantitative data obtained from the DTI-AT were saved to Microsoft Excel and then copied and pasted directly into SPSS for analysis of means, standard deviations, ranges, and

Figure. Continued

27. **In relation to the diagnosis I eventually make,**
I usually have very few doubts *I often feel too uncertain for my own comfort*
28. **In making a diagnostic decision,**
I decide by considering each possible diagnosis separately on its own merits *I decide by comparing and contrasting the various possible diagnoses*
29. **When I know a lot about a particular type of disease and have to make a diagnosis,**
I check up on most possibilities before reaching a decision *I often have lots of ideas that I don't explore further*
30. **As the case unfolds,**
I do not find it useful to summarise as I go along *I periodically take stock of the data and my ideas*
31. **When I reach my diagnostic decisions,**
There is often left-over information I have just forgotten about *I usually will have considered all the information*
32. **When I have got an idea about what might be wrong be the patient,**
I feel most comfortable if I can follow it up without being diverted *I feel happy to go off on another tack and come back to my original ideas later*
33. **When I come up with a broad idea as to what might be wrong with the patient,**
I can usually proceed to a specific diagnosis *I find it difficult to put it into specific terms*
34. **Throughout the interview,**
I manage to test my ideas even if I let the patient control the interview *I am only successful if I can control the direction of the interview*
35. **In relation to choosing from among the diagnostic ideas that I have,**
I am usually not capable of wholly ruling out any of the ideas I have had *I am capable of ruling out most of my ideas completely*
36. **Once I have made up my mind about a patient,**
I am prepared to change my mind *I really do not like to change my mind*
37. **When I consider my diagnostic ideas, I do so on the basis of,**
The case as a whole so far *A few outstanding symptoms or signs*

reliability for total DTI-AT scores, flexibility in thinking scores, and structure of memory scores.

RESULTS

Cronbach α was calculated for total DTI-AT score and the flexibility in thinking and structure of memory subcategories. A strong reliability was found for total DTI-AT ($r(41) =$

0.846, power = 0.99) and an acceptable reliability for flexibility in thinking ($r(21) = 0.731$, power = 0.85) and structure of memory ($r(20) = 0.771$, power = 0.92). These reliability levels were slightly higher than those originally reported by Bordage et al.¹⁷ See Table 2 for mean, SD, and range.

The purpose of including interview questions within the pilot study was to determine if the wording and methods of asking

Figure. Continued

<p>38. If I do not know what to make of a clinical interview,</p> <p><i>I can readily see the information in new ways</i></p>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<p><i>I find it difficult to see the information in new ways</i></p>
<p>39. When I order laboratory tests, (When I determine which diagnostic tests (eg: MRI, CT scan, ultrasound) I would like ordered,)</p> <p><i>I do it as part of the routine clinical investigation</i></p>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<p><i>I do it expecting specific information or supporting evidence</i></p>
<p>40. In considering diagnostic possibilities,</p> <p><i>I compare and contrast the possible diagnoses</i></p>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<p><i>I consider each diagnosis separately on its own merits</i></p>
<p>41. In terms of the way I conduct an interview,</p> <p><i>I usually cover the ground that I need to during the interview</i></p>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<p><i>Quite often I do not ask all the questions that I should at the time</i></p>

questions would elicit information regarding the participants' personal and professional behaviors thought to either hinder or enhance their critical reasoning ability, thus increasing content validity. Participant responses were initially analyzed by the principle investigator and subsequently reviewed using critical friend analysis and member checking to determine if the data was representative of information we desired to obtain from the interview and to challenge primary investigator biases. Additionally, interview data analysis using a general inductive approach was conducted to ensure that proper analysis techniques will be used in future studies of a broader athletic trainer and athletic training student spectrum. Due to lack of saturation for answer content of the original 5 interview questions (see Table 1), that specific data is not presented; however, 100% of participants responded positively to additional validity-determining questions regarding their understanding of the interview questions, inventory, and introductory scenario.

DISCUSSION

Based on our results, the refinement of the original DTI into the DTI-AT has not limited the reliability and may provide face validity for adoption of the instrument. The strong reliability scores combined with high power demonstrate this tool can be effective for measuring different methods of clinical reasoning abilities in athletic training students even with small participant numbers. Since discrimination index analysis determined the original DTI to have content validity, the similar participant scores and reliability analysis adds to

the potential of content validity of the DTI-AT. In addition to the peer review prior to data collection, face validity was further determined by asking the participants if there were any specific items on the inventory they found unclear or confusing. All participants indicated each DTI-AT question was clear, and at no point in the inventory were they confused regarding the questions or any of the potential answer alternatives. Additionally, the DTI-AT introductory situation was clear to each student and helped to provide context for the inventory questions. Since the inventory was clear to senior-level undergraduate students, it stands to reason it will be clear to professional athletic trainers. Therefore, researchers and educators should feel confident in using the DTI-AT to determine athletic training student clinical reasoning abilities. However, more research needs to be conducted in order to determine if the DTI-AT is a valid tool for measuring clinical reasoning of other individuals within the profession of athletic training and in using the DTI-AT to determine progression of clinical reasoning following changes in curriculum or pedagogy, as has been done in medical education.^{22,24,25,32}

The participant scores on the DTI-AT were similar to those found with medical students in previous studies, demonstrating the alterations do not affect the reliability of the inventory. Additionally, inventory score comparison revealed that athletic training students appear to have similar clinical reasoning abilities to medical students.^{22,24,25} Bordage et al¹⁷ originally reported total DTI scores of 153.9 and 158.3 for first- and third-year medical students, respectively. In a study

Table 1. Interview Transcript

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 that you have engaged in over time that you feel have helped to develop your clinical reasoning ability?
3. Please explain some professional activities (clinical experiences and professional development for students) that you have engaged in over time that you feel have helped to develop your clinical reasoning ability?
4. What are some issues in your personal life that act as barriers to your clinical reasoning development?
5. What are some issues in your professional (clinical experiences and professional development for students) life that act as barriers to your clinical reasoning development?

Table 2. Diagnostic Thinking Inventory for Athletic Training Pilot Study Scores

	Mean ± SD	Range
Total Diagnostic Thinking Inventory for Athletic Training	175.85 ± 15.61	153–204
Flexibility in thinking	89.54 ± 9.22	75–107
Structure of memory	86.31 ± 7.91	74–102

of second-year medical students, Windish et al²² reported DTI scores of 145.3 for the control group with no training in clinical reasoning development and 149.3 of those who completed clinical reasoning training. Jerant and Azari²⁴ found scores of 164.6 and 175.1 of third-year medical students' preclerkship and postclerkship, respectively. Additionally, the authors found these scores correlated well with other tools being used to measure clinical reasoning. Finally, Lee et al²⁵ determined similar DTI scores of 162 in fourth-year undergraduate medical students in Hong Kong. Interestingly, the scores of the athletic training participants were higher than previous studies (see Table 3); however, this could be attributed to several potential factors such as their specific undergraduate curriculum program stressing clinical reasoning development throughout their athletic training education, varied clinical/placement experiences, level of autonomy provided by preceptors, diagnostic reflective activities accentuated within programs, or number of diagnostic opportunities afforded to students.

There were several limitations of this study. First, the participant size of 13 was small. Although this did not limit the power of quantitative data analysis, a more robust study needs to be conducted with a wide variety of athletic training student and athletic trainer participants to better understand a broader spectrum of clinical reasoning in the field of athletic training and provide content validity. Additionally, students were purposefully sampled from institutions using a clinical reasoning-based pedagogy; therefore, results cannot be generalized to the athletic training student population as a whole. Finally, the small number of interviews did not allow for true saturation of the 5-question interview data, however was sufficient to determine the introductory scenario, DTI-AT, and interview questions used were understood and would lead to the collection of intended data. Additionally, the presence of the scenario for the DTI-AT may have altered the scores of the participants by forcing the participants to answer in a context-specific manner as opposed to dependent on the specific scenario. It is unknown if the scores on the DTI-AT measured the true trait of clinical reasoning ability or rather a state of clinical reasoning specific to the provided scenario. We think the DTI-AT can be a valid measure of clinical reasoning ability; however, the high scores of the student participants with relatively limited experience need to be

further analyzed with a more expansive athletic training student participant range.

Further studies are currently being conducted using the DTI-AT and interview questions to determine true athletic trainer and athletic training student clinical reasoning abilities and perceptions across various years of experience, practice settings, and educational levels. This additional research will aid in providing standard scores of clinical reasoning across the profession to aid in comparison of abilities. Further studies using multiple scenarios need to be conducted to add to the validity of the DTI-AT as a resource for measuring true clinical reasoning ability and development. In addition, further analysis of future qualitative interview data should be conducted to determine true relationships between the perceived enhancers and barriers to clinical reasoning development.

In conclusion, the modifications made to the DTI-AT in order to better address the population being studied supported the strong reliability reported by the authors of the original inventory. Therefore, the current DTI-AT can now be further used and analyzed in order to determine its validity across various subpopulations and within other contexts. Therefore, the modified DTI-AT reported here can be considered an effective tool for determining clinical reasoning strengths and weaknesses of athletic training students and therefore may be an effective inventory for athletic training educators wishing to study clinical reasoning abilities and pedagogies.

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Table 3. Diagnostic Thinking Inventory (DTI) Study Comparison Scores

Study	Total DTI Score	Structure of Memory	Flexibility in Thinking
DTI for Athletic Training pilot study	175.85	86.31	89.54
Bordage et al ¹⁷	153.9 and 158.3	74.7 and 81.6	79.2 and 76.7
Windish et al ²²	145.3 and 149.3	Not available	Not available
Jerant and Azari ²⁴	164.6 and 175.1	79.7 and 85.5	84.9 and 89.6
Lee et al ²⁵	162	77.7 (11.6)	84.3 (10.7)

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