Institution: University of Gloucestershire

Unit of Assessment: UoA C-26 (Sport & Exercise Sciences, Leisure & Tourism)

Title of case study: Protect their knees: Reducing injury risk in paediatric sporting populations

1. Summary of the impact

The research of **Professor Mark De Ste Croix** has begun to question well-established practice in injury prevention and has proposed a change in focus that is directly related to fatigue resistance. The research has led to new approaches to injury prevention for young athletes that are specific to growth and that do not simply adopt adult models. The three constituencies upon which the research has had impact are:

(i) Enriching and informing practice of national (The Football Association), European (UEFA) and World (FIFA) governing bodies of sport;
(ii) Informing and changing the pre-habilitation practices of physiotherapists, sports scientists, strength and conditioning specialists, coaches, and medical professionals for youth footballers;
(iii) Reducing injury risk and incidence in youth footballers.

2. Underpinning research

The underpinning research for this impact case study has been undertaken at the University of Gloucestershire by **De Ste Croix** (2004-present) and published in international peer reviewed journals (over 60 articles), books (1 co-edited book) and book chapters (n=25) disseminated at international conferences (over 70 conference presentations), as an invited Keynote speaker (15 International conferences), and via successful research grants. **De Ste Croix** has carried out work in three distinct but related areas:

1. <u>The development of children's neuromuscular strength</u>

The development of children's strength has not been well documented especially in relation to eccentric muscle actions. **De Ste Croix** is one of the few authors to have described the age and maturation related changes in strength using isokinetic dynamometry and from longitudinal data.[a,e] This has provided a clear understanding of when sex differences start to emerge in strength development and have highlighted that this divergence is both muscle group and muscle action specific. Importantly, **De Ste Croix** has established the neuromuscular mechanisms associated with the development of strength during childhood. This has included using sophisticated equipment such as magnetic resonance imaging and appropriate statistical techniques (allometric and multi-level modelling). This has led to an increased knowledge in talent identification and development models, challenging accepted practices and re-evaluating perspectives.[c] Understanding the normal age and sex-associated development in strength has provided a baseline from which to explore changes that may increase or reduce injury risk and subsequently how training might reduce this risk in paediatric populations.

2. <u>Injury risk and injury prevention in paediatric populations</u>

There is a dramatic increase in injury incidence in children between the ages of 11-16 years which might be ascribed to a number of neuromuscular, maturation and biomechanical effects. **De Ste Croix's** work in this area is underpinned by a number of highly competitive research grants from FIFA, UEFA and the Football Association. Research that underpins this case study has demonstrated that fatigue plays a key role in injury risk in youth as it affects neuromuscular functioning. Importantly, the detrimental effects on muscular and neuromuscular function is both

age and maturation specific.[d] These data reinforce the need for organisations to re-evaluate their current provision for injury prevention which is not individualised based on maturation stage. In particular, the world-wide established *FIFA 11+* (injury prevention programme) is not suitable for children given that: (i) it does not focus on fatigue resistance; and (ii) progressions are not suitable for maturational stages of puberty.

3. Effectiveness of pre-habilitation programmes for injury prevention

De Ste Croix's work has examined whether commonly used stretching techniques influence both muscular force production and neuromuscular capability. These studies (2009-present) have indicated that stretching does not influence neuromuscular functioning and should be included in pre-habilitation programmes as they improve the range of movement and subsequent length-tension relationship.[f] This research has also informed current practice in eccentric conditioning by demonstrating improvements in length-tension relationship and torque production after eccentric training of the hamstring muscles. **De Ste Croix's** work is influencing current knowledge and understanding of pre-habilitation programmes for injury prevention in youth athletes by indicating that they need to be maturational stage-specific, aimed at fatigue resistance, and inclusive of stretching exercises and eccentric conditioning.

3. References to the research

Articles that have been published relating to this case study have been cited 485 times (380 times since 2008) (ref: Google Scholar 22.11.13). The case study is underpinned by the following peer-reviewed publications:

a. **De Ste Croix, M.B.A.,** Deighan, M.A., and Armstrong, N. (2003). Assessment and interpretation of isokinetic strength during growth and maturation. *Sports Medicine.* 33 (10): 727-743 http://dx.doi.org/10.2165/00007256-200333100-00002 (Journal Impact Factor: 5.237, Cited = 78)

b. **De Ste Croix, M.B.A.,** Deighan, M.A., Ratel, S. and Armstrong, N. (2009). Age and sex differences in isokinetic knee muscle endurance between young children and adults. *Applied Physiology, Nutrition and Metabolism.* 34 (4): 725-731 http://dx.doi.org/10.1139/H09-064 (Journal Impact Factor: 2.131, Cited = 5)

c. Ford, P., **De Ste Croix, M.,** Lloyd, R., Meyers, R., Moosavi, M., Till, K., Williams, C., Oliver, J. (2011). The Long Term Athlete Development model: physiological evidence and application *Journal of Sports Sciences.* 29 (4): 389-402. http://dx.doi.org/10.1080/02640414.2010.536849 (Journal Impact Factor = 1.93, Cited = 49)

d. **De Ste Croix, M.B.A.,** Deighan, M.A., Armstrong, N. (2007). Functional Eccentric/Concentric ratio of knee extensors and flexors in pre-pubertal children, teenagers and adults. *International Journal of Sports Medicine.* 28 (9): 768-772 http://dx.doi.org/10.1055/s-2007-964985 (Journal Impact Factor = 2.433, Cited = 9)

e. De Ste Croix, M.B.A., Armstrong, N., Welsman, J.R and Sharpe, P. (2002). Longitudinal changes in isokinetic leg strength in 10-14 year olds. *Annals of Human Biology.* 29 (1): 50-62 http://dx.doi.org/10.1080/03014460110057981 (Journal Impact Factor = 1.975, Cited = 54)

f. Ayala, F., **De Ste Croix, M.B.A.,** Sainz de Baranda, P, Santonja, F. (2013). Acute effects of static and dynamic stretching on the hamstring eccentric length-tension relationship and unilateral hamstring to quadriceps strength ratios. *Journal of Sports Sciences*. 31 (8): 831-839 http://dx.doi.org/10.1080/02640414.2012.751119 (Journal Impact Factor: 1.93, Cited = 1)

4. Details of the impact

Professor De Ste Croix's UEFA-funded research project, designed to explore the effects of football match play on neuromuscular function and injury risk in youth female footballers (in 2012), was important due to increasing numbers in female participation in football and the increased risk of injury in female players.[1,3] Based on the findings of the project, **De Ste Croix** was commissioned by the Football Association (FA) to work in partnership on further research to inform current practice in youth injury prevention.[1] By working in collaboration with FA Centres of Excellence (CoE) the application of **De Ste Croix's** research is directly impacting individuals at risk of injury (girls aged 8-17 years who have been identified as 'at risk' groups). The intervention programme that is underway with 12 CoE (circa 1000 girls) will be expanded to all 32 CoE (circa 2500 girls) in 2014. This outreach work is looking to identify girls classified as at risk of injury and to provide individualised training programmes to reduce injury risk. This is the first national deployment of an intervention programme directed at all girls participating in an FA CoE, and aimed at reducing injuries of youth female footballers. Simultaneously, **De Ste Croix** was also awarded a research grant from FIFA (the world governing body of football) to build upon the findings of the UEFA-funded study, the remit of this research being to 'contribute to the world football family'. This research is current, evolving and aims to explore the chronic effects of football match play on neuromuscular readiness to re-perform in female youth footballers. This research will inform and develop the current globally accepted pre-habilitation programme (*FIFA 11+*) which is used by over 30 million footballers worldwide. The current 11+ programme has not been developed with paediatric populations in mind and therefore is not deemed appropriate. This applied research on injury risk and prevention in children is underpinned by **De Ste Croix's** expertise in child neuromuscular functioning. The national and international reach of this work is significant with 29 million girls and women participating in football worldwide (source: FIFA 'The Big Count').

Informing/Changing Practice:

The above research has also led to **De Ste Croix** working directly with a number of professional/elite football clubs across Europe including: FC Barcelona, SL Benfica, Athletic Club Bilbao, Bristol City and Bristol Ladies Academy. In turn, the research has started to change embedded pre-habilitation/training practice in a relatively short space of time in professional football clubs around the world, directly impacting on around 1300 players.[1,2,3,4,5] A member of the FC Barcelona medical team states that: "… this improvement in ACL prevention is a direct result of the new training protocols introduced following Mark's research. The medical staff at the club are also now more knowledgeable in the area of physical mechanics as a result of the research put forward by Mark.".[5] An additional impact that **De Ste Croix's** research has had at FC Barcelona is an increased understanding and empathy of pre-habilitation training for the women's team by the mainly male medical staff. This has impacted on the women's team by increasing the focus and attention given to the female players by the medical staff at the club.[5] As a direct result of **De Ste Croix's** research Bristol City have also increased the time spent on neuromuscular training programmes with its youth players, with the ultimate aim of reducing non-contact injuries.[2] Based on the research of **De Ste Croix,** Bristol City have re-designed and implemented an innovative pre-habilitation programme with all of their youth players (ages 8-21 years) with a focus on the principles of movement control and neuromuscular activity. This has led to Bristol City commissioning **De Ste Croix** to evaluate the effectiveness of this change in practice. Others, including a female team in the USA, have changed their practice by implementing injury prevention work towards the end of training sessions where fatigue is present.[2,3] Head of Women's Soccer at Rider University, New Jersey (USA) notes that: "We implemented a change in policy ... This change was a direct result of the research undertaken by Mark and Gloucestershire.".[3] A physiotherapist at Athletic Club Bilbao states that based on the research of **De Ste Croix** the club have introduced a new training programme for their male youth players that incorporates injury

prevention in relation to muscle fatigue.[4] This change in practice is a direct result of **De Ste Croix's** research indicating that fatigue induces a large increase in injury risk. The Football Association have also changed their policy by implementing prevention programmes with National youth teams from 13 year-olds upwards.[1] Previously such programmes were restricted to the senior teams but the Head of Physiotherapy for the FA (Women) has stated that work by **De Ste Croix** has "… proved the applicability of certain training methods to younger age groups. We have now implemented specific exercises with the U13s and upwards that we used to employ with the senior team only. This is a policy change that has occurred as a result of the work with Gloucestershire.".[1]

Reducing Injury Risk

Screening players for injury risk is an important part of reducing injury incidence. As a direct result of the research undertaken by **De Ste Croix** FC Barcelona and Athletic Club Bilbao have implemented screening protocols using isokinetic testing with the specific intention of reducing ACL injury.[4,5] Although most of these professional organisations have only recently changed their practice there is growing evidence that this change has had an impact by reducing injury incidence.[2,3,4,5] This work has included collecting injury incidence data as well as mechanism data related to relative risk to help identify youth players at risk.[1,2,4] A physiotherapist at Athletic Club Bilbao notes: "We have implemented these testing techniques into our training programmes for various groups already and we are checking injury levels and will have the data soon. We are confident that the incidence of ACL injuries will be reduced.".[4] FC Barcelona have confirmed a reduction in ACL injuries (1 in 2013), and that the potential for that injury was highlighted in the screening tests adopted following a change in practice based on **De Ste Croix's** research. This change in practice has also had a direct impact on the player as the medical team confirm that the injury was easier to treat with less rehabilitation time required.[5] Data from the FIFA funded research exploring the chronic effects of fatigue accumulated during match play on injury risk and neuromuscular readiness to re-perform is being used to inform and change training loads and recovery strategies in youth footballers.[2] Bristol City Football Club are using these data to inform their practice in implementing the FA's promotion of the new Elite Player Performance Plan (EPPP), which advises on training hours for youth players.[2] The Academy Head of Sports Science and Medicine at Bristol City states that the club's implementation of current FA policy is taking into account **De Ste Croix's** research that age, maturation and fatigue for each specific player is considered in devising and implementing their youth training programmes. This is supported by the FA who state that the direct improvements in training and recovery practices in elite youth sport that are being implemented based on this research will, over time, see improved health and well-being in sporting youth populations.[1] The FA's head physiotherapist for women's football concludes that: "… as a direct result of Mark's research we have found that we can influence the prevalence of ACL injuries by implementing preventative measures at a younger age range.".[1]

5. Sources to corroborate the impact

1. Testimony from Head Women's Physiotherapy, Football Association
2. Testimony from Academy Head of Sports Science and Medicine, Bristol City Football Club (UK)
3. Testimony from Head Women's soccer coach, Rider University, New Jersey (USA)
4. Testimony from Head of Youth Conditioning, Athletic Club Bilbao Football Club (Spain)
5. Testimony from Medical Team (Youth Conditioning), FC Barcelona (Spain)