SCIENCE IN THE CONTEXT OF CLINICAL PRACTICE – THE SYSTEMATIC APPROACH TO GENERATING CLINICAL KNOWLEDGE

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Goals for today...

1. Discuss the origins of science as a systematic process that is rooted in probability rather than proof.

2. Describe the clinical scientific method and its value in understanding how clinicians move from explanation to prediction.

3. Recognize some common misconceptions about what science is and what it isn’t with regard to determining the effectiveness of clinical practices.
Why we’re doing what we’re doing...

“As the status of the athletic trainer increases and the true value of his services are fully recognized, it becomes essential that members of the profession recognize the paucity of scientific evidence to support many of its traditional procedures. It is the sole responsibility of our profession, if we wish to be other than technicians, to critically examine practices which appear to be based on traditional usage or on excessive promotion by commercial interests...

Today’s demands on an athletic trainer’s time and budget no longer warrant the retention of practices or procedures which fail to survive the critical scrutiny of controlled study.”

What is a profession?

“An occupation whose core element is work based on mastery of a complex body of knowledge and skills. It is a vocation in which knowledge of some department of science or learning or the practice of an art founded upon it is used in the service of others. Its members are governed by codes of ethics and profess a commitment to competence, integrity and morality, altruism, and the promotion of the public good within their domain. These commitments form the basis of a social contract between a profession and society, which in turn grants the profession a monopoly over the use of its knowledge base, the right to considerable autonomy in practice and the privilege of self-regulation. Professions and their members are accountable to those served and to society.”

Cruess, Johnston, & Cruess *Teaching and Learning in Medicine* 2004
What is Science?

A human endeavor...Natural Philosophy

A way of knowing...Aristotle’s “Episteme” (Knowledge) derived from the senses...

Demonstrable and Replicable means to explain phenomena

Explanation, Inference, & Prediction...

Deduction, Induction, Abduction....

Raphael’s *The School of Athens*
Scientific (R)Evolution...

Objectivity and Reductionism...

Our senses introduce bias...therefore, objective observations are needed in which the preconceived notions of the observer are controlled for...

Reduce a complex system down to its component parts, make objective observations to uncover the simple rules that govern them, and then make inferences back to the whole...

By objectively reducing a system down to its component parts, one can begin to make inferences about the past states of the system as well as predict the future states...
Thinking, Knowing, and Problem-solving...

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<tr>
<th>Scientifically...</th>
<th>Unscientifically...</th>
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<td>Systematic</td>
<td>Tenacity</td>
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<td>Logical</td>
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<td>Empirical (Objective)</td>
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<td>Empiricism</td>
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Important thoughts to keep in mind...

“...everything about the doing of science, everything about its practice, is a human activity, wholly a human activity, and nothing but a human activity.”

“It is tempting to assume that science is simply a set of discrete statements (together constituting a ‘body of knowledge’), with an identity independent of their status as products of a particular human activity. But in fact such statements acquire or are given their status as ‘scientific’ as a consequence of how they are produced and who produces them: simply as a discrete statement (i.e. abstracted from its status as a product of the human practice of science) even $e=mc^2$ is simply incoherent, it has neither status nor meaning.”

Andrew Cunningham, *Studies in the History and Philosophy of Science* 1988
Scientific Method...

1. Develop a problem...
2. Formulate a hypothesis...
3. Gather data...
4. Analyze and interpret...

“Although scientific research is considered the highest form of acquiring knowledge, it is by no means perfect, especially when applied to the study of human behavior and performance. The complexity and variability within nature and the environment and the unique psychosocial and physiological capacities of individuals will always introduce some uncertainty into the interpretation and generalization of the data.”

Scientific (R)Evolution...

Complex Adaptive Systems...

Behavior emerges from the component parts of a system based on their unique interactions in combination with external factors.

Spontaneous self-organization and non-linearity

The whole is not equal to the sum of its parts...more and less at the same time...

Variability is a natural trait of a complex system...

Bittencourt et al. *BJSM* 2016

Mazzocchi *EMBO Reports* 2008
Important thoughts to keep in mind...

“...of all forms of mental activity, the most difficult to induce even in the minds of the young, who may be presumed not to have lost their flexibility, is the art of handling the same bundle of data as before, but placing them in a new system of relations with one another by giving them a different framework, all of which virtually means putting on a different kind of thinking-cap for the moment.”

Herbert Butterfield, 1957 (originally published 1949)

*The Origins of Modern Science*
Why screening tests to predict injury do not work—and probably never will...: a critical review

Roald Bahr¹,²  

N F N Bittencourt,1 W H Meeuwisse,2 L D Mendonça,3 A Nettel-Aguirre,4 J M Ocarino,5 S T Fonseca5
How do we incorporate scientific thinking and its (r)evolutions into clinical practice?
Evidence-based Practice Steps
Current Approach using 5 steps

Ask a clinical question

Acquire Evidence from external sources

Appraise the validity and relevance of evidence

Apply the findings of the evidence to your clinical decision

Assess the effectiveness of your evidence-based decision...

Evidence-Based Medicine: What Is It and How Does It Apply to Athletic Training?
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Evidence-based Practice Steps
Current Approach using 5 steps

1. Ask a clinical question
2. Acquire Evidence from external sources
3. Appraise the validity and relevance of evidence
4. Apply the findings of the evidence to your clinical decision
5. Assess the effectiveness of your evidence-based decision...

Best Available Research
EXTERNAL EVIDENCE: Simple Appraisal

Usefulness = \frac{\text{Relevance} \times \text{Validity}}{\text{Work}}

Internal Validity = \text{Cause and Effect}
Bias = \text{threat to internal validity}
- Perspective
- Blinding
- Randomization

External Validity = \text{Generalizability}
Does the sample match your patient?
- Similar Population
- Similar Environment

What are the results? What’s the risk of bias?

Quality Scales available: PEDro, QUADAS, STROBE, etc.
Replication as a requirement of Science...

The foundation of science is rooted in its replicability and transparency, which is currently not as solid as we think...

Collins and Tabak *Nature* 2014

What happens to knowledge when findings from one scientific experiment don’t undergo the scrutiny of replication?

“Peer review tends to favor manuscripts that contain new findings over those that improve our understanding of a previously published finding. Moreover, careers are made by producing exciting new results at the frontiers of knowledge, not by verifying prior discoveries.”

Errington et al. *eLife* 2014
**Scientia vs. Phronesis**

**Scientia** – knowledge derived from systematic observations...
Prior experience is downplayed...

**Phronesis** – practical wisdom honed from direct experiences

*Aristotle*  
*William Osler*  
*Michael Polanyi*
Ask a clinical question

Answer clinical question with Internal Evidence

Acquire Sources of External Evidence to answer clinical question

Appraise the validity and relevance of external evidence

Integrate internal and external evidence for the clinical decision

Assess the effectiveness of your evidence-based decision...

Porzsolt et al. *EBM* 2003

Professional training and clinical experiences including knowledge of anatomy, physiology, biomechanics, patient interactions, experience with case patterns and outcomes.

Sources of external evidence include Case studies, Clinical Trials, Clinical Prediction Rules, Critically Appraised Topics, Systematic Reviews, & Meta-analyses relevant to the clinical question.

Document and Disseminate your clinical decision outcomes to advance external evidence.
Clinical Wisdom...Phronesis

“The discipline of clinical medicine is not a science, an art, or a craft. It is an integral practical discipline rooted in the unchanging reality of the healing relationship between patient and physician. That is, clinical medicine is a relationship between one individual, a unique embodied self in need of healing, and another individual, who professes and promises to heal with knowledge, skill, experience, and commitment to the patient’s good...”

~Michael Pelligrino

Davis FD. *Theoretical Medicine* 1997
Thinking and Linking…

McKeon & Medina McKeon *IJATT* 2015

- **Evidence-based Practice**
  - Published sources of peer-reviewed research
  - Epidemiology
  - Diagnosis
  - Prognosis
  - Etiology
  - Therapy

- **Practice-based Evidence**
  - Professional training and clinical experiences including knowledge of anatomy, physiology, biomechanics, patient interactions, and clinical experience with case patterns and outcomes.
The Clinical Scientific Method...

Observation and Description of a Clinical Phenomenon

Develop a Hypothesis to Explain the Clinical Phenomenon

Use Hypothesis to Predict Outcomes

Develop Interventions from Hypothesis
“Good clinical practice cannot come from science alone. Good clinical practice cannot come from personal experience alone. Good clinical practice is an amalgam of *Scientia* and *Phronesis*. Both of these two foundations of good clinical practice, *Scientia* and *Phronesis*, require the same intellectual armaments from the doctor: open mind, critical reflection, ability to change.”

Fugelli P. *Schweiz Med Wochenschr* 1998
Key Points from Today

1. Science (Scientia) is a human endeavor in which we generate knowledge...External Evidence

2. Clinical Wisdom (Phronesis) is our knowledge filtered through direct experience...Internal Evidence

3. The clinical scientific method is derived from the complex interaction between both sources of evidence in conjunction with the perceptions, goals, and values of those we serve.

4. An open mind, critical reflection, and ability to change are the qualities of a clinician-scientist.
Thank You!!

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@pomckeon & @IJATT_HK
For more information...


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