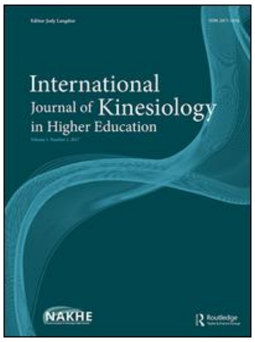

International Journal of Kinesiology in Higher Education

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/ukhe20

Applying Clinical Reasoning Theories to Kinesiology: Advancing the Education of Future Healthcare Professionals

Rebecca Ataman & Robyn J. Ibey

INTERNATIONAL JOURNAL OF KINESIOLOGY IN HIGHER EDUCATION
https://doi.org/10.1080/24711616.2021.1881418

Routledge
Taylor & Francis Group

BEST PRACTICES IN TEACHING

Check for updates

Applying Clinical Reasoning Theories to Kinesiology: Advancing the Education of Future Healthcare Professionals

Rebecca Ataman [a] and Robyn J. Ibey [b]

[a]School of Physical and Occupational Therapy, Faculty of Medicine, McGill University, Montréal, Canada; [b]Department of Kinesiology, Faculty of Applied Health Sciences, University of Waterloo, Waterloo, Canada

ABSTRACT

In Canada, kinesiology academic units are undergoing change. The growth of kinesiology as a health profession is reflected in increased clinical course offerings to train student clinicians. These courses require clinical educators, however, not all programs have clinical staff and faculty with the required knowledge or experience. In particular, prospective clinical educators may lack fundamental knowledge of clinical reasoning theory. Clinical reasoning is defined as problem solving and judgment in relation to patient or client assessment, diagnosis, treatment and management, and is considered to be essential for the development of autonomous health professionals. Clinical reasoning theory is applied in an educational context to streamline and enhance student clinician development. Unlike in the education of other health professionals, there has been no literature detailing the application of clinical reasoning theory to the kinesiology educational context. Thus, the objectives of this paper are to: (1) introduce the theories in clinical reasoning relevant to kinesiology, (2) link these theories to practical educational strategies and, (3) connect these strategies directly to the teaching of clinical kinesiology subjects.

KEYWORDS
Kinesiology; professional kinesiology; clinical reasoning; clinical teaching

Introduction

The profession of kinesiology is growing rapidly in Canada. For example, the number of registered kinesiologists regulated by the College of Kinesiologists of Ontario grew by 14% year over year since inception in 2013 (College of Kinesiologists of Ontario, 2018). Mirroring this trend, kinesiology academic units are expanding their focus from the multidisciplinary scientific study of human movement and performance (Bergeron et al., 2014; Elliott, 2007) to include a stream focussing on the development of clinicians who work in human movement and performance – kinesiologists (The Kinesiology Act, 2007). There have been alterations to the entry-to-practice undergraduate course offerings and curriculum, as evidenced by the recent increase in both clinical courses (e.g., 6 courses (University of Waterloo, 2016) versus 14 courses (University of Waterloo, 2020)) as well as the addition of advanced degree programs in professional kinesiology (e.g., (University of Toronto Faculty of Kinesiology and Physical Education, 2019) or (University of British Columbia School of Kinesiology, 2019)) such

CONTACT Rebecca Ataman rebecca.ataman@mail.mcgill.ca Davis House, 3654 Promenade Sir-William-Osler, McGill University, Montréal H3G 1Y5, Canada.

Authorship: RA conceived of the original design of the work and wrote the original draft. RI added to the design of the work, and provided critical feedback throughout the drafting process. Both authors give final approval of the version to be published and agree to be accountable for all aspects of the work.

that kinesiologists can gain additional professional skills. Clinical faculty are required, however professors in kinesiology are often experts in a specific discipline and do not possess the expertise to practice as kinesiologists (Elliott, 2007). To address this human resource gap, practicing clinicians may be called on to meet the needs of the expanding curriculum.

While clinicians will have the technical skills required to teach clinical courses to kinesiology students, they may have less experience as educators and or in related roles such as mentoring. For example, less than 1% of members reported expertise in mentoring or training in the membership statistics of one provincial kinesiology association (Ontario Kinesiology Association, 2020). Competence as both a clinician and educator is necessary to be an effective clinical educator (Irby, 2014). Although educational experience can be gained over time, knowledge of educational theories can immediately provide frameworks for clinicians to understand and implement best practices in education (Kaufman, 2003). For clinical educators, the most relevant educational theories may be those developed to describe and provide frameworks to effectively teach clinical reasoning (CR).

CR is defined as problem solving in the clinical environment and encompasses the complex cognitive processes needed to make assessment, diagnosis, treatment and management decisions (Simmons, 2010); this is an essential component of clinical practice (Higgs et al., 2019). At a practical level, to be competent in CR is to be able to appropriately apply technical skills and clinical knowledge in practice.

CR theories provide frameworks to understand the clinical decision making of expert clinicians and to enhance the teaching of CR to student clinicians. In fact, it has been demonstrated that a knowledge of CR theories and the use of derived teaching strategies can lead to better diagnostic outcomes in students (Eva et al., 2007). Thus, clinical educators with the knowledge and ability to incorporate CR theory into clinical education may offer students an enhanced learning environment.

Unlike in medicine (Elstein et al., 1978), physiotherapy (Gilliland, 2014), athletic therapy (Heinerichs et al., 2013), nursing (Banning, 2008a) and other health professions (Jensen, 2011; LeMoon, 2008; Rogers & Holm, 1991), there appears to have been no investigations into the CR of kinesiology clinicians or students, or literature regarding the application of CR concepts and theories to kinesiology education. With the greater focus on clinical subject matter, it is imperative that kinesiology educators – especially clinician educators – have knowledge of CR theories and can apply them to the kinesiology context.

Thus, the purpose of this paper is to: (1) introduce the theories in CR relevant to kinesiology, (2) link these theories to practical educational strategies and (3) connect these strategies directly to the teaching of clinical kinesiology subjects.

Major clinical reasoning theories and concepts

Historically, CR research has focused on diagnostic and assessment reasoning (Norman, 2005) although there has been recent interest in the area of management reasoning, or CR during treatment and ongoing care (Cook et al., 2019). Kinesiologists work in both contexts. It is useful to understand all relevant theories as they highlight different aspects of CR and complement one another (Young et al., 2018) (Figure 1). Furthermore, strategies arising from multiple theories are often used simultaneously by clinicians (Bowen, 2006; Norman, 2006). Although CR strategies have not been directly investigated in kinesiology, when applied to a common clinical scenario there is a similar phenomenon of simultaneous and overlapping

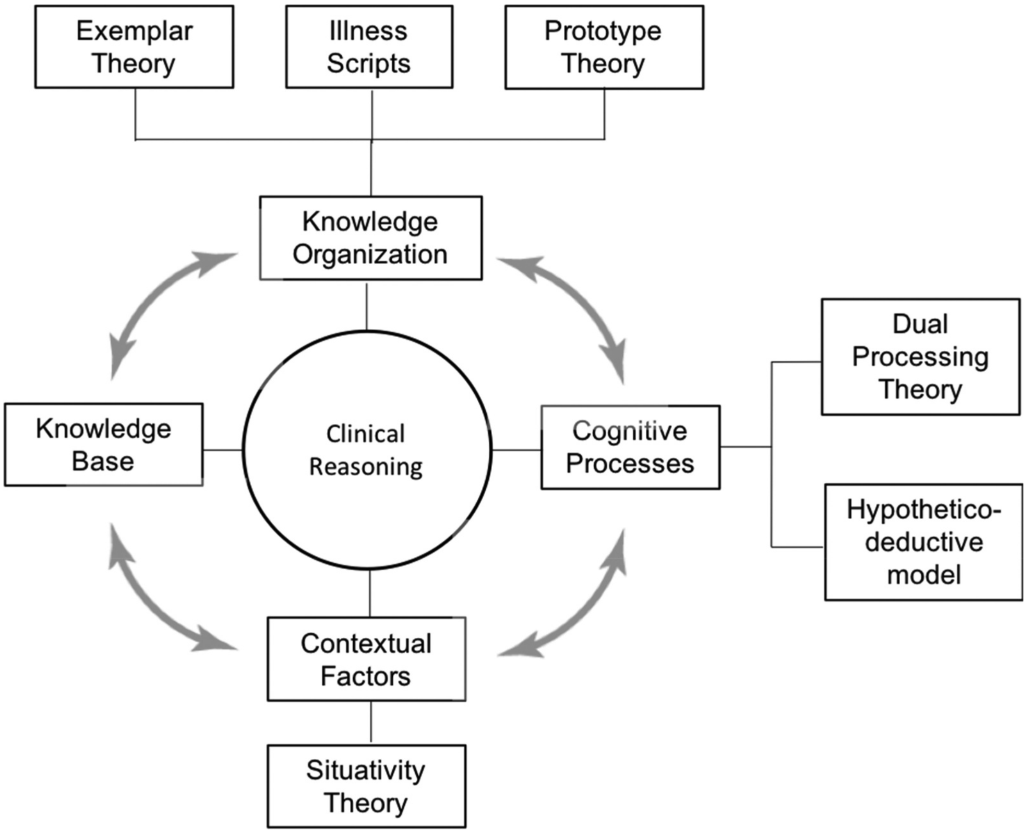

Figure 1. A visual representation of clinical reasoning theories relevant to the teaching of kinesiology due to their inclusion in both diagnostic and management reasoning literature. This is not a representation of all clinical reasoning theories found in the health professions education literature. Various aspects of clinical reasoning described by clinical reasoning theories are interconnected and overlap, and are arranged in a non-linear manner. The necessary building blocks of clinical reasoning according to the included theories (knowledge base, knowledge organization, cognitive processes, and contextual factors) are themselves building blocks for one another. This representation is not a theoretical model and is included as a visual aid only.

use of reasoning strategies (Figure 2). Therefore, multiple theories that can be applied to both diagnostic and management reasoning should inform educational strategies when teaching clinical subjects to kinesiology students. Based on clinical reasoning theories used in both diagnostic and management reasoning according to knowledge syntheses (Cook et al., 2019; Young et al., 2018), there are four domains of CR theories relevant to kinesiology: knowledge base, knowledge organization, cognitive processes and contextual factors.

Knowledge base (Figure 2: Underlies all steps)

The most basic "theory" in CR is that a strong basis of domain knowledge is required to be a domain expert (Elstein et al., 1978; K. Eva et al., 1998). Knowledge of both clinical skills and basic science subjects is critical (Boshuizen & Schmidt, 2019; Schmidt & Rikers, 2007). Research has shown that expertise in CR is not transferable from one domain to another if the clinician doesn't

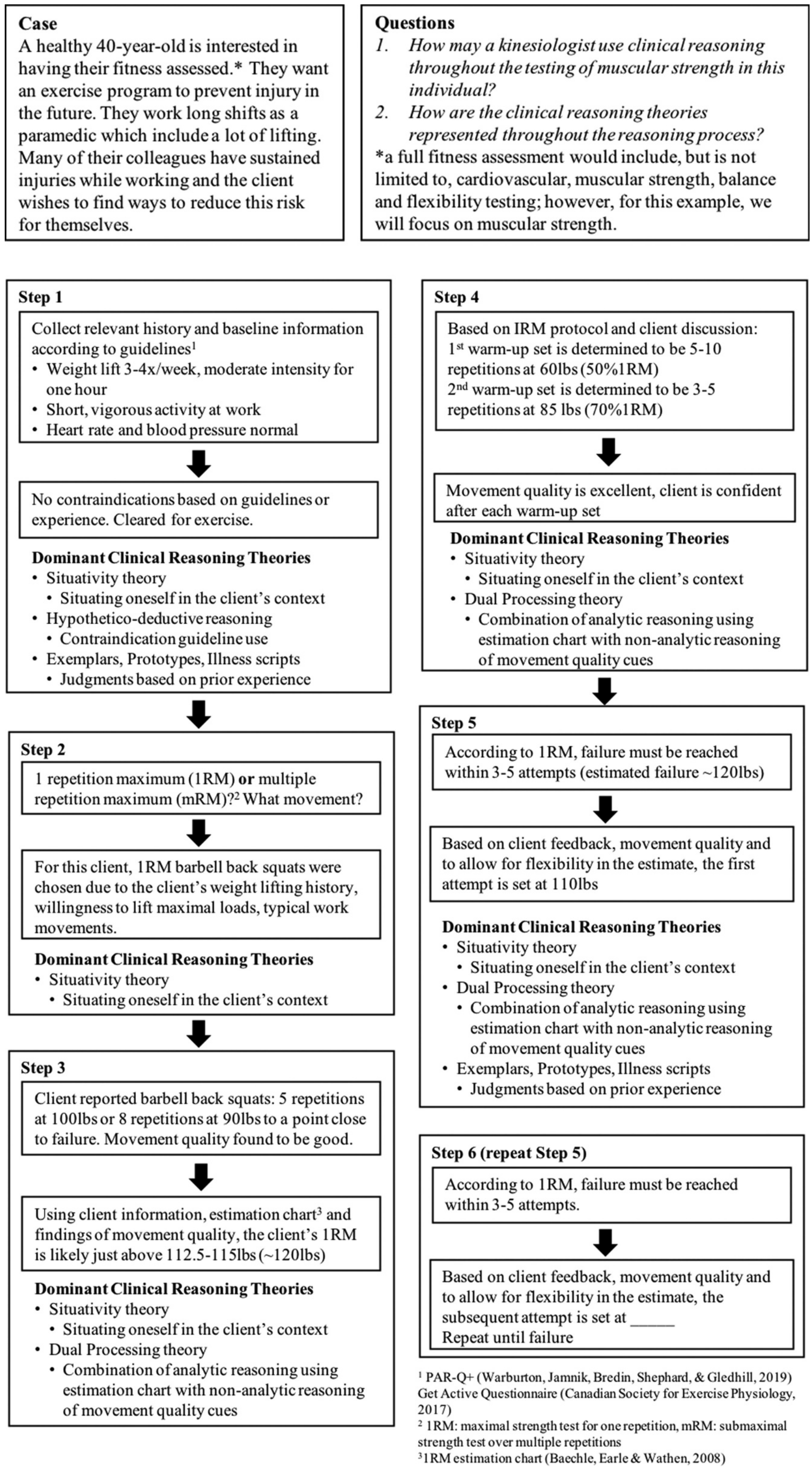

Figure 2. Kinesiology case study – Muscular strength assessment.

have a solid knowledge base in the new domain (Elstein et al., 1978). Thus, the development of CR expertise should encompass information across a clinicians' scope of practice.

Knowledge organization theories (Figure 2: Step 1, step 5)

Knowledge organization theories describe how clinically relevant information is stored in memory to be effectively used for CR (Young et al., 2018). While each theory highlights a different aspect of knowledge organization, collectively, they assert that well organized knowledge relevant to the clinical domain is required to be clinically successful within that domain.

Prototype theory

Prototype theory states that learners require a strong understanding of the typical presentation and management options of a certain ailment. Experts use these prototypes to compare and contrast different presentations and management options against that which is considered typical. To gain expertise, learners must see many cases which show a typical presentation and expected management options to form a prototype in memory (Georges Bordage & Zacks, 1984).

Exemplar theory

Exemplars are experiences stored in memory which are referred to by clinicians when confronted with similar cases. It is thought that clinicians find the exemplar that fits most closely to their current client, and proceed based on their prior experience (Brooks, 1978).

According to exemplar theory, to gain expertise learners must see a large, varied body of examples to be competent in a certain clinical scenario. The variation a learner is exposed to should span various client presentations, as well as values, preferences, communication styles, contextual factors, system constraints (e.g., cost-benefit) and potential solutions (Cook et al., 2019). Exemplar theory also suggests that new material is learned through the lens of what the individual already knows. Thus, the order of cases and examples given to learners should be carefully considered.

Illness scripts

Illness scripts propose that clinically relevant information and experiences are optimally stored in memory such that expert clinicians can quickly recognize client ailments. This limits clinician's conscious reasoning during clinical scenarios that they consider routine, and instead allows them to make highly accurate inferences and assumptions based on minimal information (Boshuizen & Schmidt, 2019).

The development of illness scripts is a multi-step process (Boshuizen & Schmidt, 2019; Custers, 2018; Schmidt & Rikers, 2007). At first, a student's illness scripts primarily contain basic science knowledge which is poorly linked to clinical concepts. As they progress, knowledge of basic science is summarized by clinical concepts (Schmidt & Rikers, 2007). For example, the clinical concept of carpal tunnel syndrome encompasses anatomical, physiological and biomechanical knowledge. Knowledge of the arrangement of bones, tendons and nerves of the wrist must be combined with the biomechanical principles of movement of that joint and the physiological effects of nerve compression to appreciate the mechanisms of injury. This arrangement of critical basic science information offers the beginnings of a multifaceted understanding of clinical concepts. Following this initial summary of knowledge, and as learners are exposed to clinical experiences, they begin to develop a true network of knowledge by making connections between interrelated information. As certain scenarios become familiar over the course of experience, this networked knowledge is arranged into a fully formed illness script which allows for inferences and non-analytic reasoning via "pattern recognition" (Boshuizen & Schmidt, 2019).

Cognitive processing theories

Cognitive processing theories describe the CR process itself, as opposed to the knowledge underlying it. Individually, each of the following theories propose a different cognitive process used by clinicians. Collectively, these theories assert that different reasoning processes are used in different clinical scenarios.

Hypothetico-deductive model (Figure 2: Step 1)

The hypothetico-deductive model describes the CR process as the initial generation of hypotheses and the subsequent analytic reasoning to test these hypotheses. This approach seeks to ensure all information relevant to diagnosis, treatment and management is collected by the clinician for informed decision making (Elstein et al., 1978).

Hypothetico-deductive reasoning is more common in student clinicians, especially for typical or "easy" clients or patients. Students in their first or second year of training have been shown to use reasoning processes which can be considered pre-cursors to hypothetico-deductive reasoning. These include trial and error (no hypothesis or plan), following protocols and checklists learned in class, and rule-in/rule-out strategies (generating hypotheses, but unable to develop and follow a comprehensive plan to test them) (Gilliland, 2014). In contrast to students, expert clinicians typically rely on hypothetico-deductive reasoning as the dominant clinical reasoning strategy for atypical or "difficult" clients only (Gilhooly, 1990).

Dual processing theory (Figure 2: Steps 3-5)

Dual processing theory states that two processes simultaneously contribute to successful CR: analytic and non-analytic. The analytic process is as previously described in the hypothetico-deductive model. The non-analytic process is very similar to the reasoning made possible by illness scripts. Namely, non-analytic reasoning consists of a quick, subconscious recognition based on prior experience as opposed to a clear, conscious line of reasoning (Evans, 2008; Kahneman, 2011; Patel & Groen, 1986). Dual processing theory builds on these by stating that reasoning is a mixture of both reasoning types, although not always in equal measure. For example, it has been hypothesized that analytic reasoning is used more during treatment and management than diagnosis due to the complex and varied factors which must be integrated into a successful plan (Cook et al., 2019). The development of reasoning according to dual processing theory follows that outlined in hypothetico-deductive and illness script sections.

Contextual factors

Situativity theory (Figure 2: All steps)

Situativity theory asserts that contextual factors (e.g., client, caregivers, resources, cost-benefit, time) have a large influence on CR (Durning & Artino, 2011). Expert clinicians have the ability to integrate contextual information into their decision-making process. In order to develop this ability, student clinicians should be exposed to contextual factors while training their clinical skills (Durning & Artino, 2011). Thus, according to situativity theory, the development of expertise depends on learning in a setting as close to real-life as possible.

It has been hypothesized that management reasoning incorporates more contextual factors than diagnostic reasoning due to its long-term and dynamic nature (Cook et al., 2019). There is currently no direct evidence to support this statement, however, the belief that management is a more difficult process than diagnosis is common in the literature (Feltovich et al., 1992). This may have implications for the development of management skills and associated CR.

Application of theory to educational practice

It is best to draw on several CR theories to design effective teaching strategies for clinical skills (Bowen, 2006; Norman, 2006). Indeed, evidence suggests that encouraging the use of multiple CR strategies will increase student diagnostic accuracy (Ark et al., 2006; Eva et al., 2007). Thus, we will discuss the application of the four domains of CR theories by considering their educational implications at the curriculum and course levels. A working example (Figure 3) demonstrates CR informed educational strategies which can be used to teach blood pressure reading. This is a clinical skill which can be taught either within one course, or developed throughout a curriculum.

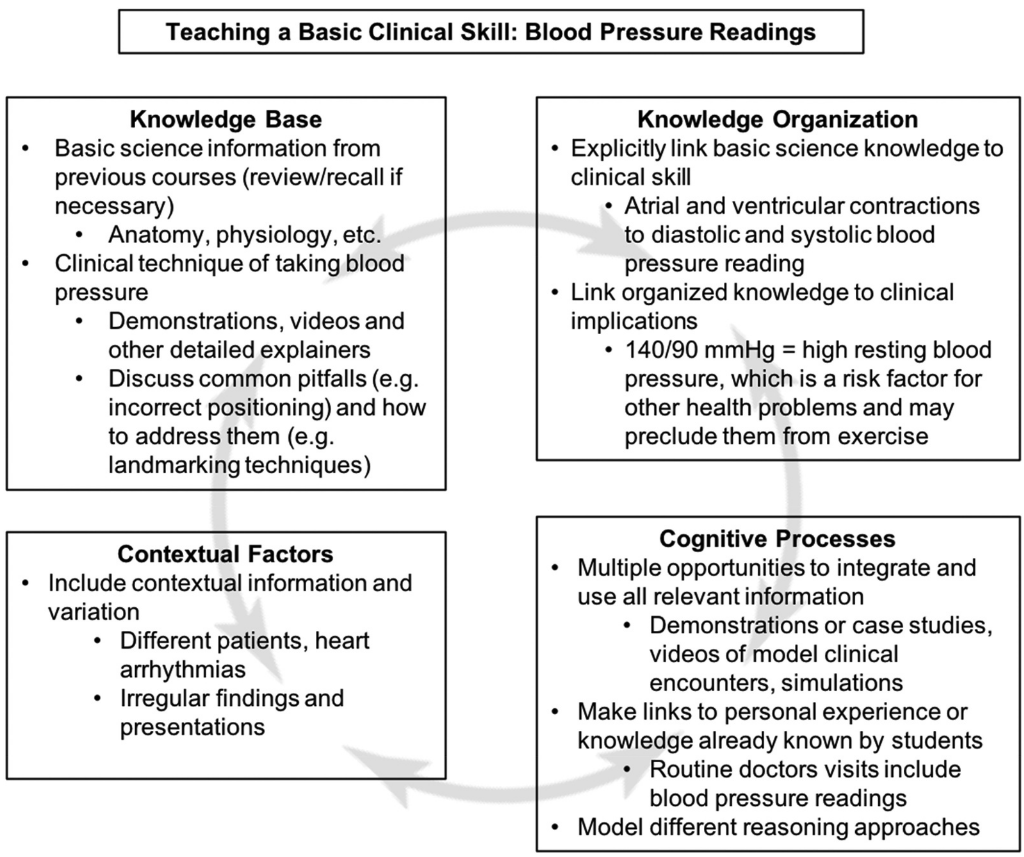

Figure 3. An outline of how one might use clinical reasoning theories to inform their teaching of the basic clinical skill of blood pressure reading. All four quadrants should be addressed when teaching a clinical skill to students such that they can be expected to appropriately incorporate the skill and interpret results during a clinical case. Note that this process is not linear and can move in either direction between components of clinical reasoning.

Knowledge base and knowledge organization

A strong foundation of knowledge is necessary for both the accessibility of a broad range of clinically relevant information and for scientific literacy (Bordage & Lemieux, 1991). A strong knowledge base requires curriculum-level coordination because much of the necessary foundational information is often taught in basic science courses (Woods et al., 2006). If an educator wants students to integrate traditionally siloed basic sciences and clinically oriented information into one interconnected knowledge network, an integrated curriculum is of great benefit (Quintero et al., 2016). These links go both ways – clinical knowledge should be integrated into basic science courses and basic science should be integrated into clinical courses. This can be achieved through formal review of the relevant information from other courses or the use of assignments, case studies (case-based learning) or other complex tasks which would require students to draw on knowledge from diverse courses to find a solution. For this strategy to be successful, an awareness of the material and assignments other instructors are giving students is required (Brauer & Ferguson, 2015).

A common method to integrate a curriculum is via problem-based learning (PBL). Although PBL can be implemented within a single course, many health professions programs base their entire curriculum on this approach. PBL relies on ill-structured, complex, real-world problems as a stimulus for learning, and for integrating and organizing learned information in ways that will ensure its recall and application to future problems (Colliver, 2000; Norman & Schmidt, 2000). PBL could be applied at the course level when teaching ill-structured problems in kinesiology, such as integrating client history and client goals to generate a tailored exercise prescription. PBL aligns especially well with both knowledge organization and cognitive process theories as it encourages students to use all knowledge available to them and all approaches to a problem to reach their answer.

According to exemplar theory in particular, the method and order in which information is delivered is thought to influence the organization and application of a learner's knowledge (Norman, 2009; Schmidt & Rikers, 2007). Thus, the design of assignments which explicitly build on previous knowledge must be carefully considered. This can be accomplished by integrating exemplar theory which suggests using a wide variety of examples and prototype theory which recommends starting with typical cases and examples so learners can understand the norms and major features before looking at case variations (Bordage, 1987). Once beginners have built a prototype, varied examples can be used in a carefully considered order to broaden understanding. It should be noted that both prototype and exemplar theory suggest that one example is not enough. Students need to be provided with many opportunities to learn and to gain expertise in that specific clinical scenario. This could apply to any clinical scenario in kinesiology, but may be most relevant for tasks which require subjective visual observations such as gait or posture abnormalities, as opposed to those with numerical cues such as recognizing diabetes via blood glucose level.

Giving many examples of the same ailment is important, but can be time consuming. To heighten the learning opportunity and maintain student engagement, one can compare and contrast the new case to previous examples and use a mixed-practice approach. In mixed practice, different but easily confusable examples are learned together and distinguishing features between them are explicitly examined (Monteiro & Norman, 2013). This is in contrast to the more traditional blocked practice approach, where one category or type of example is learned at a time. In one study examining these two teaching strategies for ECG reading skills, students taught using mixed practice had 17% higher test scores than the blocked practice group (Hatala et al., 2003). The results of this study could be directly applied to teaching kinesiology students as interpreting normal and abnormal responses to exercise using ECGs may be considered an essential competency for kinesiologists – "[demonstrates] knowledge of measurement methodologies and equipment use related to assessing human function" (College of Kinesiologists of Ontario, 2014). Either mixed or blocked practice could benefit from structured reflection, a strategy which requires students to list findings that either support or do not support a certain diagnosis or treatment plan (Mamede et al., 2014). This reflection strategy has been recommended in a highly comparable athletic therapy student cohort (Schilling, 2016).

Cognitive processes

As a student advances, the types of cognitive processes they use change. For example, first year, graduate physical therapy students often use reasoning strategies which are precursors to hypothetico-deductive reasoning, most commonly trial-and-error or following memorized protocols (Gilliland, 2014). It is likely that this basic reasoning can also be expected when kinesiology students begin introductory clinical skills courses. Educational strategies should be tailored to this stage of CR development. For example, kinesiology students in introductory clinical skills courses may benefit from clear protocols, checklists and other learning supports (e.g., relevant basic science resources, clinical skill videos). Indeed, one study found that entry-level students use more sophisticated reasoning strategies when they could remember the clinical aids given to them during class (Gilliland, 2014), perhaps removing some cognitive load and allowing greater focus on the client.

As students develop, they progress to more sophisticated analytic reasoning strategies. In a three year physical therapy program, researchers found third year students who had been exposed to clinical placements use hypothetico-deductive reasoning as their primary CR strategy (Gilliland, 2014). If upper year kinesiology students are afforded exposure to practical, hands-on opportunities as in this physical therapy cohort, their CR development may be comparable. More complex teaching strategies such as case-based learning can be used more frequently to develop reasoning at this level. In fact, case-based learning has even been used with second year athletic therapy students prior to any clinical exposure. Athletic therapy students perceived the varied clinical case studies as being beneficial in developing their CR and preparing them for a range of clinical presentations on their clinical placement (Wilson, 2012). Think-aloud strategies which require a student to say out loud what they are thinking can also be encouraged as it presents the opportunity to check students' reasoning and give them targeted feedback (Banning, 2008b).

Despite third year physical therapy students primarily using hypothetico-deductive reasoning, the use of non-analytic reasoning was also common (Gilliland, 2014). When students gain this ability to "skip" steps in their reasoning they should be encouraged to continue in this non-analytic process, especially in combination with analytic reasoning. Medical students who were told to use a combination of both analytic and non-analytic reasoning approaches had greater accuracy when reading ECGs than those who received no instruction regarding how to approach a case (Eva et al., 2007).

Contextual factors

Examples, cases, or other clinical teaching experiences should be as close to real-life scenarios as possible to incorporate contextual factors in CR. In an ideal world, workplace-based learning would provide the majority of examples and cases to student clinicians (Dornan et al., 2007). However, the capacity to provide this learning opportunity to more than a small percentage of kinesiology students is rare at Canadian universities. Other strategies which can incorporate most, but not all, contextual factors include simulated or virtual patients. Simulated patients are usually standardized or trained for this purpose (Cleland et al., 2009), but the simulated patient strategy can be used in a regular kinesiology lab environment (exercise physiology, biomechanics, rehabilitation, etc) where partners trade off being each other's clients. Preferably, students would regularly switch partners such that as many contextual factors as possible change with each "patient" encounter.

As we noted previously, CR strategies should always be tailored to the students' knowledge level and stage of learning. The addition of contextual factors raises the difficulty of a clinical task considerably. This is reflected in the common strategy of instructor-led case discussions in class followed by the integration of contextual factors in simulated patients in a lab setting (Boshuizen & Schmidt, 2019). This implies that if a simulated patient strategy is to be used, the lecture and/or pre-lab material should build to this learning strategy. Strategies are required beyond just imparting the information in a traditional lecture style. Compare and contrast exercises, instructor-led cases, concept mapping, interactive videos or other active learning strategies should be used to train students to use CR in preparation for the more difficult simulated patient task (Boshuizen & Schmidt, 2019). Similarly, simulated or virtual patients are an excellent way to prepare students for workplace-based learning, and workplace-based learning is excellent preparation to become an autonomous clinician.

Although the application of CR theory can inform decision making by helping educators understand how student cognition level can be linked to teaching strategy selection, theory does not make the teaching decisions. An educator must integrate theory with their experience and intuition to determine the appropriate level of difficulty and amount of practice their students require to be successful.

Conclusion

Clinical educators informed by CR theory have enhanced the learning outcomes of their students in other health professions (Hatala et al., 2003; Eva et al., 2007). The use of educational strategies informed by CR theory could assist kinesiology students in developing their clinical abilities. Although applying CR theory to kinesiology education is useful, there are two limitations to the current state of the literature and our approach to synthesizing it.

First, it should be noted that the CR theories and associated educational strategies we introduced are not an exhaustive list. Due to our choice to only include theories which are applied to both diagnostic (Young et al., 2018) and management reasoning (Cook et al., 2019), there are several that have gone unmentioned (Croskerry, 2002; Mamede, Schmidt, & Penaforte, 2008). Both additional clinical theories and general educational theories (Kaufman, 2003) may provide valuable insight into teaching CR in kinesiology.

Second, we primarily drew on studies on CR from post-graduate physiotherapy and medicine programs due to the dearth of information in undergraduate kinesiology programs. In an attempt to mitigate this limitation, we also drew on literature from athletic therapy and nursing, which are usually undergraduate entry-to-practice. However, all these programs typically incorporate mandatory clinical placements, a strategy which has not been incorporated into kinesiology curricula. Although the comparability of the available evidence is not ideal, we want to emphasize that the discussed CR strategies should nonetheless be applicable to all healthcare professions, including kinesiology.

In addition to investigating the development of CR in kinesiology students, future research could address the assessment of CR and clinical skills according to CR theory. While CR theories have been applied to assessment (e.g., Cook & Durning, 2019; Lubarsky et al., 2013) current strategies often have major drawbacks or foundational concerns (e.g., poor construct validity) (Monteiro et al., 2020).

This application of CR theory takes the first step toward evidence-based clinical educational practice for kinesiology students who aspire to become kinesiologists. It is our hope that more research is focused on this area within the kinesiology profession as the changes to the clinical curriculum continue in this recently regulated health care field.

Disclosure statement

No potential conflict of interest was reported by the authors.

ORCID

Rebecca Ataman http://orcid.org/0000-0001-5419-5817

References

Ark, T. K., Brooks, L. R., & Eva, K. W. (2006). Giving learners the best of both worlds: Do clinical teachers need to guard against teaching pattern recognition to novices? *Academic Medicine*, *81*(4), 405–409. https://doi.org/10.1097/00001888-200604000-00017

Baechle, T., Earle, R., & Wathen, D. (2008). Resistance training. In T. Baechle & R. Earle (Eds.), *Essentials of strength training and conditioning* (3rd ed., pp. 381–412). Human Kinetics.

Banning, M. (2008a). Clinical reasoning and its application to nursing: Concepts and research studies. *Nurse Education in Practice*, *8*(3), 177–183. https://doi.org/10.1016/j.nepr.2007.06.004

Banning, M. (2008b). The think aloud approach as an educational tool to develop and assess clinical reasoning in undergraduate students. *Nurse Education Today*, *28*(1), 8–14. https://doi.org/10.1016/j.nedt.2007.02.001

Bergeron, G., Larivière, C., Sullivan, P., & Kabaroff, L. (2014, October). Position statement: The role of kinesiologists and the promotion of physical activity and exercise in the Canadian health care system. *Canadian Council of Physical Education and Kinesiology Administrators*, 1–13. http://www.ccupeka.org/wp-content/uploads/2016/05/position-statement.pdf

Bordage, G. (1987). The curriculum: Overloaded and too general? *Medical Education*, *21*(3), 183–188. https://doi.org/10.1111/j.1365-2923.1987.tb00689.x

Bordage, G., & Lemieux, M. (1991). Semantic structures and diagnostic thinking of experts and novices. *Academic Medicine*, *66*(9Suppl), S70–S72. https://doi.org/10.1097/00001888-199109000-00045

Bordage, G., & Zacks, R. (1984). The structure of medical knowledge in the memories of students and practitioners. *Medical Education*, *18*(6), 406–416. https://doi.org/10.1111/j.1365-2923.1984.tb01295.x
Boshuizen, H. P. A., & Schmidt, H. G. (2019). The development of clinical reasoning expertise. In J. Higgs, G. M. Jensen, S. Loftus, & N. Christensen (Eds.), *Clinical reasoning in the health professions* (pp. 57–66). Elsevier Health Sciences.
Bowen, J. L. (2006). Educational strategies to promote clinical diagnostic reasoning. *The New England Journal of Medicine*, *355*(21), 2217–2225. https://doi.org/10.1056/NEJMra054782
Brauer, D. G., & Ferguson, K. J. (2015). The integrated curriculum in medical education: AMEE Guide No. 96. *Medical Teacher*, *37*(4), 312–322. https://doi.org/10.3109/0142159X.2014.970998
Brooks, D. N. (1978). Non-analytic concept formation and memory for instances. In E. Rosch & B. B. Lloyd (Eds.), *Cognition and categorization* (pp. 169–211). Lawrence Erlbaum Associates.
Canadian Society for Exercise Physiology. (2017). *Pre-screening for physical activity: Get active questionnaire*. Retrieved September 28, 2019, from https://store.csep.ca/pages/getactivequestionnaire
Cleland, J. A., Abe, K., & Rethans, J. J. (2009). The use of simulated patients in medical education: AMEE guide No 42. *Medical Teacher*, *31*(6), 477–486. https://doi.org/10.1080/01421590903002821
College of Kinesiologists of Ontario. (2014). *Essential competencies of practice for Kinesiologists in Ontario*.
College of Kinesiologists of Ontario. (2018). *Annual reports and financial statements*. Retrieved September 5, 2019, from https://coko.ca/CKO_Public/Public_Content_Records/About_/Subcontent/Annual_Reports.aspx
Colliver, J. (2000). Effectiveness of problem-based learning curricula: Research and theory. *Academic Medicine*, *75*(3), 259–266. https://doi.org/10.1097/00001888-200003000-00017
Cook, D. A., Durning, S. J., Sherbino, J., & Gruppen, L. D. (2019). Management reasoning: Implications for health professions educators and a research agenda. *Academic Medicine*, *94*(9), 1310–1316. https://doi.org/10.1097/ACM.0000000000002768
Cook, R. J., & Durning, S. J. (2019). Clinical process modeling: An approach for enhancing the assessment of physicians' clinical reasoning. *Academic Medicine*, *94*(9), 1317–1322. https://doi.org/10.1097/ACM.0000000000002730
Croskerry, P. (2002). Achieving quality in clinical decision making: Cognitive strategies and detection of bias. *Academic Emergency Medicine*, *9*(11), 1184–1204. https://doi.org/10.1197/aemj.9.11.1184
Custers, E. J. F. M. (2018). A recognition study testing the psychological validity and development of illness scripts. *Health Professions Education*, *4*(4), 259–277. https://doi.org/10.1016/j.hpe.2017.12.001
Dornan, T., Boshuizen, H., King, N., & Scherpbier, A. (2007). Experience-based learning: A model linking the processes and outcomes of medical students' workplace learning. *Medical Education*, *41*(1), 84–91. https://doi.org/10.1111/j.1365-2929.2006.02652.x
Durning, S. J., & Artino, A. R. (2011). Situativity theory: A perspective on how participants and the environment can interact: AMEE guide no. 52. *Medical Teacher*, *33*(3), 188–199. https://doi.org/10.3109/0142159X.2011.550965
Elliott, D. (2007). Forty years of kinesiology: A Canadian perspective. *Quest*, *59*(1), 154–162. https://doi.org/10.1080/00336297.2007.10483544
Elstein, A. S., Shulman, L. S., & Sprafka, S. A. (1978). *Medical problem solving: An analysis of clinical reasoning*. Cambridge, MA: Harvard University Press. https://doi.org/10.4159/harvard.9780674189089.c3
Eva, K., Neville, J., & Norman, G. (1998). Exploring the etiology of content specificity: Factors influencing analogic transfer and problem solving. *Academic Medicine*, *3*(Suppl10), S1–S5. https://doi.org/10.1097/00001888-199810000-00028
Eva, K. W., Hatala, R. M., LeBlanc, V. R., & Brooks, L. R. (2007). Teaching from the clinical reasoning literature: Combined reasoning strategies help novice diagnosticians overcome misleading information. *Medical Education*, *41*(12), 1152–1158. https://doi.org/10.1111/j.1365-2923.2007.02923.x
Evans, J. S. (2008). Dual-processing accounts of reasoning, judgment, and social cognition. *Annual Review of Psychology*, *59*(1), 255–278. https://doi.org/10.1146/annurev.psych.59.103006.093629

Feltovich, P. J., Coulson, R. L., Spiro, R. J., & Dawson-Saunders, B. K. (1992). Knowledge application and transfer for complex tasks in ill-structured domains: Implications for instruction and testing in biomedicine. In D. Evans & V. L. Patel (Eds.), *Advanced models of cognition for medical training and practice* (pp. 212–244). Springer-Verlag.

Gilhooly, K. J. (1990). Cognitive psychology and medical diagnosis. *Applied Cognitive Psychology*, *4*(4), 261–272. https://doi.org/10.1002/acp.2350040404

Gilliland, S. (2014). Clinical reasoning in first- and third-year physical therapist students. *Journal of Physical Therapy Education*, *28*(3), 64–80. https://doi.org/10.1097/00001416-201407000-00009

Hatala, R. M., Brooks, L. R., & Norman, G. R. (2003). Practice makes perfect: The critical role of mixed practice in the acquisition of ECG interpretation skills. *Advances in Health Sciences Education*, *8*(1), 17–26. https://doi.org/10.1023/A:1022687404380

Heinerichs, S., Vela, L. I., & Drouin, J. M. (2013). A learner-centered technique and clinical reasoning, reflection, and case presentation attributes in athletic training students. *Journal of Athletic Training*, *48*(3), 362–371. https://doi.org/10.4085/1062-6050-48.2.17

Higgs, J., Jones, M., Loftus, S., & Christensen, N. (Eds.). (2019). *Clinical reasoning in the health professions* (4th ed.). Elsevier.

Irby, D. M. (2014). Excellence in clinical teaching: Knowledge transformation and development required. *Medical Education*, *48*(8), 776–784. https://doi.org/10.1111/medu.12507

Jensen, J. (2011). Paramedic clinical decision-making: Results of two Canadian studies. *International Paramedic Practice*, *1*(2), 63–71. https://doi.org/10.12968/ippr.2011.1.2.63

Kahneman, D. (2011). *Thinking, fast and slow*. Farrar, Straus and Giroux.

Kaufman, D. M. (2003). Applying educational theory in practice. *BMJ*, *326*(7382), 213–216. https://doi.org/10.1136/bmj.326.7382.213

LeMoon, K. (2008). Clinical reasoning in massage therapy. *International Journal of Therapeutic Massage and Bodywork: Research, Education, and Practice*, *1*(1), 12–18. https://doi.org/10.3822/ijtmb.v1i1.2

Lubarsky, S., Dory, V., Duggan, P., Gagnon, R., & Charlin, B. (2013). Script concordance testing: From theory to practice: AMEE Guide No. 75. *Medical Teacher*, *35*(3), 184–193. https://doi.org/10.3109/0142159X.2013.760036

Mamede, S., Schmidt, H. G., & Penaforte, J. C. (2008). Effects of reflective practice on the accuracy of medical diagnoses. *Medical Education*, *42*(5), 468–475.

Mamede, S., Van Gog, T., Sampaio, A. M., De Faria, R. M. D., Maria, J. P., & Schmidt, H. G. (2014). How can students' diagnostic competence benefit most from practice with clinical cases? The effects of structured reflection on future diagnosis of the same and novel diseases. *Academic Medicine*, *89*(1), 121–127. https://doi.org/10.1097/ACM.0000000000000076

Monteiro, S. D., Sherbino, J., Schmidt, H., Mamede, S., Ilgen, J., & Norman, G. (2020). It's the destination: Diagnostic accuracy and reasoning. *Advances in Health Sciences Education, 25*(1), 19–29. https://doi.org/10.1007/s10459-019-09903-7

Monteiro, S. M., & Norman, G. (2013). Diagnostic reasoning: Where we've been, where we're going. *Teaching and Learning in Medicine*, *25*(SUPPL.1), 26–32. https://doi.org/10.1080/10401334.2013.842911

Norman, G. R. (2005). Research in clinical reasoning: Past history and current trends. *Medical Education*, *39*(4), 418–427. https://doi.org/10.1111/j.1365-2929.2005.02127.x

Norman, G. R. (2006). Building on experience — The development of clinical reasoning. *New England Journal of Medicine*, *355*(21), 2251–2252. https://doi.org/10.1056/nejme068134

Norman, G. R. (2009). Dual processing and diagnostic errors. *Advances in Health Sciences Education*, *14*(1), 37–49. https://doi.org/10.1007/s10459-009-9179-x

Norman, G. R., & Schmidt, H. G. (2000). Effectiveness of problem-based learning curricula: Theory, practice and paper darts. *Medical Education*, *34*(9), 721–728. https://doi.org/10.1046/j.1365-2923.2000.00749.x

Ontario Kinesiology Association. (2020). *Find a kinesiologist*. Retrieved May 2, 2020, from. https://www.oka.on.ca/client/roster/clientRosterView.html?clientRosterId=131

Patel, V. L., & Groen, G. J. (1986). Knowledge based solution strategies in medical reasoning. *Cognitive Science*, *10*(1), 91–116. https://doi.org/10.1016/S0364-0213(86)80010-6

Quintero, G. A., Vergel, J., Arredondo, M., Ariza, M.-C., Gómez, P., & Pinzon-Barrios, A.-M. (2016). Integrated medical curriculum: Advantages and disadvantages. *Journal of Medical Education and Curricular Development*, *3*, JMECD.S18920. https://doi.org/10.4137/JMECD.S18920

Rogers, J. C., & Holm, M. B. (1991). Occupational therapy diagnostic reasoning: A component of clinical reasoning. *The American Journal of Occupational Therapy*, *45*(11), 1045–1053. https://doi.org/10.5014/ajot.45.11.1045

Schilling, J. (2016). Instructional strategy: Administration of injury scripts. *Athletic Training Education Journal*, *11*(3), 152–157. https://doi.org/10.4085/1103152

Schmidt, H. G., & Rikers, R. M. J. P. (2007). How expertise develops in medicine: Knowledge encapsulation and illness script formation. *Medical Education*, *41*(12), 1133–1139. https://doi.org/10.1111/j.1365-2923.2007.02915.x

Simmons, B. (2010). Clinical reasoning: Concept analysis. *Journal of Advanced Nursing*, *66*(5), 1151–1158. https://doi.org/10.1111/j.1365-2648.2010.05262.x

The Kinesiology Act. (2007) . *S.O. 2007, Chapter 10, Schedule O*. The Government of Ontario.

University of British Columbia School of Kinesiology. (2019). Graduate (MA, MSc, MKin, PhD). Retrieved May 23, 2019, from https://kin.educ.ubc.ca/programs/graduate-ma-msc-mkin-phd/#Masters-1

University of Toronto Faculty of Kinesiology and Physical Education. (2019). *Master of Professional Kinesiology*. Retrieved June 24, 2019, from https://kpe.utoronto.ca/academics-research/graduate-studies/master-professional-kinesiology

University of Waterloo. (2016). *Kinesiology*. Retrieved May 3, 2020, from http://www.ucalendar.uwaterloo.ca/1617/COURSE/course-KIN.html#KIN000S

University of Waterloo. (2020). *Kinesiology*. Retrieved May 3, 2020, from http://www.ucalendar.uwaterloo.ca/2021/COURSE/course-KIN.html

Warburton, D. E., Jamnik, V., Bredin, S. S., Shephard, R. J., & Gledhill, N. (2019). The 2019 Physical Activity Readiness Questionnaire for Everyone (PAR-Q+) and Electronic Physical Activity Readiness Medical Examination (ePARmed-X+). *The Health & Fitness Journal of Canada*, *11*(4), 80–83.

Wilson, L. M. (2012). Problem-based learning and clinical reasoning in sports therapy practice. *International Journal of Therapy and Rehabilitation*, *19*(12), 682–688. https://doi.org/10.12968/ijtr.2012.19.12.682

Woods, N. N., Neville, A. J., Levinson, A. J., Howey, E. H. A., Oczkowski, W. J., & Norman, G. R. (2006). The value of basic science in clinical diagnosis. *Academic Medicine*, *81*(Suppl), 124–127. https://doi.org/10.1097/00001888-200610001-00031

Young, M. E., Dory, V., Lubarsky, S., & Thomas, A. (2018). How different theories of clinical reasoning influence teaching and assessment. *Academic Medicine*, *93*(9), 1415. https://doi.org/10.1097/acm.0000000000002303