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Towards a Grand Unified Theory of sports performance

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A R T I C L E   I N F O

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A B S T R A C T

Sports performance is generally considered to be governed by a range of interacting physiological, biomechanical, and psychological variables, amongst others. Despite sports performance being multi-factorial, however, the majority of performance-oriented sports science research has predominantly been monodisciplinary in nature, presumably due, at least in part, to the lack of a unifying theoretical framework required to integrate the various subdisciplines of sports science. In this target article, I propose a Grand Unified Theory (GUT) of sports performance—and, by elaboration, sports science—based around the constraints framework introduced originally by Newell (1986). A central tenet of this GUT is that, at both the intra- and inter-individual levels of analysis, patterns of coordination and control, which directly determine the performance outcome, emerge from the confluence of interacting organismic, environmental, and task constraints via the formation and self-organisation of coordinative structures. It is suggested that this GUT could be used to: foster interdisciplinary research collaborations; break down the silos that have developed in sports science and restore greater disciplinary balance to the field; promote a more holistic understanding of sports performance across all levels of analysis; increase explanatory power of applied research work; provide stronger rationale for data collection and variable selection; and direct the development of integrated performance monitoring technologies. This GUT could also provide a scientifically rigorous basis for integrating the subdisciplines of sports science in applied sports science support programmes adopted by high-performance agencies and national governing bodies for various individual and team sports.

1. Introduction

It is generally accepted that sports performance is governed by a complex interaction of variables, such as physiological fitness, psychological preparedness, physical development, biomechanical proficiency, and tactical awareness, amongst others (e.g., nutrition, genetics, general health and wellbeing, sociocultural factors, etc.). Despite sports performance being multi-factorial, however, the overwhelming trend historically has been for sports performance research to be monodisciplinary in nature—that is, it has tended to be conducted within the confines of one of the subdisciplines of sports science, usually either sports physiology, sports biomechanics, or sports psychology (e.g., Abernethy et al., 2013; Burwitz, Moore, & Wilkinson, 1994). The lack of genuine interdisciplinary collaborative research, where sports scientists operate in *symbiosis* to fully *integrate* principles, concepts, methods, and data from their respective fields to solve applied research problems and enhance knowledge of sports performance (Freedson, 2009), has been a perennial issue over the years despite repeated calls

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for sports scientists to engage in such agendas. For example, Dillman (1985) argued: *"It is my opinion that there is a major weakness in sports science, and this deficiency stems from the lack of integration of ideas and problem solving both within various disciplines and among areas. Thus, I believe that until a concerted effort is made to form interdisciplinary teams, the field of sports science will stagnate and not produce effective solutions to many problems*" (p. 107). In a forthright and provocative essay, Morgan (1989) also claimed: *"It is not possible for a given individual, operating from the perspective of a given discipline (e.g., psychology or physiology) or subdiscipline (e.g., sport psychology and exercise physiology), even to raise the right questions much less to answer the right questions. It is possible for the unique individual to become a true hybrid (e.g., bioengineer, exercise physiologist, engineering psychologist, or sport psychologist), but it is more efficient for competent, well-trained individuals from two or more disciplines to join forces as an interdisciplinary or multidisciplinary team*" (p. 106). More recently, Elliott (1999) further endorsed the need for more interdisciplinary research and highlighted the importance of uniting sports scientists by stating: *"Seldom is a complex question answered by research based in a single science discipline. Hence, the biomechanist must combine with the exercise physiologist and biochemist, the sport psychologist and the motor development specialist to structure appropriate research design*" (p. 307). Similar recommendations have also been made by Shephard (1984), Cavanagh (1990), Davids, Handford, and Williams (1994), Franks and McGarry (1996), Gregor (2008), Buttfield, Ball, and MacMahon (2009), and Davids and Glazier (2010), amongst others.

One of the reasons for this fragmented approach and the general paucity of interdisciplinary research might be that a unifying theoretical framework capable of integrating the various subdisciplines of sports science has, to date, been lacking. Indeed, Sands and McNeal (2000) cited the absence of a unifying theoretical framework as one of the main reasons why sports science has generally been poor at predicting sports performance. In this target article, I propose a Grand Unified Theory (GUT)[1] of sports performance, based on the conceptual model introduced originally by Newell (1986), which could provide the platform for much-needed interdisciplinary work in sports science and better explain, and possibly predict, sports performance at both the intra- and inter-individual levels of analysis. Although Newell's constraints model is nearly 30 years old, and despite it receiving exposure in the sports medicine (e.g., Davids, Glazier, Araújo, & Bartlett, 2003; McKeon & Hertel, 2006), physical therapy and rehabilitation (e.g., Holt, Wagenaar, & Saltzman, 2010; Newell & Valvano, 1998; Wikstrom, Hubbard-Turner, & McKeon, 2013), talent development (e.g., Phillips, Davids, Renshaw, & Portus, 2010), skill acquisition (e.g., Araújo, Davids, Bennett, Button, & Chapman, 2004; Davids, Button, & Bennett, 2008; Renshaw, Davids, & Savelsbergh, 2010), motor development (e.g., Haywood & Getchell, 2014; Piek, 2002), physical education (e.g., Chow et al., 2006, 2007), strength and conditioning (e.g., Holmberg, 2009; Ives & Shelley, 2003; Jeffreys, 2011), sports biomechanics (e.g., Caldwell, van Emmerik, & Hamill, 2000; Glazier & Davids, 2009a; Seifert & Chollet, 2008), and sports performance analysis (e.g., Glazier, 2010; Glazier & Robins, 2013; Vilar, Araújo, Davids, & Button, 2012) literatures recently, I believe that its scope and potential contribution to applied sports science research and support work has generally been overlooked by the sports science community at large. Moreover, I suggest that, not only can this constraints-based GUT offer greater explanatory power and versatility than some other prevailing paradigms in sports science (e.g., deterministic modelling – Glazier & Robins, 2012; information processing theory – Zelaznik, 2014), and provide a more holistic understanding of sports performance, it could help break down some of the silos that have developed over recent years (see Gregor, 2008; Kretchmar, 2008) and restore greater disciplinary balance to the field (see Ives & Knudson, 2007), as well as provide stronger rationale for data collection and variable selection, and direct the development of integrated performance monitoring technologies.

In the following sections, I provide an introduction to the concept of constraints and outline the basic tenets of Newell's (1986) constraints model (Section 2). I make the distinction between organismic, environmental, and task constraints, and provide examples from sports of these three categories of constraints. Despite its deceptively simple appearance—which can be considered a virtue given my intention to apply it to sports performance and the need for it to be accessible to athletes and coaching practitioners (Meyers, 2006)—this framework has deep theoretical roots that can be traced back to the pioneering work of Kugler, Kelso, and Turvey (1980, 1982) on the application of principles and concepts of non-equilibrium thermodynamics (Nicolis & Prigogine, 1977), homeokinetics (Soodak & Iberall, 1978), and synergetics (Haken, 1977) to the study of human movement. I then discuss how the different types of constraints shape emergent patterns of coordination and control at both the intra- and inter-individual levels of analysis by providing 'equations of constraint' that metaphorically get 'written over' multiple independent component parts or degrees of freedom (DOF) to functionally combine them into task-specific structural units known as a coordinative structures (Section 2.1). Once formed, these special-purpose devices are able to operate relatively autonomously by exploiting ubiquitous processes of self-organisation that are inherent to many natural physical and biological systems (Camazine et al., 2001; Kelso, 1995; Yates, 1987). Next, I outline the implications of the proposed GUT for the various subdisciplines of sports science, particularly how it can provide the conduit for the interdisciplinary integration of principles, concepts, methods, and data from motor control and development, skill acquisition, sports performance analysis, sports biomechanics, sports physiology, sports psychology and sports technology (Section 3). Because of their often significant impact on sports performance, special consideration is then given to how key physiological

[1] Grand Theories represent the broadest form of theory within a discipline (Ayres, 2008) and are prevalent in a variety of diverse fields from quantum mechanics to sociology and nursing. They attempt to explain the inter-relationships amongst numerous concepts and are designed to be universally applicable over all scales of space and time. Grand Theories can be useful as organising frameworks for knowledge development or as foundations for mid-range theory development (Ayres, 2008). They have often been described as being 'normative'—that is, they are prospective in their outlook and describe not the way a discipline is, but the way that discipline should be. The GUT for sports performance—and, by elaboration, sports science—proposed in this target article fulfils many of the qualifying criteria for a Grand Theory.

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