



Examining Core Dysfunction in Football Athletes through Interdisciplinary Systematic Design Problem Solving

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Background and Problem Definitions. Football athletes are required to have exceptional explosive power moving lateral, forward, and backward to either achieve leverage for block or evasion of their opponent. An athletes' explosive power is correlated with sports performance and their rate of injuries (Brodt et al., 2008; Adams et al., 1986). Nearly two-thirds of NCAA football injuries are core related injuries, which is a staggering five-times likelier than an injury to the head, including concussions (NCAA.org, n.d). In 2016 alone, 62% of \$547 million U.S. wholesale football equipment sales was for protection (Statista, 2017). With the prevalence of core-related injuries, and the amount of money dedicated towards football equipment, there is limited football protective products that address core related injuries.

Purpose and Research Questions. The purpose of this study is to examine the problem of core-related injuries in football athletes and propose a prototype for a lower body football girdle. The study is based on Labat and Sokolowski's (1999) systematic design problem-solving, by way of a biomechanical and physiological approach. Specifically, the study implemented problem definition/research allowing previously found data to lead the next research question. Research questions include (RQ1) What are the strengths and limitations of commonly used methods for neuromuscular feedback (NMF) to address core dysfunction?; (RQ2) What are the common functional traits of textiles used in lower extremity football protective equipment; and (RQ3), What is an effective NMF application for a prototype?

Method. To answer research questions, market research and comprehensive literature reviews were first conducted. About 80 articles and online resources focusing on core related biomechanics, NMF and core dysfunction (CD) were reviewed and an online market analysis of the most popular style of lower extremity football pads was conducted. Based on the analysis, the design research process included: (a) deconstructing a popular football girdle model and a compression short to inspect the pad placement, seam construction, and textile properties, (b) examining a total of seventeen sewn-in football girdles to determine common functional textile attributes that are breathable, moisture control, and compression using textiles with spandex or lycra, and (c) constructing a prototype of a compression short that integrates kinesiology tape (KT) methods using elastic bands.

Results. The research found a significant component of sports performance and core related injuries is CD. A conventional method to address CD is increasing neuromuscular activity in the lower back muscles through a passive stimulus that induces NMF. The study also found that NMF is commonly accomplished with compression fabric, KT and EB with less common thermoplastic polyurethane (TPU). Each solution has its strengths and drawbacks. KT and CF

have been found to increase performance, while decrease CD and injuries, however, KT may cause skin irritations and is difficult to apply without professional assistance. CF has a narrow ideal compression stiffness window for NMF. For example, CF used for medical purposes may be too constrictive while commercial CF may not be stiff enough to achieve needed benefits. Further, CF has been found to cause individuals to overheat. TPU bands tensile strength also increase performance; yet, the thickness of the band required may restrict the proper range of functional motion needed, thus TPU bands were excluded from the research. The research also shows that a posterior star with modified belt produced a similar visual hip tilt. The proposed prototype incorporated moisture wicking stretch mesh fabric for the crotch and abdominal regions of the prototype. It also included hip pads, thigh pads and a tailbone pad where each pad was encased in high compression power mesh allowing for ventilation and flexibility.

Significance and Implication. This research is pertinent on multiple level and the findings contribute to both industry and academia. From a sports perspective, the research shines a light to the overshadowed issue of core related football injuries. The research also reaffirms the academic necessity to have interdisciplinary approaches to functional design. From an industry perspective the proposed design may potentially legalize the investment in NMF products for sports performance and injury reduction. Lastly, from an athlete perspective this conceptual design may aid their pursuit to do the remarkable with the best protective equipment. Future study may include conducting subject testing and evaluation of the prototype's functional and aesthetic properties to refine the prototype. More specifically testing the prototype versus KT in performance including biomechanical kinematic and kinetic measures; comfort levels through wearer assessments; and marketability through user's perceived risk. As well, future prototype consideration should address aesthetic functionality, mass customization, garment durability/retention and sustainable product cycle.

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