# Chaos Revisited: From the Brickyard Into the Weight Room

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## SUMMARY

RAPID EXPANSION OF THE STRENGTH AND CONDITIONING FIELD, THE NUMBER OF PROFESSIONALS, AND SOURCES OF AVAILABLE INFORMATION HAVE RESULTED IN A "CHAOS" SITUATION. THE ROLES OF EDUCATION, TRAINING, AND EXPERIENCE SHOULD BE ASSESSED TO MAINTAIN OR ENHANCE THE QUALITY AND STANDARD OF PRACTICE. THE ACTIONS OF EACH INDIVIDUAL IN THE FIELD CONTRIBUTE, EITHER POSITIVELY OR NEGATIVELY, TO THE DEVELOPMENT OF STRENGTH AND CONDITIONING AS A PROFESSION.

## INTRODUCTION

In 1963, Forscher (15) wrote a seminal letter describing the de-evolution of the scientific process associated with the rapid growth of science in academe. Entitled "Chaos in the Brickyard," this letter has been widely reviewed in specific disciplines, for examples, see references (5,25), within and outside science, describing a phenomenon where professional approaches have shifted from a philosophical base to randomness and from long-term vision to immediate profit and gain. The lack of philosophy can also be observed in strength and conditioning and has become apparent in this Internet age with many practitioners using novel training fads and gimmicks as opposed to developing a methodical approach based on science and evidence. In many cases, research has demonstrated the inefficacy of these fads (1,6).

Recent trends in Western society have resulted in a large focus on physical activity, health and wellness, and life quality. These foci have been beneficial for strength and conditioning as a field, increasing the visibility of professional practitioners, funding for researchers, available jobs, and salaries for these jobs. However, this rapid expansion has also created "chaos" in terms of the quality and standard of practice (6,9), which may ultimately be deleterious to the development of strength and conditioning as a professional discipline.

## THE BRICKYARD

Forscher (15) described the role of early scientists metaphorically, involving builders who constructed edifices (i.e., knowledge) out of bricks (i.e., scientific research). Because of the scarcity of bricks available, the builders were also the brick makers. The making of bricks was labor intensive, with bricks made on an on order basis, meaning the making of bricks was for the sole purpose of constructing a certain edifice. To ease the task of making bricks, junior brick makers were employed and over time, some junior brick makers progressed to the status of builder. However, the growth of brick makers resulted in mass production of bricks, many of suspect quality. The use of these bricks to construct an edifice ultimately resulted in the edifices collapse. Furthermore, many individuals began to confuse bricks for edifices. The concept of brick makers and builders also applies outside of science and academe. Theories and principles in strength and conditioning were developed by practitioners and sports scientists. The advancement of training methodology is therefore dependent on experienced practitioners and scientists (i.e., builders), who often employ assistants, graduate students, and interns (i.e., brick makers).

Forscher's brickyard describes a scenario that has appeared to occur in a number of disciplines, and in this article, a case is made that such a situation exists in strength and conditioning today. The approach to constructing an edifice cannot be random and haphazard. An edifice is only structurally sound if (a) it is constructed of quality bricks and (b) it is built by qualified individuals. Furthermore, each edifice is constructed for a certain purpose, and therefore, there are appropriate uses for each edifice.

## THE EDIFICE

Each edifice represents a piece of knowledge. In strength and conditioning, an edifice may be a certain training method or modality. Within a city, multiple edifices exist and the proper operation of the city requires the appropriate use of each edifice. As practitioners gain knowledge, they

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should be able to integrate that knowledge into the development of a philosophy or philosophies. A philosophy is a system that each practitioner forms for conducting their practice. Practitioners in any field should ask themselves why they do what they do. Anecdotally, in strength and conditioning, reasons for using a given method or modality include popularity, the use of the method or modality by a famous individual, or simply because it was learned in a university course, a conference seminar, or an article. However, the inappropriate use of a method or modality may result in no training effect (best-case scenario) or injury (worst-case scenario). Thus, it is important for each practitioner to determine if their approach is based on a philosophy or simply copying others (6). A philosophy-based approach requires one to evaluate the knowledge available to ensure its proper application.

The evaluation of a method or modality should be more extensive than simply determining whether it is effective (6,11). Other issues that are important include the relative effectiveness compared with another method/modality, safety, and appropriateness for the given population (Table 1). The latter consideration has received much attention recently, going beyond the individual at a given instant in time but also where the individual is in a long-range plan. In sports, this is referred to as long-term athlete development. In brief, the immediate gain in performance must be weighed relative to how current training will affect long-term improvements in performance.

The National Strength and Conditioning Association Certification Commission has identified important domains relevant for minimum competency as a strength and conditioning practitioner (32). These domains can be categorized into general and specific areas of knowledge, which is consistent with the original curriculum set forth by the Coaching Association of Canada's National Coaching Certification Program (18,21). For strength and conditioning practitioners, general areas of knowledge include anatomy, muscle physiology, bioenergetics, endocrinology, and biomechanics (a full list of these domains is identified in Table 2). These scientific disciplines form the foundation from which practitioners can evaluate and assess specific or practical domains, such as exercise technique, program design, and testing and evaluation. A key difference between the Canadian program and the National Strength and Conditioning Association is that in the Canadian program, coaching education is tiered (18,21). The multiple levels of education required increase in the time to become an expert coach. This is exemplified in the new Coaching Association of Canada model, which emphasizes that certification is a consequence of completing the coaching education process, which may involve a number of years. Similar tiered programs have been developed by the Australian Strength and Conditioning Association.

In addition to general and specific education, practitioners also require experience applying their knowledge, which is referred to as the art of coaching (17,22,23,27). Further discussion of experience follows later. Through a combination of education and experience, strength and conditioning professionals can develop philosophies to guide the application of their knowledge to achieve optimal outcomes for their athletes, clients, or patients. It should be noted that

**Table 1**
**Some questions for assessing the usefulness of information**

| |
|---|
| 1. Is the training method or modality effective? |
| a. For what purposes is it effective? |
| b. For what purposes is it not effective? |
| 2. What population(s) is this method or modality applicable to? |
| a. Are there populations that it is NOT applicable to? |
| 3. How does the effectiveness of the training method or modality compare with other methods or modalities? |
| 4. What are the mechanisms (physiologic, biomechanical, and so on) behind which the training method or modality is effective? |
| a. Does the training method or modality work for the reasons I (or others) think it does? |
| b. What is not known about why the training method or modality is effective? |
| 5. How does modifying the training method or modality affect its effectiveness? |
| 6. How does this training method or modality interact with other methods or modalities that are (or will be) used concurrently? |
| a. Is there a synergistic effect between this and other methods or modalities? |
| b. If yes, how can the synergistic effect be optimized? |
| 7. What is the relative safety of the training method or modality? |
| a. What are the potential dangers or risks associated with the method or modality? |
| b. How can potential dangers be minimized? |
| Strength and conditioning professionals should be capable of answering these questions before the use of a given training method or modality. |

**Table 2**
**Potential education and experiences for the strength and conditioning professional**

| | |
|---|---|
| General Education | Undergraduate coursework |
| | Exercise/sport science: anatomy*, physiology*, biomechanics*, motor learning/control* |
| | Basic sciences: biology, chemistry, physics, and mathematics |
| | Pedagogy, sport psychology*, and nutrition* |
| | Athletic training/therapy and sports medicine |
| | Writing, statistics, research methods, computer applications |
| | Graduate or advanced course in above |
| | First aid and cardiopulmonary resuscitation |
| Specific Education | University coursework (including laboratory experiences) in strength and conditioning* and evaluation and measurement* |
| | Discipline-specific seminars/symposiums |
| | Coaching courses: weightlifting, track and field, and so on |
| | Independent study (self-directed or under guidance from a mentor) |
| Experience | Intern and/or graduate assistant in a strength and conditioning facility |
| | Competitive sports background with strength training component |
| | Experience training/competing in weightlifting and/or powerlifting |
| | Participant in strength and conditioning research study |
| | Investigator in strength and conditioning research study |

Items marked with an asterisk (*) are identified in the National Strength and Conditioning Association Certification Commission Role Delineation Study, see reference (32).

a philosophy should be dynamic and open to evaluation given changes in the body of knowledge or through experience garnered through practice. Thus, at any one point in time, there is no single correct solution, but rather a myriad of solutions, given the current available knowledge, ranging from optimal to suboptimal.

## THE BRICKS

An edifice, or knowledge, is constructed of bricks, or evidence. A number of sources are available to obtain evidence to enhance knowledge and formulate philosophies. However, in developing a philosophy, the accuracy and validity of the evidence used should be assessed (6,11). Peer-reviewed information, such as research studies, is arguably the most accurate and valid source of information, as a result of the critical review process (2,6,10). Controlled research studies (14), in particular, are important sources in identifying the mechanisms of specific training methods and modalities. However, sports science research (33,34) is also valuable in the application of such knowledge. Coaches have been reported to value evidence from sports scientists and peer-reviewed sources; however, at the same time, the coaches are often not likely to use such material (12,24,29,30). The more common information sources for coaches include learning by doing; interacting with other coaches; and attending clinics, seminars, or conferences (12,31). A problem with these sources is that it is impossible to determine how extraneous variables may influence the results; therefore, the actual validity of this information can be questioned.

Regardless of the source of information, the quality of the evidence must be assessed (14). The quality of evidence can be divided into accuracy, reliability, and validity. Accuracy simply indicates whether the information is correct. For example, it is commonly purported that the knees should remain behind the toes during squatting exercise. However, biomechanical analyses have demonstrated that ankle dorsiflexion range of motion (forcing the knees in front of the toes) is important in achieving a parallel or deep squat position (16). Furthermore, a simple observation of elite weightlifters in training and competition would also indicate that it is possible to squat with the knees passing forward of the toes, and research demonstrates no long-term deleterious effect in this population (19). This highlights the importance of proper education because it provides practitioners with the

fundamental knowledge to assess the accuracy of training information or the skills to determine its accuracy (27,32,34).

The issue of reliability is important when considering "case studies" or information regarding a single or few individuals. Although "case studies" may provide insight into a particular training methodology or modality, practitioners should question whether similar results would be obtained in other individuals. Although validity encompasses accuracy and reliability, it also pertains to the applicability of the evidence (20). As an example, studies of elite athletes may not be applicable to the training of novices and vice versa (5). Similarly, an effective training protocol used for a given athlete may not be appropriate for other athletes in the same sport but of different caliber. Without considering these aspects of validity, practitioners may be led astray, believing in popular methodologies that have little or incomplete evidence to support them, or are applicable only in limited situations. A prime example of this is the transverse abdominis and core stability trends that have pervaded strength and conditioning in the past decade. Recent research has indicated that the role of this muscle has been misunderstood, and practitioners have been urged to use caution when translating novel scientific and research evidence into practice (1,6).

In addition to evaluating the validity of a source, practitioners should assess the limitations associated with the material (6,14). These limitations may include considerations that would invalidate the material, other possible explanations for the results obtained, facts that are contrary to the material, and what the information cannot explain. Feynman (14) addressed the importance of this approach in science more than 30 years ago, highlighting personal knowledge of situations where such strict scrutiny was not applied. This approach, however, should extend beyond scientific material and encompass all sources of information available, such as conference presentations, books, and discussions with colleagues. Although it is simple to highlight fascinating and novel information, it is rare that authors and presenters discuss what may be wrong or what they are missing. Thus, it is up to each individual practitioner to critically evaluate the evidence that they incorporate into their knowledge base and use to formulate their philosophies.

## BUILDERS AND BRICK MAKERS

Forscher (15) discussed the increased number of storage places (i.e., journals) required for the proliferation of bricks by the increasing number of brick makers. In strength and conditioning, it is now possible to get evidence or information from sources other than journals, such as the Internet. A brief Internet search on a particular training method or mode will yield hundreds or thousands of links to pictures, videos, or articles by supposed experts. However, without a stringent peer review process, the Internet allows many individuals to claim to be an expert, whereas it is likely that most are not. The question is who are the true experts and what qualifications are required to become an expert. An expert can be defined as someone who is a specialist, is an authority, or possesses specialized skills. Thus, not everyone can be an expert. By definition, a specialist or possessing specialized skills cannot exist if everyone is a specialist or possesses those skills.

Etymologically, an expert is an individual who is wise through experience. Thus, an individual does not become an expert overnight. So-called 10-year and 10,000-hour rules have been proposed as the minimum length of time required to attain mastery in a given field (13). This computes to approximately 20 hours a week of deliberate practice per week over the 10-year period. Empirically, in sport, there is evidence in support of these rules. Before the 1980s Bulgarian weightlifters started training at an average age of 12 years, entered the junior national team on average at 18 years, and the senior national team at 22 years (8). In the 1980s, weightlifters were started when 10 years old, entering the junior national team on average at 16 years, and the senior national team at 19 years (8). This suggests that while an earlier age of onset may decrease the time required to attain mastery, it does so only by a small amount.

The 10-year rule is not limited solely to sporting endeavors. The time required for mastery has been demonstrated in other endeavors such as music, chess, typing, and science (13). In medicine, the 4-year undergraduate degree is followed by 3–4 years in medical school followed by residency training and often subspecialty training. In academe, the road to a doctoral degree often involves a 4-year undergraduate degree, 2-year master's degree and 3–5 years (or more) completing the doctoral degree. It can be further argued that individuals who have completed a terminal degree (i.e., PhD, EdD, and like) are not experts; rather they may progress to such level over the course of their career. The process of attaining tenure and promotion provides support for this notion.

Simple participation or practice alone is not sufficient to obtain mastery (13). It is often assumed, particularly in the field of sports, that success in performing an activity is equivalent to the ability to teach that activity. This is seen when retired athletes are hired for coaching positions despite a lack of coaching education or experience. While experience in an activity is an important component in the coaching education process (17), it should not be the sole component. Furthermore, the reasons for success in performing the activity should be considered critically. Success may be the result of a number of factors, many of which, such as genetic potential, are irrelevant in developing mastery as a coach.

The characteristics of appropriate practice to achieve mastery include deliberate practice in domain-specific activities (Table 2), the participant having sufficient motivation to carry out the activities, and feedback to modify performance. It should not be

forgotten that domain-specific activities are dependent on having developed the general abilities required to engage in domain-specific activities. As discussed earlier, general and specific domains of knowledge have been identified for strength and conditioning professionals (17,22,23,32). The application of knowledge is also important, which can be obtained through experience in a strength and conditioning facility. However, to meet the criteria for feedback, novice professionals should be mentored by more experienced professionals (22,23,27).

The process of mentoring young professionals extends beyond the field of strength and conditioning. In trades, such as construction and automotives, serving time as an apprentice is often required for credentialing or licensure. Internships and residencies are part of the curriculum for medical doctors and physical therapists. Teachers are required to complete student teaching hours. Even in sports, elite coaches rise through the ranks, often starting as an intern or graduate assistant, progressing to assistant coach and eventually head coach. Thus, attainment of an undergraduate degree and certification are not sufficient to achieve mastery, nor are they indicators of expertise. These credentials only indicate that an individual has achieved minimum competency (27).

## FUTURE DIRECTIONS

The field of strength and conditioning and the demand for competent practitioners is growing, particularly because of growing participation in sport, either as a competitive or as a recreational activity, and exercise for health and wellness. In order for strength and conditioning practitioners to be seen as professionals, quality standards must be identified (27), either formally or informally, and adhered to. Practitioners should also be directed with the responsibility for their own training. This includes not overstating their qualifications or experience and recognizing where they are in the process of achieving mastery. Even advanced degrees (i.e., master's and doctoral degrees) alone are not appropriate indicators of expertise.

It is often assumed that doctoral graduates are capable of teaching responsibilities as an assistant professor; however, most universities offer teaching education services as graduate students typically do not receive formal education in teaching methods. For professors in exercise and sport sciences, courses may involve teaching exercise technique, measurement and evaluation tests, and other practical abilities; however, a degree alone is not a guarantee that the professor is capable of doing so. For professors to teach these practical abilities, they must have experience performing and perhaps more importantly coaching these abilities. This highlights the importance of experience for developing mastery. Novice individuals should seek mentors to facilitate deliberate practice and gain experience. At the same time, experienced individuals should make themselves available to mentor novices.

For practitioners, experience alone is not sufficient. Formal academic preparation in the sciences is required to understand how the human body functions and adapts to training (17,21,34). Most professional organizations and sport governing bodies understand the importance of formal education, which is why coaches are generally required to have some coaching education, whether through a university degree or through specific coaching courses (18,21,32). In strength and conditioning, at the minimum, practitioners should hold an undergraduate degree in exercise and sport science or a similar discipline (27,32). This builds a foundation for which the practitioner can evaluate evidence and develop a philosophy. An important question to ask is, how much education is necessary for practitioners? To date, no universal standard or consensus has been developed for the optimal education required for coaches.

Regardless of current education and experience, all practitioners should continue to seek knowledge that can be applied to practice. This knowledge may be available through a variety of sources, and it is often prudent to expand beyond the traditional sports science fields to obtain knowledge (24); however, the quality of sources should always be evaluated. All evidence must be considered in the context of the available body of knowledge, as opposed to independently. It is only through the integration of available evidence by skilled professionals that an edifice can be constructed (5,24).

As science and research in strength and conditioning continues to increase the available knowledge, it should be recognized that the criteria for mastery will progress. It is apparent in most fields that expertise grows, setting new standards over time. A simple example is the progression of world records in sport. For many sports, world record holders 50 years ago would not even qualify for international competitions today. In physical therapy, there has been a transition in the education process from being prescriptive to evidence based (26). This has been accompanied by increased formal education; in the United States, the master's in physical therapy is transitioning to a doctorate in physical therapy, and in Canada, the bachelor's in physiotherapy is transitioning to master's in physiotherapy. The evidence-based approach in physical therapy follows that which occurred in medicine starting in the 1990s. Medicine itself has advanced considerably in the past 2 centuries from "medieval medicine" to "modern medicine," which follows major scientific advances in chemistry and biology (10). Before the evidence-based approach, medical doctors based treatments off of observations and current practice beliefs as opposed to scientific reasoning (10).

Strength and conditioning has followed a similar path to physical therapy and medicine. Historically, training methods and modes were developed through trial and error. Even the pioneering work of Delorme (7), who popularized progressive resistance exercise, developed from trial

and error, as well as observation. Scientific research in strength and conditioning started appearing in the 1950s and 1960s, including the classic work by Berger (3,4). The development of strength and conditioning as a profession followed expanding rapidly in the 1970s with the founding of the National Strength Coaches Association. Recently, standards and guidelines for practice have been established (27), based on the currently available knowledge. In order for the profession to continue developing, an evidence-based approach should be emphasized, allowing advances in science to further the practice of training (11).

As with other fields, the knowledge held by strength and conditioning experts 50 years ago may now be common knowledge and, while their accomplishments should not be dismissed, new experts have arisen over the years. Some of this knowledge has been found to be incorrect, or better modes and methods have been developed. A prime example is the evolution of the organization of training. Delorme's (7) progressive resistance exercise method was advanced by Berger's (3,4) research on optimal set and repetition combinations. Subsequently, research on periodized training programs became available, and the optimal methods for periodizing training continue to be refined (28). Experienced practitioners should always seek to further their knowledge. At the same time, novice practitioners must first reach this level of knowledge to further progress. Expertise should not be seen as a static construct but rather dynamic. An expert who does not improve their abilities while their profession evolves falls behind others that do and those on the rise.

## SUMMARY

As the popularity of sports and the emphasis on health and wellness grow, the opportunities available to strength and conditioning practitioners will increase. However, each practitioner should be aware of the difference between being a practitioner and a professional. For the field of strength and conditioning to be viewed as a profession, quality standards must be in place (27), both in terms of the education and training of personnel and the application of such education and knowledge. Each practitioner is a representative of the field, and thus each practitioner is responsible for the development of strength and conditioning as a profession. This includes acquiring the minimum knowledge and experience required for competency, continually seeking new knowledge and experience, and critically assessing information presented to them. A large number of bricks and edifices are available in strength and conditioning. However, it is up to the individual to assess their quality and determine their appropriate use. Improper use of bricks and edifices, no matter how structurally sound, may result in damage or harm to others. Ignoring bricks and edifices will leave us outside in the dark, in other words, returning to chaos.

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