Institution: Leeds Trinity University		
Unit of Assessment: 24		
Title of case study: Enhancing the performance of domestic and international team sport players by implementing new match-day practices: A focus on substitutes and half-time protocols		
Period when the underpinning research was undertaken: October 2016 – November 2020		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	**Role(s) (e.g. job title):**	**Period(s) employed by submitting HEI:**
Mark Russell	Professor	Oct 2016 – present
Martin Barwood	Reader	Aug 2016 – present
Jon Radcliffe	Lecturer	Sept 2013 - present
Carlton Cooke	Professor	Sept 2015 – June 2020
Sam Hills	Lecturer	Aug 2020 - present
Period when the claimed impact occurred: 2017 - present		
Is this case study continued from a case study submitted in 2014? N		

1. Summary of the impact

Leeds Trinity University's (LTU) research (led by Russell) informs the match-day practices of elite rugby and soccer players competing for top tier domestic and international-standard teams both at home and abroad. Key performance indicators have been improved by discontinuing sub-optimal practices, and modifying the recommendations made to players concerning the: 1) pre-match warm-up, 2) pitch side rewarm-ups after kick-off, and 3) half-time interventions. Russell's research has contributed directly to changes in the practices of professional sports teams and informs international expert statements. Pathways to impact have primarily been through partnership working and influencing practitioners delivering professional services who embed the research into the routines of athletes.

2. Underpinning research

Context: The concept of aggregating "marginal gains" to enhance competitive performance has become commonplace in professional sport in the last decade. Match-day provides coaching staff with opportunities during the competitive calendar to directly influence athletic performance. However, research recruiting professional sportspeople, especially to studies monitoring match-day itself, is extremely challenging given the reluctance to interrupt competitive performances. Introducing substitutes and adopting specific pre-pitch-entry practices (including at half-time), can influence match outcomes thereafter but few studies have investigated such strategies.

Nature of the insight: LTU's Enhancing Human Performance researchers, led by Russell, used assess then address approaches to answer applied performance questions associated with characterising responses to: existing player practices (papers 1,2,4), including better understanding of practitioner perceptions (paper 3), and intervention opportunities (papers 4,5,6). To enhance performance, Russell's work has contributed to the **evolution of recommendations made to professional team sports players** regarding the match-day half-time and pre-pitch entry practices undertaken by both substitute and non-substitute players, including **discontinuation of sub-optimal practices and the development of best-practice guidelines**.

Quantifying the previously unknown match-day demands of professional soccer substitutes (paper 1) indicated that pre-match and half-time (re)warm-ups were conducted in isolation from starting players and yielded lower than anticipated physical demands (total distance: ~1 km). Substitutions occurred ~30 min before matches ended, so significant periods of time (whereby players mostly remained seated/inactive) separated pre-kick-off warm-up activities and pitch-entry. When substitutions were made, incoming players experienced reduced physical performance in 50% of the variables measured following the first five minutes of match-play; questioning the efficacy of existing pre-pitch-entry practices, including those conducted at half-time. In support, applied practitioners from professional soccer clubs also questioned whether current practices promoted optimal readiness for substitutes' match-introduction (paper 3).

To gain further insight, papers 2 and 4 recreated the applied practices of professional soccer players in controlled laboratory scenarios while employing robust physiological and performance-related outcomes. Notably, for substitute players, readiness for pitch-entry was compromised

(primarily attributable to reductions in body temperature) when typical match-day practices were undertaken (paper 2), and for non-substitute players, existing half-time protocols reduced the efficacy of strategies previously deemed to be ergogenic (i.e., reductions in blood glucose concentrations throughout the initial stages of the second half limiting the physiological effects of carbohydrates consumed to enhance second half performance; paper 4). Alternative intervention opportunities, primarily regarding the consumption of novel carbohydrate beverages and additional half-time physical exercise, were subsequently proposed (papers 4,5,6).

Implementing a carbohydrate ingestion strategy that was better suited to applied practice (i.e., consuming a greater concentration of drink than previously reported, 12% versus 6%, post-warm-up and during half-time instead of adhering to established recommendations of frequent smaller boluses during a sport with limited breaks in play), improved impairments in physical, technical and cognitive performances induced by soccer-specific exercise (paper 4). Furthermore, following cessation of existing practice, and implementation of modified substitute protocols in real-world scenarios (paper 6), **heightened movement responses were observed by professional soccer players performing integrated (with starting players), versus isolated, pre-match warm-ups (total distance: ~1.5 km, ~50.3 m·min^{-1} vs. ~1 km, ~37.9 m·min^{-1}), and adopting longer (i.e., ~13 min vs. ~6 min) staff-led half-time activities. Upon pitch-entry, key performance indicators (total, high-speed running distances: ≤10%, ≤24%, respectively) were improved and maintained for durations three-times longer using the modified versus existing protocols (~15 vs. 5 min).**

3. References to the research

All outputs referenced have been published in peer-reviewed upper quartile sports science journals; each having undergone rigorous peer review based on initial editor screening and anonymised (double-blind) refereeing by at least two referees (including at least one round of author revision). Where available, evidence that the output has been used as a reference point for further research beyond the research group and submitting institution is included.

Paper 1: Hills SP, Barrett S, Feltbower RG, Barwood MJ, Radcliffe JN, Cooke CB, Kilduff LP, Cook CJ, Russell M (2019). A match-day analysis of the movement profiles of substitutes from a professional soccer club before and after pitch-entry. PLoS ONE 14(1): e0211563. https://doi.org/10.1371/journal.pone.0211563

- Key findings include…
  - Substitutes performed ~3 bouts of rewarm-up activity (with each bout being 3-6 min and covering between 230 and 430 m) prior to entering the pitch.
  - No sprinting and negligible high-speed running occurred in each rewarm-up bout (including half-time).
  - Substitutes performed at substantially higher intensities during the first 5 min following match introduction compared with 5–25 min thereafter - questioning whether pre-pitch-entry strategies contribute to such declines after 5 min.
- The output has been cited in articles published in peer-reviewed upper quartile journals titled: Sports Medicine, and European Journal of Sports Sciences, https://scholar.google.com/scholar?oi=bibs&hl=en&cites=3990052778077681033
- Altmetric: Reached >173,000 followers (as of 12/3/21; https://www.altmetric.com/details/54768364/twitter)

Paper 2: Hills SP, Aben GJ, Starr DP, Kilduff LP, Arent SM, Barwood MJ, Radcliffe JN, Cooke CB, Russell M (2020). Body temperature and physical performance responses are not maintained at the time of pitch-entry when typical substitute-specific match-day practices are adopted before simulated soccer match-play. Journal of Science and Medicine in Sport https://doi.org/10.1016/j.jsams.2020.11.013

- Key findings include…
  - The typical match-day practices of soccer substitutes did not maintain body temperature or physical performance responses between warm-up cessation and simulated second-half pitch-entry – questioning whether a substitute's existing pre-pitch-entry strategies are optimal.

    - The absence of substantial performance-limiting fatigue during ~30 min of simulated match play highlights that bespoke post-match training and recovery strategies are warranted for substitutes.
- Altmetric: Reached >47,000 followers (as of 12/3/21; https://www.altmetric.com/details/95183309/twitter)

Paper 3: Hills SP, Radcliffe JN, Barwood MJ, Arent S, Cooke CB, Russell M (2020). Practitioner perceptions regarding the practices of soccer substitutes. PLoS ONE 15(2): e0228790. https://doi.org/10.1371/journal.pone.0228790

- Key findings include…
    - Substitutes' pre-match warm-ups are typically led by team staff, however practitioners reported providing varying levels of input with regards to the practices adopted between kick-off and pitch-entry.
    - Practitioners remained largely uncertain as to the efficacy of current pre-pitch-entry practices.
    - 100% of practitioners from professional clubs highlighted pre-pitch entry 'preparatory strategies' as at least a 'moderately important' area for future research.
- The output has been cited in articles published in peer-reviewed upper quartile journals titled: International Journal of Environmental Research and Public Health https://scholar.google.co.uk/scholar?oi=bibs&hl=en&cites=12940893614458179519
- Altmetric: Reached >53,000 followers (as of 12/3/21; https://www.altmetric.com/details/75384069/twitter)

Paper 4: Harper L, Stevenson E, Rollo I, Russell M (2017). The influence of a 12% carbohydrate-electrolyte beverage on self-paced soccer-specific exercise performance. Journal of Science and Medicine in Sport, 20(12), 1123-1129. https://doi.org/10.1016/j.jsams.2017.04.015

- Key findings include…
    - Soccer-specific exercise impaired physical, technical and cognitive performance despite players starting exercise in a fed state.
    - Drinking 250 ml of a 12% carbohydrate-electrolyte beverage towards the end of the warm-up and at half-time provided a practical hydro-nutritional strategy for soccer players without further compromising abdominal discomfort relative to water.
    - Practitioners should be aware of transient glycaemic reductions occurring during the initial stages of the second half despite carbohydrate-electrolyte consumption.
- The output has been cited in articles published in peer-reviewed upper quartile journals titled: British Journal of Sports Medicine, Nutrients, Journal of Sports Sciences https://scholar.google.co.uk/scholar?oi=bibs&hl=en&cites=8915967102088621577
- Altmetric: Reached >108,000 followers (as of 12/3/21; https://www.altmetric.com/details/19495151/twitter)

Paper 5: Hills SP, Russell M. (2017). Carbohydrates for soccer: a focus on skilled actions and half-time practices. Nutrients 10(1), 22; https://doi.org/10.3390/nu10010022

- Key findings include…
    - Current half-time practices may compromise the efficacy of strategies previously found to be ergogenic by eliciting sub-optimal physiological responses (e.g., reduced blood glucose concentrations, body temperature reductions) at the start of the second half when investigated in more-realistic match-day conditions.
    - Modifying half-time practices, including the consideration of ingesting higher concentrations of carbohydrates, and prioritising exogenous energy consumption during a half-time rewarm-up, offer possible solutions to practitioners.
- The output has been cited in articles published in peer-reviewed upper quartile journals titled: Nutrients, Current Nutrition Reports. https://scholar.google.com/scholar?oi=bibs&hl=en&cites=7276319079646344540
- Altmetric: Reached >148,000 followers (as of 12/3/21; https://mdpi.altmetric.com/details/30903671/twitter)

Paper 6: Hills SP, Barrett S, Hobbs M, Barwood MJ, Radcliffe JN, Cooke CB, Russell M (2020). Modifying the pre-pitch entry practices of professional soccer substitutes may contribute towards improved movement-related performance indicators on match-day: A case study. PLoS ONE 15(5): e0232611. https://doi.org/10.1371/journal.pone.0232611

- Key findings include…
  - Heightened movement-related key performance indicators occurred when substitutes were included within a new whole-team pre-match warm-up, undertook a supervised half-time rewarm-up, and received ongoing player education about the importance of rewarm-up activities.
  - Substitute players were more efficient following the modified match-day protocol as improved goal differentials (defined as: goals scored minus goals conceded) occurred following 26% of the substitutions made - despite substitutes being introduced ~7-10 min later into the match.
  - Existing practices resulted in worsened scorelines following 20% of substitutions (i.e., paper 1), this figure was almost halved (i.e., 11%) following the new protocol.
- Altmetric: Reached >67,000 followers (as of 12/3/21; https://www.altmetric.com/details/81452835/twitter)

4. Details of the impact

Research led by Russell since 2016 informs the scientific evidence base underpinning the match-day recommendations made to elite team sports players competing in the UK and Internationally. Pathways to impact include: working with partners, and engaging stakeholders and beneficiaries.

Partnering and co-creating knowledge with Hull City AFC (between 2017 and 2020) led to **a deeper understanding of the match-day activities of professional first team soccer players** (S1); findings which, especially in the case of substitutes, were unknown beforehand. **Raised awareness** amongst senior staff (S1), including the head coach, **that match-days elicited lower than anticipated physical demands for substitutes** (paper 1) highlighted intervention opportunities, including the **cessation of senior team practices deemed to be sub-optimal** (S1). Observing **compromised physiological and performance readiness before pitch-entry led to a modification of the match-day protocols** of all senior, reserves and under 23 teams of the partner club (approx. 100 athletes); moving away from activities deemed sub-optimal and incorporating novel interventions (S1).

In line with the project's initial remit, **senior team substitutes were more effective upon pitch-entry when adhering to a new protocol** (S1) that included a whole-team pre-match warm-up, a supervised half-time rewarm-up, and provision of ongoing player education about the importance of rewarm-up activities; impact which was confirmed by paper 6. Consequently, **substitute players were more efficient** as improved goal differentials (defined as: goals scored minus goals conceded) occurred following 26% of the substitutions made - a value equivalent to pre-intervention data (paper 1) despite substitutes being introduced ~7-10 min later into the match (paper 6, S1). Where **existing practices resulted in worsened scorelines following 20% of substitutions (paper 1), an almost halving of this figure (i.e., 11%) accompanied the new protocol** (paper 6). **Key performance indicators also improved** (i.e., total, high-speed running distances: ≤10%, ≤24%) **and were maintained for three-times longer on pitch-entry** compared to pre-intervention (~15 vs. 5 min; paper 6). The significance of such changes to the partner club should not be underestimated in a "marginal gains" performance environment (S1).

The half-time practices of domestic and International sports teams have changed as a result of Russell's research cited here. Expert advice and contributions to continuing professional development by Russell have benefited the applied practices of athletes competing at the highest level of team sport, both nationally and internationally – the efficacy of such interventions is corroborated by S1-7. Notably, M. Naylor (Head of Nutrition Services at the English Institute of Sport, and consultant to the English Rugby Union and English Football Association men's and women's national teams) commented: "*The discussions we have had, and the professional development training that he [M Russell] has provided (webinar), has led directly to changes to protocols on match-day that were used in the 2018 FIFA World Cup, 2019 FIFA Women's World Cup, and 2019 Rugby World Cup. For instance, policies relating to half-time rewarm-up activities, in-game carbohydrate supplementation strategies, and substitute practices have all been amended (including discontinuation of some) based on Mark's research. As a result, players and*

staff alike have seen benefits at the start of the second half, both in normal and extra-time; players just feel better prepared..." (S2). The Swedish Football Association also report that since implementing half-time protocols underpinned by this body of research, **the percentage of the total number of goals scored in the opening 15 minutes of the second half have improved significantly from 8 to 26% between consecutive seasons (30 game comparison);** findings which are attributed to the added half-time rewarm-up activity (S8). Authoritative consensus statements reaching over 770,000 followers (Altmetric) make explicit mention of LTU's research, with the UEFA expert statement on nutrition in elite football (S9) stating: "*It is…recommended that…carbohydrate is consumed after warm-up and again at half-time to meet these guidelines*."

Outside of collaborating partners, applied sports physiology, performance nutrition, and strength and conditioning practitioners have benefitted from LTU's research. Individually, Russell has shared these data in **numerous invited presentations at key practitioner events nationally and internationally** (e.g., United Kingdom Strength and Conditioning Association annual conference, Sports Science Summit, International Society of Sports Nutrition Expert workshops, American College of Sports Medicine annual conference) and has been specifically targeted to provide consultancies which draw upon the research cited. Since 2017, **Russell has delivered practitioner education workshops** to the staff of International (English Football Association, England Rugby Football Union, England Rugby League, Scottish Rugby Football Union, DC United and Houston Dynamo; USA; S2-4) and domestic (AFC Bournemouth, Chelsea FC, Barnsley FC; S7) sports teams; with follow-up evaluations highlighting that all respondents were **better able to: "describe the responses of substitute players before and after pitch-entry while also highlighting contextual influences", "implement strategies on match-day for the benefit of whole and partial match players", and "feel more confident in the planning and preparation of match-day practices for bespoke populations of players/circumstances."** Furthermore, key practitioner texts drawing upon this body of research have been published both in the UK (S10 disseminated to all professional clubs via the Football Medicine and Performance Association) and internationally (S11). In addition to the beneficiaries identified, nearly 600,000 people from all over the World (i.e., United Kingdom, United States, Australia, New Zealand, Ireland, Brazil, China, Italy, Estonia, Cyprus, Norway, Germany, Belgium, South Africa, Mexico, Peru, Poland, Netherlands, Singapore, Spain) have interacted directly with our underpinning research (see Altmetric data; section 3).

Based on Russell's work, substitute player responses and half-time in team sports have now become areas of academic and practitioner focus (papers 1-6, S5, S9, S10). Influencing practitioners delivering professional services in a field where the smallest improvements can be meaningful, has resulted in the match-day practices of sports teams competing in National and International tournaments, being improved by LTU's "Enhancing Human Performance" research.

5. Sources to corroborate the impact

S1: Hull City AFC testimonial
S2: England Rugby Union, English Football Association, English Institute of Sport testimonial
S3: England Rugby League, GB Rugby League Lions, Wigan Warriors RLFC testimonial
S4: England Rugby League, Scottish Rugby Union, Wigan Warriors RLFC testimonial
S5: https://footballmedicine.net/should-footballers-ingest-carbohydrates-half-time/
S6: Dietician Houston Dynamo corroboration
S7: Head of Sports Science, Barnsley FC; formerly DC United, Swansea City AFC corroboration
S8: Swedish Football Association corroboration
S9: Collins et al. (2020). UEFA expert group statement on nutrition in elite football. British Journal of Sports Medicine (https://bjsm.bmj.com/content/early/2020/11/08/bjsports-2019-101961#ref-17)
S10: Football Medicine and Performance Association article (https://www.fmpa.co.uk/2019/09/23/spotlight-substitutes-know/)
S11: National Collegiate Athletic Association Safety textbook – Korey Stringer institute (https://www.taylorfrancis.com/books/e/9780429465536)