

***International Movement Screening and Interventions Group (IMSIG)
Football Task Group***

**Next Steps Workshop:
'Movement Quality for Injury Prevention and Performance in Youth Football'**

Hosted by: Manchester Institute of Health & Performance (MIHP), Manchester UK
Thursday 21st February 2019

Notes

Summary

The purpose of the workshop was to:

- Review research conducted to date, and determine potential applications and research priorities for:
 - a new movement screen to assess movement quality, that focuses on the hip and pelvis (Hip and Lower Limb Movement Screen; HLLMS)
 - a neuromuscular exercise programme (modified 11+) developed from the HLLMS
- Discuss implementation and adherence to neuromuscular programmes in general
- Consider the future direction for movement screening and neuromuscular exercise prevention programmes
- Foster new and existing international partnerships for collaborative research

This interactive workshop involved 33 participants (see Appendix 1&2), including national and international experts in research (some also coaches, clinicians and athletes themselves), and coaches and administrators from various sports. Brief presentations set the scene for in-depth discussions on the relevance of movement quality, and how it relates to different types of injury prevention and performance in sport. Presentations were typically 10-15 minutes, with 3-minute pitches on specific projects. Although the focus was on football, the workshop was open to all sport interests such that the principles of the research and implementation discussions could be considered across all sports.

These notes on the day's events highlight the key messages that are shaping the next steps in movement quality collaborative research based in the Centre for Sport, Exercise and Osteoarthritis Research Versus Arthritis, and beyond.



Workshop participants at the Manchester Institute of Health & Performance

Session 1: Movement Quality for Prevention and Performance – Chair: Carolyn Emery
Two speakers opened the workshop to provide background to the day’s main topics:

Jackie Whittaker spoke on *‘Preventing Osteoarthritis in Sporting Populations: Who is at greatest risk following joint injury and implications for targeted interventions?’* Jackie described the broad continuum of preventing post-traumatic osteoarthritis (PTOA; Whittaker & Roos, 2019): primary prevention (prevent injuries); secondary prevention (delay or prevent onset of PTOA); and tertiary prevention (improve function and reduce disability in those who have already developed PTOA). This differs from the continuum of preventing injuries: primary (prevent injury in uninjured sport participants, both acute and overuse injury causing microtrauma); secondary (prevent injury recurrence); and tertiary (prevent consequences of injury such as osteoarthritis, including rehabilitation) prevention.

Lee Herrington spoke on *‘How Movement Quality Relates to Performance’*



Carolyn Emery facilitates the panel discussion with (left to right): Jackie Whittaker, Lee Herrington, Kati Pasanen and Jem Lawson

Key messages:

1. The continuum of prevention (primary, secondary, tertiary) should not be viewed in isolation and research could draw on lessons across the three areas
2. Good quality movement (motor control and joint alignment) may be associated with lower injuries and better performance but research is needed to support this theory
3. Neuromuscular training (NMT) warm-up programmes for injury prevention are successful but uptake is not widespread.
4. Some coaches fail to see the importance of their role in injury prevention.
5. When discussing injury prevention programmes with coaches and athletes, it is as important to emphasise the performance benefits as it is to emphasise the injury prevention benefits
6. Players are more motivated to do warm-up exercises to improve performance than prevent injury, so if warm-up programmes improve performance, this is how they could be promoted.
7. Performance outcome measures are important to capture in movement quality research
8. Injury prevention and movement quality are facets of optimal performance, so could be packaged as such by promoting warm-up programmes to enhance performance
9. Need to sell warm-up programmes better to coaches and managers (e.g. greater player availability)
10. Joint ownership between administrators, coaches, medical staff, and players
11. Need better advocacy for NMT warm-up programmes from elite sports and find effective mechanisms for this to trickle down to grass roots level

12. There are numerous movement screens and exercise programmes focused on prevention, so consensus is needed
The subsequent sessions addressed these challenges

Session 2: Movement Screening for Exercise Prescription – Chair: Maria Stokes

Why do we need another movement screen? Before reporting the workshop discussions, a brief revisit of the reason for developing the Hip and Lower Limb Movement Screen (HLLMS) is warranted. Hip and groin pain is common in footballers and joint replacement surgery due to osteoarthritis (OA) is more common in retired footballers than the general population.

Changes in the hip joint have been found on magnetic resonance imaging in young footballers. Soft tissue hypertrophy at the femoral head-neck junction occurred as young as 10 years, preceding bony changes of increased alpha angle and epiphyseal extension (Palmer et al 2017). The bony changes, which occur most rapidly between 12-14 years during skeletal development, indicate the cam morphology type of femoroacetabular impingement (FAI), a known precursor of OA (Agricola et al 2013). These morphological changes were significantly greater in young footballers than in age-matched non-footballers (Palmer et al 2017).

We know the prevalence of clinical hip OA and radiographic OA are higher in former professional footballers than their age-matched controls (Petrillo et al. 2018) and incidence of hip joint replacement is higher in the footballers (Turner et al. 2000; Shepard et al. 2003

The goal is to reduce hip OA in later life by finding ways to protect the hips of young footballers e.g. a targeted hip and pelvic screening tool to indicate poor movement quality (indicating abnormal loading, which remains to be confirmed) to inform intervention aimed at reducing the abnormal loading during repetitive bony contact that causes micro trauma and structural damage, which may eventually lead to hip OA.

A first step would be to examine the ability to control hip and pelvic movement in young footballers with and without FAI changes, undergoing similar training loads (with the rater being blinded to FAI status), to understand the relationship between movement quality and FAI. It will be important to track training load, as this is a known contributor to the development of these changes (Palmer et al 2017). Given the high incidence of FAI changes in young footballers in professional academies, such a study would require a large multicentre trial to achieve the numbers of those without FAI to be reached. In the meantime, to help fill knowledge gaps, we can draw on what is known about the knee:

- Bennell et al (2011) finding of an association between poor movement quality (knee adduction moment impulse) and reduced cartilage thickness in older individuals with radiographic OA
- NMT can improve knee alignment during functional activities (hence movement quality; Ford et al 2015)

There is also anecdotal evidence that that NMT improves movement quality and symptoms at the hip (Wilson et al 2018).

Building on this background of association between movement quality and joint loading, the ability to assess movement quality accurately would enable exercises to be developed to improve the poor movements identified. Existing movement screens lack focus on assessing control of the hip and pelvis. The purpose of this screen is to inform exercise programmes for good quality movement control at the hip and pelvis to maintain health of all lower limb joints in the long-term through good alignment and preventing abnormal loading on joints.

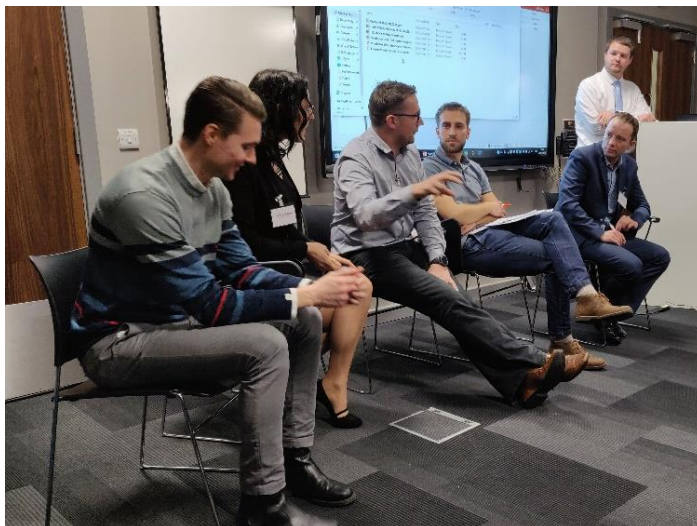
Nadine Booyesen, who led the development of the HLLMS, described the seven tests of the screen. The tests were selected from the literature, and some commonly used in clinical practice and sports physiotherapy to focus on the hip and pelvis. The criteria developed to assess movement quality against the optimal benchmark formed the novelty of the screen. Nadine then presented her work that characterized movement quality in adolescent academy footballers.

Other researchers using the HLLMS shared their findings and recommendations on refining the screen. Their 3-minute pitches, chaired by Paul Muckelt, included the following groups:

- a) Adolescent footballers and adult professional golfers (UK) – intra- and inter-rater reliability of the HLLMS – Dave Wilson and Nadine Booyesen
- b) Adolescent footballers and rugby players (Italy) – characterizing movement quality using the HLLMS and feasibility study of NMT intervention – Paolo Dainese
- c) Adolescent footballers in Poland: relationship between the HLLMS and groin symptoms - Pawel Linek
- d) Adolescent footballers (UK) – validity of the HLLMS versus 3D motion analysis and sensitivity to change after intervention – Dave Wilson
- e) Military recruits (males and females, UK) – characterizing movement quality, reliability and sensitivity to change of the HLLMS; movement quality of NMT intervention in new recruits compared to control group - Conor Power.
- f) Dancers (UK) – characterizing movement quality using the HLLMS - Paul Muckelt

The limitations of these preliminary studies were discussed including: small sample sizes; lack of control group for comparison (apart from the military study); limited ability to consider confounding variables; consideration of minimal clinically important difference (MCID); considering validity and reliability of measures; validity with respect to predicting injury, FAI changes and OA.

The studies presented are at various stages of being conducted or peer reviewed for publication, so no data or conclusions are included in these notes.



Panel discussion with presenters: Conor Power, Nadine Booyesen, Dave Wilson, Paolo Dainese, Pawel Linek. Paul Muckelt (standing) had chaired their presentations

Key messages on the HLLMS:

1. Reliability of the HLLMS

- Moderate overall
- Some criteria excellent reliability
- Criteria with poor reliability have been removed or redefined in a modified version
- Revised screen needs to be examined for reliability in multicentre study

2. Validity of the HLLMS

- Criterion validity versus 3D motion analysis was moderate overall (only examined in 4 of the 7 tests to date)
- Some criteria showed excellent validity
- Criteria with poor validity have been removed from the screen or redefined

The revised screen needs to be examined for validity to assess motion accurately

- Validity studies on professional footballers, for translating principles to grass roots, where multiple sports can dilute the picture. Reliability needs to be established in each new cohort tested in the hands of the investigators
 - Sensitivity to change – this was demonstrated in different studies in Session 3. Improvements in movement quality were demonstrated by changes in the HLLMS that were greater than the minimal detectable change (MDC) scores from initial reliability studies. The MDCs are likely to be reduced when the revised version of the screen is examined for reliability, so the HLLMS would potentially become more sensitive to change and document changes after intervention with greater precision.
3. A manual is being developed (including video links) for teaching the HLLMS, which aims to standardise its use and improve reliability. This manual will be made available free of charge through the International Movement Screening and Interventions Group (IMSIG).
 4. Potential use of the HLLMS – There is preliminary evidence for the knee joint that poor movement control (i.e. knee adduction moment impulse) is associated with reduced medial knee joint cartilage thickness in persons (age 64.4±8.0 years) with knee osteoarthritis (Kellgren & Lawrence grade 2) (Bennell et al 2011). This concept could be translated for investigating the hip, using the HLLMS for detecting poor hip control in athletes/personnel undertaking sports/occupations known to involve high demand on the hip joints. The abnormal loading biomechanics and workload are modifiable factors, as opposed to genetic predisposition, for which targeted exercise interventions could be investigated.
 5. It was suggested that using the term movement screen for the HLLMS tool may be misleading, as its primary role is not to predict injury but to inform exercise prescription for reducing abnormal loading on joints

Session 3: Neuromuscular Training Warm-up Programmes Chair: Jackie Whittaker

Why do we need another neuromuscular warm-up programme?: The 11+ programme can reduce injury risk but hip and groin problems persist in footballers. Adding exercises to the 11+ programme specifically for hip and pelvic movement control may be beneficial. The HLLMS was used to identify common movement faults (poor control) in footballers and exercises were developed to improve hip and pelvic control. It is recognised that we need to know if poor movement quality is associated with increased injury risk, which could be examined through retrospective analysis of our military data.

3.1 Review of Hip & Lower Limb Exercise Programme (informed by HLLMS)

Nadine Booyesen presented the revised 11+ programme, which included 10 new exercises across levels 1 to 3, focussing on hip and pelvic control. These exercises were added to the motor control training, strength and balance section of the 11+, replacing some of the original 11+ exercises, to ensure the time to complete the programme was no longer than 15 minutes (considered acceptable by coach and player representatives). If we pursue the modified 11+, we could consider adding the Copenhagen Adductor Exercise, which has been shown to enhance the 11+ programme by reducing groin injury (Harøy et al 2017).

Preliminary feasibility and proof of concept studies that used the new exercise programme were presented as 3-minute pitches, chaired by Paul Muckelt:

- a) Nadine described her work with amateur adolescent footballers, which indicated that the NMT exercises could improve movement quality (assessed by the HLLMS), and highlighted barriers and facilitators to conducting a larger community based trial. Limitations of this preliminary study included: small sample size; no long term follow-up to indicate changes persisted; no association between changes and a positive outcome (i.e., reduced injury, reduced FAI, improved performance). So movement changed but to what end? Due to the small sample size there was no way to account for individual movement variability. Further studies should address these limitations.
- b) Paolo presented his work with adolescent footballers and rugby players, again indicating improvements in movement quality with NMT.
- c) Conor described a feasibility study of the intervention in Phase-1 military training centres, which found improvements in movement quality compared with a control group, and improvement was related to level of compliance.

Key messages on the modified 11+

1. The goal of the intervention is to improve movement control of the hip and pelvis, in addition to reducing injuries with the current 11+, which ultimately will improve control at other joints in the kinetic chain
2. Improvements in movement quality assessed by the HLLMS indicate that the tool is sensitive to change, thus contributing to its validity. The minimal detectable change (MDC) values have been produced from reliability studies and we now need clinical studies on injured athletes to determine minimal clinically important difference (MCID).
3. Larger studies of the modified 11+ are warranted to examine its effectiveness, using appropriate designs, e.g. clustered randomised control trials, step-wise controlled trials
4. The modified 11+ hip/pelvic focussed programme needs an appropriate name
5. The HAGOS (Copenhagen Hip and Groin Outcome Score) used in these studies needs to be validated and examined for reliability in adolescents.
6. Investigate whether a positive response to the programme, in terms of movement quality, is linked to pain in those who are symptomatic
7. Future studies need to include measures of performance and injury rates to be of relevance to coaches
8. Implementation and adherence studies are needed – other programmes could be used to discover barriers (e.g. Caroline Finch's Translating Research into Injury Prevention Practice (TRIPP) framework) – see Session 4

3.2 GLA:D® Programme - does it have a role in secondary prevention?

Ewa Roos presented the GLA:D programme (Good Life with osteoArthritis in Denmark), which was launched to implement guidelines for the treatment of knee and hip OA in clinical care nationwide in Denmark. The program has three components: a) 2-day courses for clinicians, b) patient education and neuromuscular exercises delivered by these clinicians; and c) an electronic registry for prospective data collection. By strengthening and correcting daily functional movement patterns, participants overcome functional instability, increase their trust in the OA joints and train their bodies to move correctly. Data from 30.000+ patients with knee and hip OA show that the GLA:D® programme reduces pain by about 25%, 1/3 stop taking pain killers, with lower sick leave and increased levels of physical activity (Roos et al 2018). Results persist at one year.

Ewa explained how parallels could be drawn between use of the GLA:D for tertiary prevention in OA patients and post-injury secondary prevention.

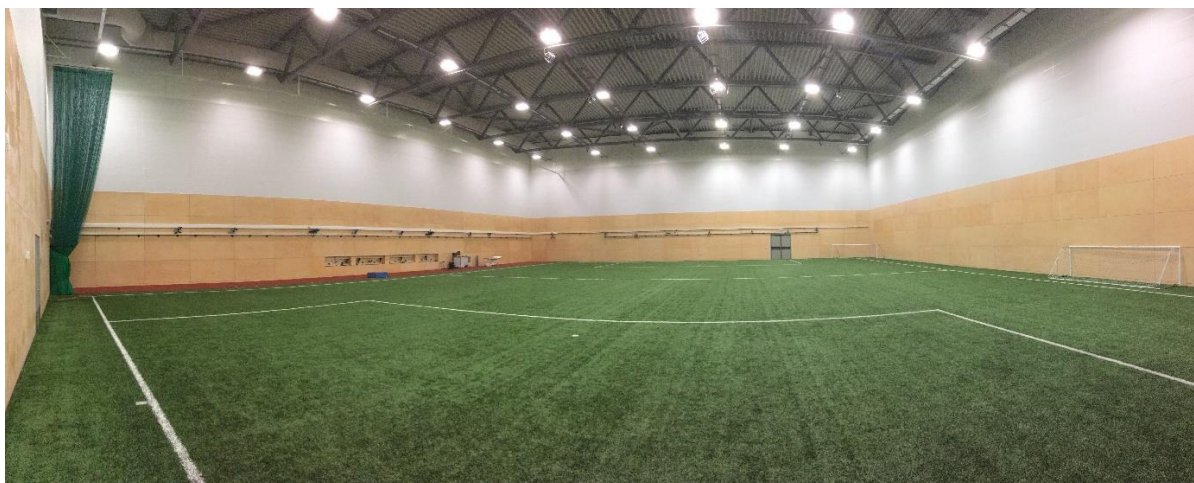


Ewa Roos brings a new perspective to injury prevention through the GLA:D Program used for managing osteoarthritis

A panel discussion on secondary prevention then followed, chaired by Jackie Whittaker, involving Ewa Roos, Merete Møller and Carolyn Emery.

Key Messages

1. Is there still a need for evidence of effectiveness of exercise programmes? The GLA:D programme is known to be effective for tertiary prevention and could be translated for secondary prevention
2. Focus on research of implementation and adherence of the GLA:D for secondary prevention, rather than effectiveness
3. Better education for coaches is needed
4. Musculoskeletal research needs consensus, in a similar way to cancer research, which speaks in one voice. This is an aim of the IMSIG, to agree and have a simple message



Tour of the MIHP: our host, Richard Jones, showed us around the facilities at MIHP, including this indoor football pitch and running track with a multiple-camera motion analysis system that enables movement to be measured accurately during sport

Session 4: Implementation & Adherence to Neuromuscular Training (NMT) Programmes

Chair: Carolyn Emery

Kati Pasanen spoke about '*Upscaling NMT programmes in youth sport*' sharing her experience from Finland and more latterly Canada. Kati illustrated how her background enables her to approach research from three perspectives, as a researcher, a coach and an athlete.

Carly McKay gave an overview of '*Behavioural Adaptation: Adherence and Long-term Maintenance*', which are at the core of successfully implementing warm-up programmes in sport, to achieve optimal performance and the associated improved movement quality and reduction in injury. The principles will inform the basis for studies on warm-up programmes in order to optimize behaviour change for adherence, and maintenance to such programs.

Paul Muckelt introduced a plan for a study on '*Adherence to NMT training programmes in community based youth football*'. This study arose from a request from grass roots coaches to help them make warm-up programmes an integral part of training for young players. This project will draw on the extensive expertise of participants in the workshop and the literature.

The panel discussion for this session was integrated with a general Next Steps discussion

Carolyn Emery facilitates the 'Next Steps' panel discussion with:
Paul Muckelt
Ewa Roos
Carly McKay
Kati Pasanen
Merete Møller



Next Steps Priorities

1. HLLMS

- a) Do we need another screen? Current screens lack focus on hip and pelvic movement control, which is needed for assessing athletes in sports known to place high demands on the hips and be associated with high rates of pathology and/or symptoms, e.g. FAI. The HLLMS focuses on control of the hip and pelvis
- b) Re-examine reliability of the revised screen
- c) Re-examine validity of the revised screen
- d) Examine the relationship between movement quality and injury to see if there is an association.

2. Neuromuscular Training Warm-up Programmes

- a) Implementation of programmes already shown to be effective is a priority
- b) For implementation and adherence, draw on what is known from other sports and football in other countries
- c) Do we need another warm-up exercise intervention? Not an entirely new programme but a modified 11+ specifically for protection of the hip joint, as hip and groin pain persist, despite use of the 11+ programme. Alternatively, use an existing programme from Kristian Thorborg's group in Denmark (Harøy et al 2017), who have developed a screen and exercises for adductor strength, to use in our mechanisms study of mode of effect of NMT exercises.
- d) Long-term effectiveness of the programme on hip joint health requires research.
- e) Examine relationships between improvements in movement quality, performance and injury occurrence after neuromuscular training

3. Investigating mechanisms

There were differing opinions as to what role mechanisms have to play in research on movement quality, injury prevention and optimizing performance

- a) Is there a need to examine mechanisms of how neuromuscular exercises work? Yes, but for specific reasons, such as optimising the selection of programme components and evaluating exercise fidelity and quality of movement.
- b) There may be aspects of studying mechanisms that are specific across the continuum of injury prevention. For example, understanding mechanisms of the effects of exercises may be more relevant for tailoring targeted exercises in secondary or tertiary prevention, rather than primary prevention. There may still be cases for understanding mechanisms in primary prevention, such as when a particular sport is known to cause problems with a particular joint, such as the hip or shoulder.
- c) Biomechanical and neuromuscular physiological mechanisms need investigating.

4. Integrated collaborative approach across types of injury prevention

There are obvious parallels between primary, secondary and tertiary prevention giving a sound rationale for not conducting research on each in isolation. Ewa Roos' presentation provided opportunity to learn from the GLA:D programme used in tertiary prevention.

Closing Remarks

Mark Batt, Director of the Centre for Sport, Exercise and Osteoarthritis Research Versus Arthritis, thanked Richard Jones for hosting the Workshop at MIHP, Maria Stokes for organising the event, and participants for travelling from several countries in North America and Europe. Mark gave special thanks to Jo Bartram for meticulous arrangements for the workshop and her excellent administration of the IMSIG over the years 2014. Mark wished Jo well in her new job. He encouraged participants to join the IMSIG and to enlist their colleagues, so the group is as inclusive as possible, to achieve a more standardised approach to research on movement quality.

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Acknowledgements

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Joining IMSIG

The International Movement Screening and Interventions Group (IMSIG) was set up in 2014 to gain international consensus on the use of movement screening tools and interventions to develop a strong evidence-based approach for research and clinical practice. There are over 70 members worldwide and several task groups are working on specific challenges.

<http://www.sportsarthritisresearchuk.org/international-movement-screening-and-interventions-group-imsig/imsig.aspx>

We welcome researchers, clinicians, coaches and athletes from all sports to join the group.

If you would like to become a member, please email:

centre-seoa@nottingham.ac.uk

**CENTRE FOR SPORT, EXERCISE
& OSTEOARTHRITIS RESEARCH**
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ARTHRITIS

Appendix 1: Workshop Participants

Name		Institution / Affiliation
Craig	Barden	University of Bath
Jo	Bartram	Centre for Sport, Exercise and Osteoarthritis Research Versus Arthritis
Mark	Batt	Centre for Sport, Exercise and Osteoarthritis Research Versus Arthritis
Nadine	Booyesen	University of Southampton
David	Clancy	Isokinetic Medical Group
Paolo	Dainese	University of Turin, Italy
Katie	Denton	England Netball
Nick	Dobbin	Manchester Metropolitan University
Carolyn	Emery	University of Calgary, Canada
Stephanie	Filbay	University of Oxford
Helen	French	Royal College of Surgeons in Ireland
Lee	Herrington	University of Salford
Paul	Jones	University of Salford
Richard	Jones	University of Salford
Eddy	Kavanagh	British Wrestling
Jem	Lawson	Centre for Sport, Exercise and Osteoarthritis Research Versus Arthritis – lead lay representative
Pawel	Linek	The Jerzy Kukuczka Academy of Physical Education in Katowice, Poland
Steve	McGregor	Manchester Institute of Health and Performance
Carly	McKay	University of Bath
Merete	Møller	University of Southern Denmark
Paul	Muckelt	University of Southampton
Debbie	Palmer	Edinburgh Napier University
Kati	Pasanen	University of Calgary, Canada
Conor	Power	University of Southampton
Ewa	Roos	University of Southern Denmark
Damian	Sikora	The Jerzy Kukuczka Academy of Physical Education in Katowice, Poland
Neal	Smith	University of Chichester
Julie	Snow	England Netball
Chelsea	Starbuck	University of Salford
Maria	Stokes	University of Southampton
Cari	Thorpe	Manchester Metropolitan University
Jackie	Whittaker	University of Alberta, Canada
Dave	Wilson	University of Southampton

Appendix 2: Speakers, Panel Members and Facilitators

Professor Mark Batt

Director, Centre for Sport, Exercise and Osteoarthritis Research Versus Arthritis, Consultant in Sport & Exercise Medicine Nottingham University Hospitals

Expertise: Clinical Sport & Exercise Medicine. Research including the long-term effects of exercise and sport, including Osteoarthritis

Dr Nadine Booyesen

Visiting Research Fellow, School of Health Sciences, University of Southampton (Recently completed PhD and moved to New Jersey, USA).

Expertise: musculoskeletal physiotherapy; research focuses on assessment of movement control patterns and neuromuscular exercise programmes for prevention and management of musculoskeletal conditions. She developed the Hip and Lower Limb Movement Screen (HLLMS) to assess movement quality.

Professor Carolyn Emery

Associate Dean Research & Professor, Faculty of Kinesiology at the University of Calgary; Chair, Sport Injury Prevention Research Centre (International Olympic Committee), Canada

Expertise: background in physiotherapy. Research focuses on injury prevention in youth sport and recreation, concussion and paediatric rehabilitation; aimed to reduce the public health burden of injury including long-term consequences (e.g. post-traumatic osteoarthritis).

Paolo Dainese,

Post: MSc in Sports Sciences, Post-graduate researcher / study bursary, School of Exercise and Sport Sciences, University of Turin, Italy.

Expertise: Background in Sports Sciences. Research focuses on assessment of movement control patterns and movement retraining programmes. He assessed the feasibility of the Hip and Lower Limb Movement Screen (HLLMS) in young Italian footballers and rugby players.

Dr Lee Herrington

Senior lecturer in Sports Injury Rehabilitation, University of Salford, Technical lead Physiotherapist, English Institute of Sport

Expertise: Musculoskeletal Physiotherapy, with research focusses on Injury screening, ACL injury and anterior knee pain assessment and rehabilitation.

Professor Richard Jones (host)

Professor of Clinical Biomechanics, Knee Biomechanics and Injury Research Programme Lead, University of Salford, Biomechanics Lead, Manchester Institute of Health and Performance, Manchester

Expertise: Clinical biomechanics background. Research focusses on biomechanical and clinical outcome measures in musculoskeletal disorders of the knee including ACL, meniscal injuries and conservative management of osteoarthritis.

Jem Lawson

Patient and Public Involvement (PPI) Representative, Centre for Sport, Exercise and Osteoarthritis Research Versus Arthritis

Expertise: has had various roles: PE teacher, a coach, an official, a race organiser and managed national elite triathlon teams, now primarily sports administration and governance at national and international level. Jem is an age group triathlete and the current British Open Water Swimming Champion in his age group.

Dr Pawel Linek

Associate Professor, Head of Musculoskeletal Elastography and Ultrasonography Laboratory, The Jerzy Kukuczka Academy of Physical Education, Katowice, Poland; Visiting Research Fellow, School of Health Sciences, University of Southampton, UK.

Expertise: Research focuses on ultrasound imaging applications in physiotherapy, and evaluation of physiotherapy in musculoskeletal conditions. Has studied the HLLMS in adolescent footballers in relation to hip and groin pain, and the Functional Movement Screen.

Dr Carly McKay

Lecturer in Injury Prevention, Department for Health, University of Bath

Expertise: Research into on psychosocial and behavioural factors in sport injury risk and recovery; behaviour change for injury prevention.

Dr Merete Møller

Assistant Professor, Department of Sports Science and Clinical Biomechanics, University of Southern Denmark, Odense, Denmark

Expertise: Background in physiotherapy. Research focuses on injury risk reduction in youth sport by aiming to connect injury aetiology research to injury prevention initiatives in real-world sporting context that seek to keep youth athletes active throughout their lives. Special interest in training load management, physical training and implementation.

Paul Muckelt

Post: Research Fellow and PhD student, Centre for Sport, Exercise and Osteoarthritis Research Versus Arthritis, and School of Health Sciences, University of Southampton

Expertise: Sports Therapy and Sports Biomechanics by training, and a gymnastics coach. Used the HLLMS in dancers.

Dr Kati Pasanen

Assistant Professor, Faculty of Kinesiology at the University of Calgary; Sport Injury Prevention Research Centre (International Olympic Committee), Canada

Expertise: Background in sport physiotherapy, and strength and conditioning coaching. Research focuses on prevention of musculoskeletal injuries in youth and adult sport – special interest in neuromuscular training and training load monitoring.

Conor Power

PhD student, School of Health Sciences, University of Southampton

Expertise: Sports Scientist. Used HLLMS and neuromuscular training in military cohort

Professor Ewa Roos

Professor and Head of Research Unit for Musculoskeletal Function and Physiotherapy, and co-lead for Center for Muscle and Joint Health, Department of Sports Science and Clinical Biomechanics, University of Southern Denmark, Odense, Denmark.

Expertise: Prevention and treatment of joint injury and osteoarthritis with a focus on exercise therapy and surgical interventions. Bringing science into action internationally through the Good Life with Osteoarthritis in Denmark (GLA:D®) project. Developer of a number of patient-reported outcome measures, including the KOOS, with a keen interest in improving interpretation and applicability in research and clinical practice.

Professor Maria Stokes

Professor of Musculoskeletal Rehabilitation, Head of Active Living Research Group, School of Health Sciences, University of Southampton; Centre for Sport, Exercise and Osteoarthritis Research Versus Arthritis (Southampton lead)

Expertise: Background in physiotherapy and neuromuscular physiology. Research focusses on active living and healthy ageing of the musculoskeletal system – mechanisms of dysfunction, assessment tools and exercise interventions to prevent and manage joint conditions.

Dr Jackie Whittaker

Assistant Professor, Department of Physical Therapy, Faculty of Rehabilitation Medicine, University of Alberta, Canada

Expertise: Clinical specialist in musculoskeletal physiotherapy. Research focuses on understanding the origins of osteoarthritis in youth, and shifting the approach taken to manage osteoarthritis towards preventing or delaying its onset and progression.

Dr Dave Wilson

Post: Research Fellow, School of Health Sciences, University of Southampton

Expertise: musculoskeletal physiotherapy, conducted research on the reliability and validity of the HLLMS before and after an exercise intervention