

**Institution:** University of Leicester

**Unit of Assessment:** UoA24 Sport and Exercise Sciences, Leisure and Tourism

## 1. Unit context and structure, research and impact strategy

### OVERVIEW

The University of Leicester (UoL) is proud to have developed a critical mass in physical activity research enabling our first institutional submission to UoA24. This is supported by the College of Life Sciences' (CLS) strategic aim to embed physical activity research as a cross-cutting theme of excellence linking areas of clinical strength; **diabetes, respiratory diseases, and chronic kidney disease**. This strategic priority was formalised in 2012 through the award of the NIHR Leicester-Loughborough Diet, Lifestyle and Physical Activity Biomedical Research Unit (BRU), and subsequently in 2017 through the successful NIHR Leicester Biomedical Research Centre (BRC) application. This strategy was in response to mounting policy recognition that national action is needed in targeting lifestyle behaviour through the NHS, evidenced by *Healthy Lives, Healthy People* (2010), the *NHS Five Year Forward View* (2014), the *NHS Long Term Plan* (2019), and the roll out of the *Healthier You: the NHS Diabetes Prevention Programme* (2016 – present).

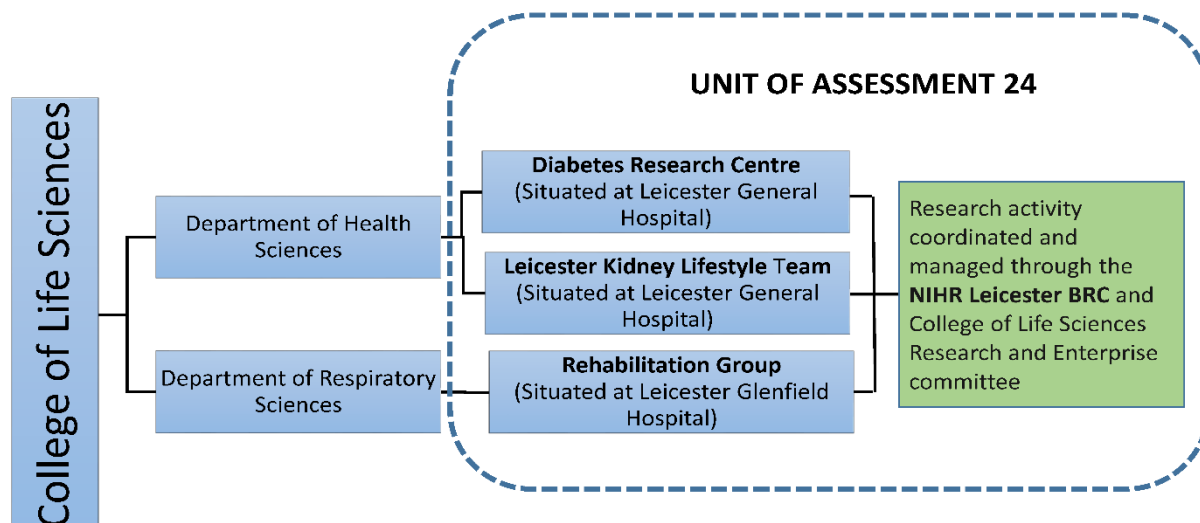
Our unit has been brought together by a combination of nurturing excellence internally and strategic appointments. This focus on people has been matched by a focus on place, where inward capital investment has built two bespoke physical activity testing, supervision and measurement laboratories; one situated within the Diabetes Research Centre (DRC, Leicester General Hospital), and a bespoke respiratory sciences research facility (Leicester Glenfield Hospital). These are adjacent to some of the largest NHS diabetes, respiratory and renal clinical services in the UK, encouraging crosstalk between physical activity research and clinical care. Our 9 (8.8 FTE) submitted researchers have generated a thriving portfolio of translational research that, over the submission period, has attracted £8.45M in research income (£0.96M/FTE), published 477 Scopus indexed articles (54/FTE) and generated >10,000 citations. We have informed national and international public health and clinical guidelines and translated evidence-based physical activity-focused prevention and rehabilitation

### STRUCTURE AND RESEARCH AND IMPACT STRATEGY

Our overarching aim is to build complementary interdisciplinary research capacities with which to **generate evidence-based physical activity therapies for chronic disease prevention, management and rehabilitation**.

### STRUCTURE

Our researchers are part of the Departments of Health Sciences (5.8 FTE) and Respiratory Sciences (3 FTE) within CLS. Our collective research activity is coordinated and managed through the **NIHR Leicester BRC**, organised across clinical themes of diabetes, respiratory disease and renal disease (**Figure1**), and co-located with the corresponding clinical services within University Hospitals of Leicester NHS Trust (UHL).



**Figure 1:** Unit structure within CLS

**DIABETES:** Yates, Edwardson, Rowlands, Harrington and Dempsey lead programmes of physical activity research within the DRC, which is recognised by the International Diabetes Federation and one of the largest Diabetes Research Centres in Europe with >150 researchers and clinical staff, housed directly above a busy diabetes out-patient clinical service. Research is focused on harnessing the full physical activity-spectrum (i.e. from reducing sitting behaviour to high intensity exercise interval training) to develop evidence-based, physical activity therapies for the prevention and management of type 2 diabetes and related comorbidities. Our research is strategically supported by the Centre's Clinical Directors, Davies CBE [UoA1] and Khunti [UoA2]; internationally renowned clinical academics who ensure our research is aligned to clinical need with subsequent impact on national and international routine clinical care pathways.

**RESPIRATORY:** Singh, Greening and Evans lead the rehabilitation group, part of a wider respiratory research facility housing >50 clinical research and support staff embedded within the largest clinical service for acute respiratory admissions in the UK. Research is focused on the development, evaluation and implementation of in-patient and out-patient exercise-based rehabilitation, with a focus on those with Chronic Obstructive Pulmonary Disease (COPD) and breathlessness. Research is supported strategically by Brightling [UoA1] and Steiner [UoA2].

**RENAL:** Smith leads the Leicester Kidney Lifestyle Team of 6 postdoctorates and 5 NHS support staff within the large John Walls Renal Unit and kidney out-patient services at LGS, adjacent to the DRC. Research is focused on understanding the mechanisms underlying poor physical function and frailty in chronic kidney disease (CKD) and how exercise modalities can be optimised to combat underlying impairments in muscle physiology. Research is supported clinically by renal physicians Brunskill and Barrett [UoA1].

Our unit is a key part of the **NIHR Leicester BRC** (£11.6M 2017-2022), led by Davies [UoA1], which is used to provide strategic research direction, as well as the management of

staff, equipment and resource allocation across our clinical areas. This enables our researchers to work as a coordinated whole with a shared research infrastructure (see section 3). The Lifestyle theme (one of three research themes) within the Leicester BRC is run as a collaboration with Loughborough University (as a subcontracted partner) and builds on the success of the NIHR Leicester-Loughborough Diet, Lifestyle and Physical BRU (£4.5M 2012-2017), the only NIHR BRU that was entirely focused on physical activity. NIHR BRUs and BRCs are awarded to institutions that can demonstrate a critical strength and depth of world leading translational research. Through the Leicester BRC our research is aligned with the National Centre for Sport and Exercise Medicine East Midlands (NCSEM-EM)

Our research is also coordinated and overseen by the CLS Research and Enterprise committee (**Yates** as member), providing a College-wide forum for sharing and supporting research and encouraging interdisciplinary initiatives.

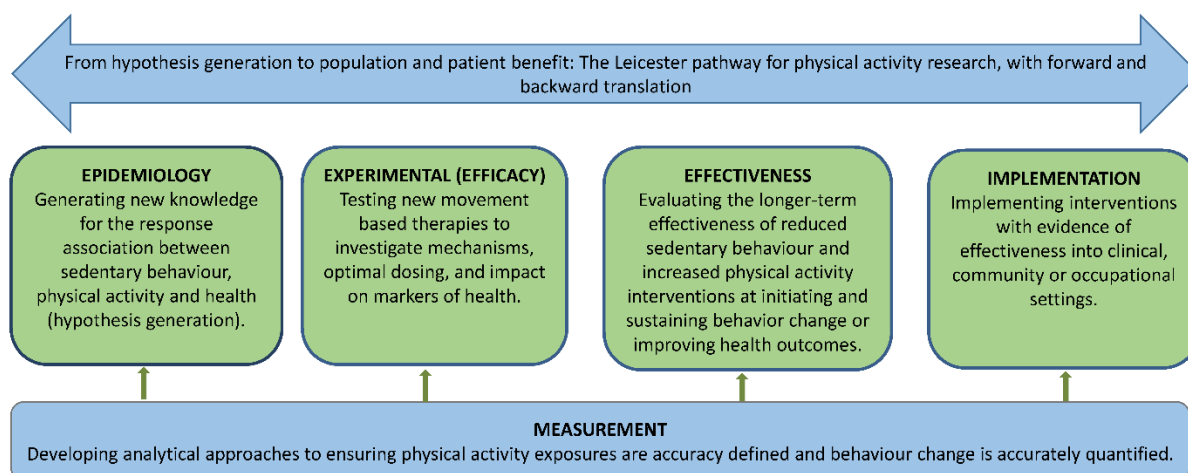
### **OUTPUT METRICS HIGHLIGHTING RESEARCH STRENGTH AND DEPTH**

Despite our small submission (8.8FTE), we have generated substantial research outputs. SciVal metrics for the REF environment census period evidenced we have co-authored **477 articles** (54 per FTE), with 26% in the top decile of the most cited articles internationally. Our articles generated **>10,000 citations** with field weighted citations impact factors of 2.47. This is a result of our strategy to publish in leading general medical (*Nature Medicine, BMJ, PLOS Medicine*), disease specific (*Circulation, Diabetes Care, Am J Respir Crit Care Med*) and physical activity (*Br J Sports Med, Med Sci Sports Exerc, Int J Behav Nutr Phys Act*) journals. Our outputs are disseminated within a culture of Open Research (Institutional Environment Statement [IES] section 2.6) through platforms such as FigShare and library funds for open access publishing. During the assessment period, 78% of our outputs were published open access, compared to the Russell Group average of 63% (SciVal).

The quality of our physical activity research has ensured we rank highly within our areas of clinical expertise more generally. **Yates** and **Singh** rank within the top 0.1% of the most impactful type 2 diabetes and COPD researchers internationally, respectively (Expertscape July 2020).

### **APPROACH TO TRANSLATIONAL PHYSICAL ACTIVITY RESEARCH**

Our track record in research excellence is underpinned by a focused translational research strategy, from hypothesis generation to improved public health and clinical care, **Figure 2**. This mirrors the Bench to Bedside research focus within the CLS, with the interdisciplinary nature of our research underpinned by the UoL Citizens of Change strategy [IES, 2.8].



**Figure 2: UoA24 Research Pathway**

### Epidemiology

Over the REF period, we have accrued 16,200 participants within clinical lifestyle research, with further cohorts (~3000 participants) recruited from community settings, generating unique datasets enabling the application of observational epidemiology for hypothesis generation, complemented by access to national datasets (UK Biobank, Health Survey for England). Statistical and methodological support is provided from the Real World Evidence Unit (hosted within the DRC) coordinated by epidemiologist Dr Zaccardi [UoA2].

### Highlighted findings

- **Respiratory:** Small quadriceps are an independent risk factor for unscheduled readmission or death in COPD (**Greening**).
- **Renal:** Habitual walking pace >3 mph is associated with 63% reduction in risk of mortality in CKD compared to slow walkers (**Smith, Yates**).
- **Diabetes:** High levels of sedentary behaviour and physical inactivity are independently associated with glucose regulation, markers of cardio-metabolic health and mortality; furthermore, when physical activity is undertaken, intensity is independent of volume in associations with health (**Dempsey, Yates, Edwardson, Rowlands**).
- Brisk walkers live up to 20 years longer than slow walkers (**Yates**).

### Experimental

We test the efficacy of exercise-based interventions at targeting the key etiological pathways within specific chronic diseases.

### Highlighted findings

- **Respiratory:** Eccentric exercise produces lower ventilation and leg fatigue compared to concentric exercise for a given load in people with COPD (**Evans**).
- **Renal:** Intradialytic exercise does not exacerbate immune dysfunction and is well tolerated (**Smith**). CKD is associated with dysregulated intramuscular inflammatory, mitochondrial and myogenic responses to exercise, which are partially mitigated by exercise (**Smith**).

- **Diabetes:** Breaking up sitting with short (e.g., 5 minute) regular (e.g., every 30 minutes) light-intensity physical activity (of various modalities) in people with diabetes, prediabetes and obesity improves postprandial glucose regulation, with strongest effects in those with low fitness, a high BMI, insulin resistance and a South Asian ethnicity (**Yates, Dempsey, Edwardson**).

### Effectiveness

Once proof of efficacy is established, we generate proof of effectiveness.

### Highlighted findings

- **Respiratory:** Delivered the largest (n = 389) in-patient trial in chronic respiratory disease, showing that progressive exercise-based rehabilitation should not be started during the early stages of admission to hospital due to lack of effectiveness (**Greening**). Demonstrated a self-management programme (SPACE FOR COPD) is effective in a primary care population, and non-inferior to hospital-based rehabilitation (**Singh**).
- **Renal:** Undertook a 6-month programme of cycle exercise during dialysis provided clinically beneficial effects on cardiac structure and function, and reduced hospital admissions (RCT of 130 end stage CKD patients) (**Smith**).
- **Diabetes:** Conducted three major randomised controlled trials (RCTs) in over 3000 individuals at high risk of developing diabetes (Let's Prevent, Walking Away, PROPELS) demonstrating that pragmatic real-world pedometer-based interventions can increase physical activity over 12 months, but may not maintain changes over the longer-term (up to 48 months) (**Yates, Edwardson**). The Stand More AT (SMARt) Work RCT demonstrated that providing standing desks and behavioural support to office workers reduced sitting time and improved presenteeism, musculoskeletal health, work performance and quality of life over 12 months and was cost-effective (£3 returned for every £1 spent) (**Edwardson, Yates**).

### Implementation

Working with the NIHR Applied Research Collaboration East Midlands (ARC-EM), led by Khunti [UoA1], we ensure our research is translated into practice.

### Highlighted activity

- **Respiratory: Singh** runs the Leicestershire pulmonary rehabilitation service through UHL, the largest exercise rehabilitation service in the UK with >2,500 referrals annually. **Singh** also led the development of the online rehabilitation programmes for COPD (SPACE for COPD), heart disease (Activate Your Heart) and COVID-19 (Your COVID Recovery); to support the clinical response to the COVID-19 pandemic; these programmes were made free of charge prior to July 2020 and used by >200 hospital trusts nationally.
- **Renal: Kidney Beam**, a free online platform for kidney disease patients to improve physical and mental wellbeing was launched in early July 2020, funded by Kidney Research UK <https://beamfeelgood.com/kidney-disease>. The Leicester Kidney Lifestyle Team (**Smith**) developed the physical activity content. By the end of July 2020, 452 patients had registered.
- **Diabetes: Harrington** leads Leicester Cities Changing Diabetes (CCD). Leicester was the first UK city to join the network of global cities leading the fight against diabetes. CCD includes industry partner Novo Nordisk. **Harrington** brought together

Public Health and Transportation teams at City Council level, the city's professional sports clubs (Leicester City FC, Leicester Tigers, Leicestershire County Cricket Club, Leicester Riders) and numerous places of work and worship to embed physical activity and healthy lifestyles within usual ways of working. Each professional sports club has initiated community level physical activity initiatives under CCD. **Harrington** showcased CCD at the All Party Parliamentary Group International Diabetes Conference, 2018, alongside national (Minister for Public Health, National Clinical Director for Diabetes and Obesity, NHS England and NHS Improvement) and international (Health Mayor of Copenhagen, Italian MP and Vice-President of the Italian National Association of Municipalities, and members of Parliament for Western Australia) policy makers. In 2019 Leicester CCD won two national awards ('Type 2 Diabetes Prevention' and 'Research Project of the Year'). Further examples of our implementation activity for prevention (ICS2) and sedentary behavior (ICS1) are detailed in the impact case studies.

### Measurement and data processing

Developing accurate and reliable measures of sedentary behaviour, physical activity and function underpins our research.

### Highlighted outputs

- *Physical activity*: **Edwardson** and **Rowlands** are at the forefront of establishing valid and reliable objective assessments of physical activity and sedentary behaviour. This includes the development of a free Java tool 'Processing PAL', (450 downloads July 2020), new physical activity metrics using wrist worn accelerometer data (Sedentary Sphere, Intensity Gradient, MX metrics) and the development of novel machine learning methods (FilterK, collaboration with the Department of Mathematics).
- *Physical function*: The incremental shuttle walking test (ISWT) (developed by **Singh**) is used by 50% of rehabilitation services in the UK and was further validated during the REF period with 35 - 40 meters found as the minimum clinically important difference across disease groups. The ISWT was submitted to FDA for approved outcome status within pharmaceutical trials by a COPD Foundation consortium (**Singh** as member; application under consideration).
- *Muscle function*. We have optimised and validated (against MRI) the use of ultrasound for the assessment of muscle size, quality and sarcopenia within chronic disease, which has been implemented in clinical populations (e.g. hospital inpatients). (**Smith, Greening**).

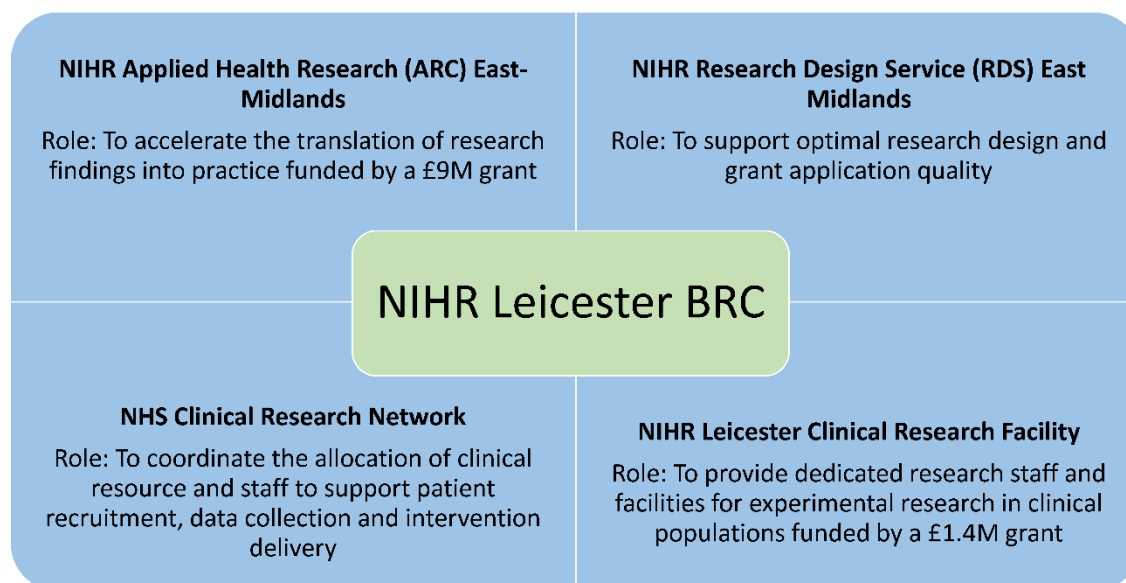
### ETHNIC MINORITY RESEARCH

Leicester is the most ethnically diverse city in the UK. We work with the Centre for Black and Minority Ethnic Health (housed within DRC) to ensure our research represents this diversity. We tailor our methods and interventions to meet the needs of minority ethnic groups whilst also investigating how different ethnicities respond to physical activity interventions. We have shown that South Asian ethnicities gain a greater absolute metabolic benefit than white Europeans when breaking their sitting time and when engaging in high intensity interval exercise (**Yates, Edwardson**). We have also reported reference values of the ISWT in a South Asian population (**Singh**).

### INTERFACE WITH THE NHS

A strategic aim of CLS since 2014 has been to strengthen research links with the NHS,

achieved through the Leicester Academic Health Partnership (LAHP), which includes the UoL Pro-Vice-Chancellor for Research and Enterprise. This ensures appropriate deployment of financial, estate and human resource to support research and enterprise activity and has directly benefited our UoA. Most importantly, the NIHR Leicester BRC is hosted by UHL, with UoL the main academic partner. Facilitated by the NIHR Leicester BRC, we also routinely access other NHS hosted research infrastructure and support services (**Figure 3**).



**Figure 3:** NHS hosted resources accessed by our unit

As previously described, our alignment to the NHS is strengthened by our unit collaborating with and being mentored by leading clinical academics including Davies [UoA1], Khunti [UoA2], Brightling [UoA1], Brunskill [UoA1] and Barrett [UoA1]. This wealth of clinical support enables our researchers to conduct exercise interventions within severe disease groups, including those with diabetic foot, hospital inpatients with COPD and end stage CKD patients undergoing dialysis.

### INTERFACE WITH INDUSTRY

Our ability to address areas of clinical need through physical activity research has attracted industry engagement and research income (~£450k).

#### Highlighted examples

- **Respiratory:** A phase 2b trial (n=238) of a novel monoclonal antibody in patients hospitalised with COPD, including impact on physical activity, function and sarcopenia (GlaxoSmithKline).
- **Renal:** The largest study conducted investigating combining iron supplementation and exercise therapy on muscle function and metabolism in CKD patients (Vifor Fresenius Medical Care).
- **Diabetes:** Investigating the interaction between exercise training and sodium-glucose co-transporter 2 therapy on physical function and fitness in those with type 2 diabetes (Astra Zeneca).

### RESEARCH QUALITY AND INTEGRITY

We work to ensure the highest level of research quality and integrity. UoL is a signatory of the Concordat for Research Integrity and set up a Research Integrity Working Group in 2014 (IES 2.4). We have access to dedicated Research Support Officers and Research Quality Managers assist with NHS research ethics applications. Compliance to GDPR is ensured through mandatory annual data protection training, with each study undergoing a data risk assessment. All staff and PGRs are required to complete Good Clinical Practice (GCP) training biannually. Our large trials are supported by registered Clinical Trials Units (CTU) (e.g., Leicester CTU situated on main campus). Our smaller studies are managed through the NIHR Leicester BRC and REDCap which includes a core dataset for physical activity research, with standard operating procedures shared and tracked through the online Q-Pulse system. We host specific training for undertaking physical activity research in clinical populations, including treating hypoglycaemia and resuscitation training. During the REF period, 78 University and NHS staff supporting our physical activity research received such training. Training is underpinned by detailed standard operating procedures for exercise testing and training within clinical populations.

### COVID-19 PANDEMIC RESPONSE

Our unit has contributed to the COVID-19 research response. **Evans** helped design and is the lead clinical co-investigator for the UoL led Post-HOSPitalisation COVID-19 (PHOSP-COVID) study (UKRI £8.4M awarded July 2020) investigating longer-term health outcomes in patients surviving COVID-19. **Singh** led the development and roll-out (July 2020) of *Your COVID Recovery* to 198 services nationally supported by funding from NHS England and industry partner GlaxoSmithKline (£80k). **Singh has** also made her existing online rehabilitation programmes free of charge to hospital trusts during the pandemic and is a co-investigator on the UKRI (£430k) COVID-NURSE project. **Yates** was awarded £127k (UKRI) to investigate the risk of COVID-19 in minority ethnic groups and associations with lifestyle factors, with his research cited in Public Health England's document 'Excess weight and COVID-19: insights from new evidence' (July 2020). We also adapted ongoing studies to collect lifestyle behaviour data during the first national lockdown (**Yates, Rowlands, Edwardson, Harrington**).

### AIMS FOR NEXT 5 YEARS

We will build on our strength and depth in translational physical activity research to further enhance and increase the range of evidence-based physical activity therapies and programmes available for disease prevention, management and rehabilitation.

#### **Research aims:**

- Harness our translational research pathway (**Figure 2**) in addressing research gaps, including consideration of the 24-hour sleep/activity cycle along with identifying mediators/moderators of the effects of sedentary behaviour/physical activity on health
- Better inform real-world chronic disease pathways by investigating how physical activity and exercise therapies can be optimised for use with other concomitant interventions (e.g. pharmaceutical therapies).
- Evolve our research strategy to include areas of emerging public health and clinical need, such as continuing factors related to COVID-19, younger adults with chronic disease, multi-morbidity, in-patient populations, or symptom-based research.
- Continue developing novel approaches to the measurement of physical activity, frailty



and muscle function and embed objective measurement technologies across clinical programmes of research regionally and nationally.

***Our aims for supporting capacity and capability are:***

- Continue to grow our team through developing early career researchers and attracting new appointments, whilst retaining our equitable ratio of men and women and advancing our equality, diversity and inclusion agenda.
- Maintain our excellent grant income of £1M for our staff.
- Contribute to national and international health and wealth by translating and commissioning our research findings into practice.

## 2. People

### OUR TEAM AND STAFFING STRATEGY

#### OUR TEAM

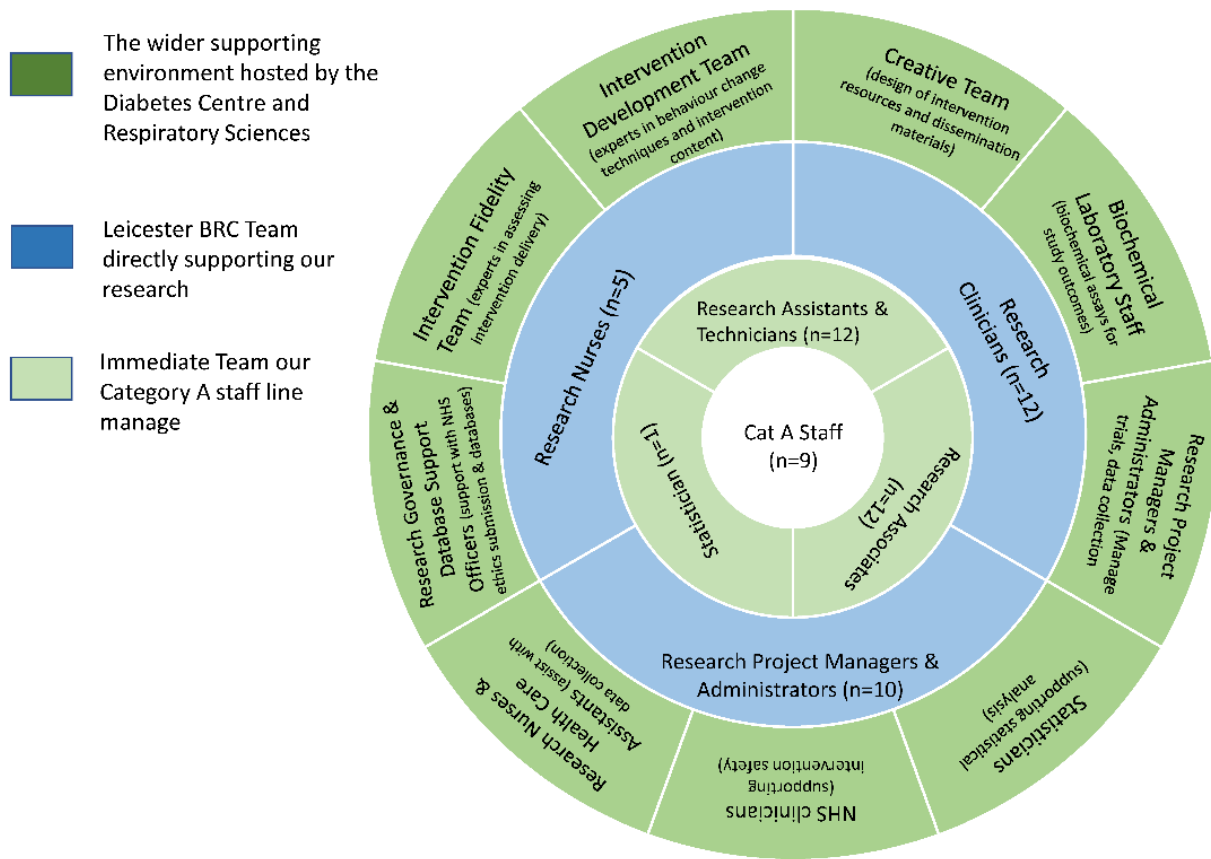
Over the REF period we have built a team of physical activity experts from clinical and non-clinical backgrounds through identifying and mentoring our star postdocs into positions of leadership whilst working to build capacity and depth with strategic external appointments.

#### Category A Staff

The REF period has seen an increase in category A staff (from 3 to 9). **Yates** and **Edwardson** joined UoL as postdocs in 2008 and 2013, respectively, and have been mentored into positions of leadership with **Yates** promoted to Professor (2018) and **Edwardson** to Associate Professor (2016). **Harrington** was a newly appointed lecturer in 2013. **Smith** was appointed as a Professor in 2017 following transfer from a full-time NHS appointment with an honorary contract with UoL. **Evans** transferred from an NHS clinical consultant post on success of a NIHR Clinician Scientist Award in 2016. **Greening** was appointed in 2017, on the success of a NIHR Post-Doctoral Fellowship, having been an Academic Clinical Lecturer previously. **Singh**, a research physiotherapist, was appointed to an academic position in 2019 to lead our rehabilitation research. **Rowlands** (2015) and **Dempsey** (2019) were new appointments to strengthen our translational research pathway. As our team has grown, we have continued to appoint (11 this REF period) and retain excellent postdocs that are being mentored into the Category A researchers of tomorrow.

#### Wider team

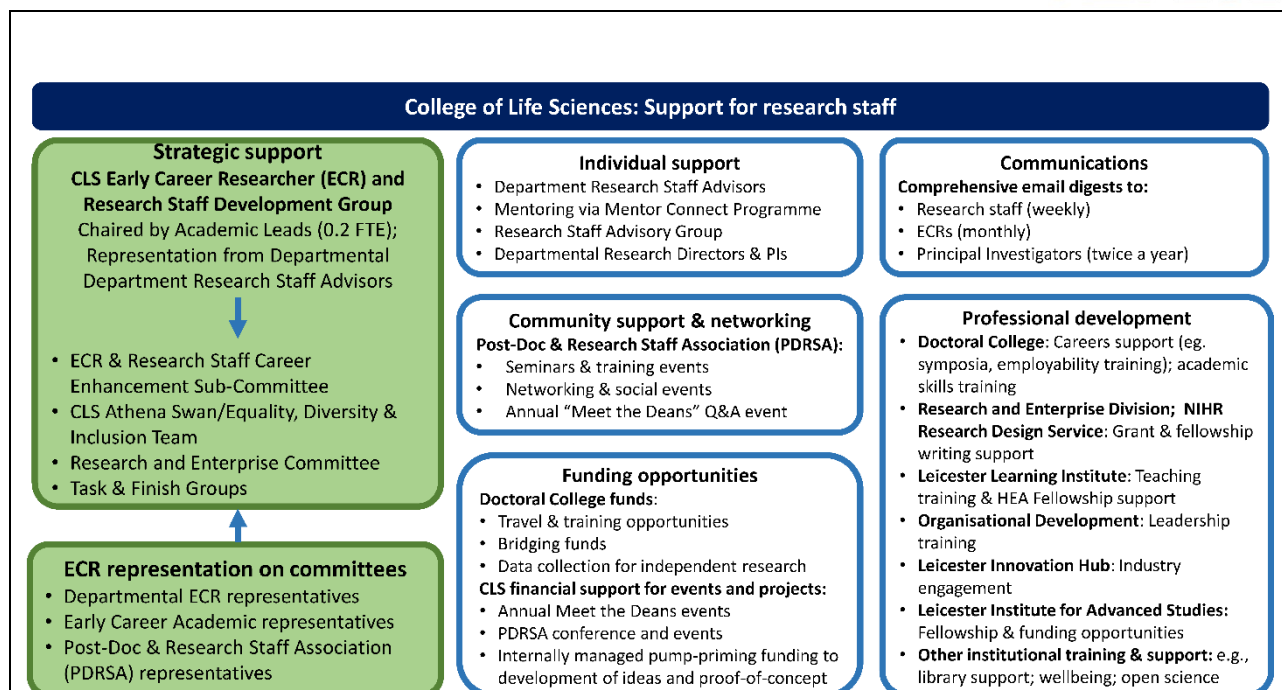
**Figure 4** summarises the number and type of staff directly funded to support physical activity research, along with the wider network of staff contributing to our research, usually through costing their time into our research grants; these are accessed across all three of our clinical areas. Our effectiveness and implementation work particularly benefit from this large multidisciplinary team employed through the BRC, DRC, CTU or NHS. For example, the SMART Work & Life (**Edwardson**) and PROPELS (**Yates**) RCTs worked with the Intervention Development, Fidelity, Creative, Nursing, Research Administrator, Biochemistry and Statistical teams in developing and evaluating behavioural interventions.



**Figure 4:** Our immediate and wider supporting team

**Support and development opportunities through UoL and CLS**

In 2020, UoL retained its HR Excellence in Research Award in recognition of its success in implementing the ‘Concordat to Support the Career Development of Researchers’ (IES, 3.2). A key element of this is the Leicester Academic Career Map (LACM) pathway (introduced in 2016); recognising contributions to citizenship and leadership as well as to research and teaching. Appraisal is managed via annual personal development discussions (PDDs); these are guided by the LACM and support career progression. An extensive range of training and development is available for all staff through the Leicester Learning Institute, the Research and Enterprise Division, the Staff Development Team and IT Services. CLS specifically has an established mentoring scheme for all staff with dedicated training for mentors and mentees, with 95 trained mentors. The recently launched Mentor Connect ensures all new staff are offered a mentor at induction and 35% of College staff currently have a mentor. CLS offer a range of development opportunities (Figure 5).



**Figure 5: Summary of staff support within CLS**

Our staff have benefited from tailored professional development opportunities in leadership through the NIHR future leaders scheme (**Evans**), the 3-year Diabetes UK Innovators in Diabetes (**Edwardson, Harrington, Dempsey**), AURORA Women in Leadership (**Harrington**), and one-to-one coaching by Pod Ltd (**Edwardson, Yates**).

Our Category A and postdoctoral staff have directly benefited from internal funding opportunities. (**Edwardson** (2014, 2018, 2020), **Harrington** (2018) and **Greening** (2020)) and three postdocs have been awarded pump-priming funding totalling >£25k through the Doctoral College, Wellcome Trust Institutional Strategic Support Funding, Impact Development fund, Equipment and Infrastructure fund, MRC Proximity to Discovery funding and Leicester Drug Discovery and Diagnostics (LD3). Work enabled through these internal awards led to research impact (ICS1) and external awards through NIHR (**Edwardson**), Industry (**Harrington**) and Charity, totaling >£1M.

### **Development opportunities through our research infrastructure and networks**

Category A and postdoctoral staff access training opportunities and events through the UHL NHS Trust, DRC, NIHR Leicester BRC, ARC-EM, the NIHR Academy and the NCSEM-EM. This includes our bi-monthly BRU/BRC ACES programme, run in collaboration with Loughborough University, which includes training in research and clinical techniques, and opportunities for developing skills related to presentation and protocol development. We also run topic focused seminars, journal clubs and writing groups that include developing analytical skills using our internal datasets. Our ethos of inclusion is evidenced by our postdocs co-authoring >80% of our publications. Our postdocs are mentored in grant writing, with 70% of current postdocs contributing as investigators to 20 awarded grants from external sources such as Kidney Care Appeal, Kidney Research UK, Diabetes UK, Novo Nordisk, AstraZeneca, MRC and NIHR (totaling £5M, range: £1.5k to £2.5M). We also use

BRC funds and dissemination costs within grants to encourage our staff (Category A and postdocs) to attend and present at national and international conferences, with all current postdocs having attended a local or national conference and 70% an international conference. We actively encourage and fund our postdocs to engage in local, national and international research networks and societies; including the American College of Sports Medicine, American Society of Nephrology, British Renal Society Rehabilitation Network and East Midlands Research into Ageing Network. This training and support platform has enabled our postdocs to establish esteem measures, including membership of the social media committee for the International Society for the Measurement of Physical Behaviour and the UK representative of the organising committee for the Global Renal Exercise Group. We have also used our networks to support international collaborative placements for staff members, e.g. **Edwardson** accompanied a postdoc on a two-month research placement in 2014 to the University of Queensland.

### **POSTGRADUATE RESEARCH STUDENTS (PGRs)**

We aim to develop world class researchers for academic and non-academic careers across the world. The number of PGR submissions 12 PGRs completed (100% completion rate) within our Unit reflects our relatively small size and recent inception, with all but one completing their studies from 2017/18 onwards. In addition to UoL PGRs, our staff have co-supervised 7 Loughborough University registered PGRs (Section 4). As our team continues to grow, we will increase our supervisory capacity and expand our PGRs numbers.

### **PGR Support and Training through UoL and CLS**

Our PGRs are funded through the NIHR, CLS or by international organisations such as Nantong University. All studentships are advertised via open-access online forums including FindAPhD.com and jobs.ac.uk. Entry requirements require a BSc of 2:1 or higher or a Masters degree. Shortlisted applicants undergo an interview with panel members who have undergone EDI and unconscious bias training.

The University's Doctoral College (IES, 3.2, 3.3), in collaboration with each department, manages recruitment, admissions, induction, research and personal development training, probation reviews and examination. Formal supervision meetings take place at least monthly for full time students (every two months for part-time students). All training and monitoring of PGRs is managed online through MyPGR. Throughout their studies, PGRs have access to a Postgraduate Research Tutor and Postgraduate Research Administrator. The Doctoral College and Careers Development Office provide a diverse range of general and tailored training, as well as opportunities to showcase research, engage with the public, and network (IES, 3.3). The Postgraduate Research Experience Survey results from our Health Science and Respiratory Science departments demonstrate high levels of satisfaction with supervision (86%), the professional development opportunities (80%) and overall PGR experience (81%).

In recognition of the disruption to PGRs by the COVID-19 pandemic, UoL provided financial support totaling £272k in the form of funded extensions, fee waivers and emergency hardship funds for current students. This was unique within the sector. This opportunity provided 3-month funded extensions to four of our PGRs.

### **Support and training through our research infrastructure and networks**

PGRs are provided with specific skills and training for physical activity research through the NIHR Leicester BRC and NHS, including phlebotomy and cannulation, competence with

exercise supervision, blood assays, statistical training, accelerometer use and data processing, and basic life support. Our ACES programme also acts as a forum for PGRs to present their study protocols and results and gain experience of answering questions. Our portfolio of large trials means that our PGRs have the opportunity to experience intervention delivery, data collection and community outreach programmes that are different to their own. We host undergraduate placement studentships, usually full time for one year, from other Universities, hosting 15 such students since 2014. We embed these placement students within our PGR research programmes to give our PGRs experience of mentoring and supporting others. We also supervise intercalated MSc/BSc medical research students annually, one of whom won the Bert Thurston prize for their research project, along with four PhD students from other national and international institutions who have completed visiting projects within our laboratories.

To develop presentational and networking skills and establish collaborations, PGRs are encouraged to submit abstracts and attend at least one major national or international conference: 100% of our PGRs have had abstracts accepted and attended conferences, of which 9 (75%) attended international conferences, and 3 (25%) awarded best poster or presentation. Through the support of the NIHR Leicester BRC, three of our students were awarded places on the prestigious NIHR Doctoral Research Training Camp. We also support and encourage our PGRs to publish their research; all have appeared as co-authors on published articles during their studies, with 11 students (92%) as first author.

The value of our PGR training and development programme is evidenced by the success of our alumni: three retained at the UoL as postdoctoral researchers to support our PA research, four others moving to posts at national and international Universities (Loughborough University, University College London, Auckland University of Technology [New Zealand] and Nantong University [China]), one moving to the healthcare industry and one starting a nutritional consultancy business.

### **EQUALITY, DIVERSITY AND INCLUSION (EDI)**

EDI is embedded in UoL's Strategic Plan and central to the working ethos (IES, 3.1), successes include gaining HeforShe status (the United Nation's solidarity campaign for gender equality), Race Equality Charter signatory, Top 50 Stonewall employer and the University of Sanctuary award. Our commitment to gender equality is evidenced by CLS gaining Silver Athena SWAN award in 2020 (replacing previous departmental Silver awards), with UoL gaining an institutional Silver award in 2018. There are diversity champions in every department and annual mandatory EDI and Challenging Unconscious Bias training, recorded on our Blackboard system and checked during PDDs.

Our unit has good gender representation, with 56% women. Of the current three professors, two are women. Our submitted staff are 100% white ethnicity; we recognise the need to achieve a better ethnic minority representation going forwards. Our wider team of staff are 62% women and 27% Black and Asian minority ethnicity, with PGR completers being 58% women; 25% of ethnic minority. We will work to ensure that we continue to foster a research environment that allows our diverse group of postdocs to progress to research independence.

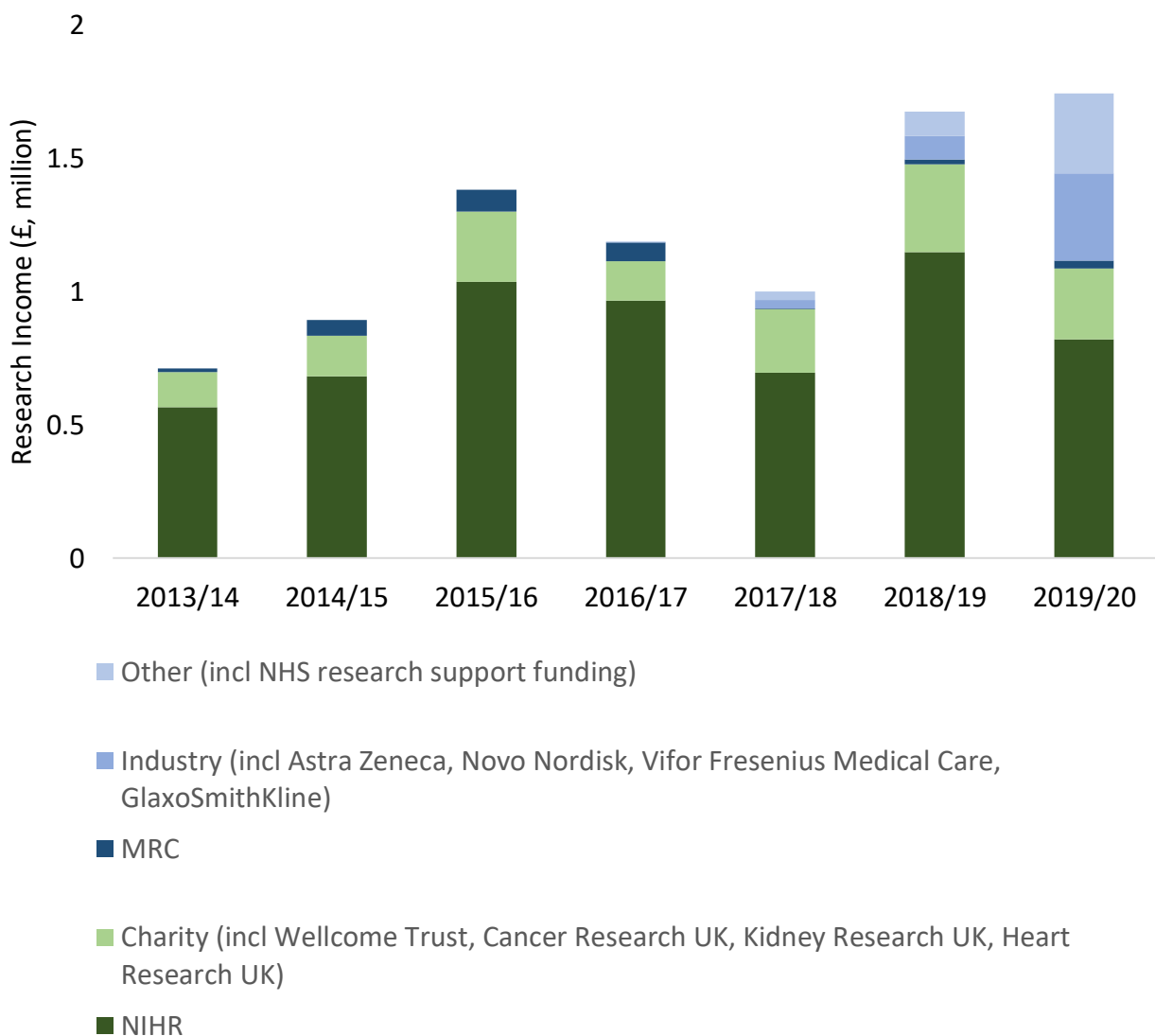
This UoA benefits from a clear set of UoL employment practices, including: leave policies for maternity, adoption, paternity, special, compassionate, careers, study and annual leave

purchase; flexible working; dignity at work; zero tolerance for bullying and harassment; and return to work schemes. Staff health and wellbeing policies also exist on menopause, stress at work, smoke-free and domestic violence and coercion. Staff can also access Validium Employee Assistance and staff counselling provider, which provides counselling and manager support, along with legal, financial, debt and health and wellbeing guidance.

**Section 3. Income, infrastructure and facilities**

**INCOME**

Our submission is underpinned by a strong track record of grant income (**Figure 6**) that has built our research profile, established a core expertise in physical activity research that supports our wider group of staff and PGRs.



**Figure 6: year-on-year research income**

During the REF period, our unit received **£8.45M (Figure 6)** in research income that directly funded physical activity and lifestyle research, equating to almost **£1M per FTE**. The upward trajectory in grant income since 2014 demonstrates we have optimised our research activity

as our team has grown, in addition to generating a more diverse portfolio. Our research income was supported by 31 grant awards during the REF period (3.5 per FTE).

### **INFRASTRUCTURE AND FACILITIES**

DRC is situated in 4500m<sup>2</sup> of refurbished research space funded by >£2M in internal and external capital, including a dedicated exercise testing and supervision laboratory, opened in 2013 by Sir Steve Redgrave. Previously staff were housed in ad-hoc offices across the three Leicester hospitals. This investment enabled the growth of the DRC, enabling the multi-disciplinary team to be brought together, with dedicated research and office space. The DRC hosts the NIHR Leicester BRC Lifestyle theme, NIHR ARC-EM, the Centre for Black and Minority Ethnic Health and the Real World Evidence Unit (RWEU).

Leicester Kidney Lifestyle Team are located within dedicated office and meeting space within the Leicester General Hospital, a short walk from the DRC where the exercise facilities and staff are jointly accessed, operated and funded.

The rehabilitation group work within a state-of-the-art £2M, 1,470 m<sup>2</sup> respiratory research facility, funded by NIHR, UoL and UHL, that hosts infrastructure for conducting clinical research, including an exercise testing laboratory supported by the Leicester BRC.

Within the DRC and respiratory research facility we operate the following which are accessed and shared across our teams:

**Exercise training and testing laboratories:** Includes four automated breath-by-breath gas analysers, treadmills including specialist treadmills for bariatric surgery patients, cycle ergometers, resistance measurement (including Biodex Dynamometer) and exercise machines, function training equipment, a specialist room for conducting sedentary behaviour (i.e., sitting) research and adjacent clinical measurement rooms, all supported by medical safety equipment, including resuscitation trolleys.

**Physical activity measurement:** We manage a large stock of 3000 wrist, waist and thigh worn accelerometers, with dedicated space and staff to manage their audit, storage, charging, initialisation, data download and data processing allowing us to embed objective measures of physical activity across our portfolio research studies.

**Biochemical laboratories and 'omics':** DRC operate a specialist biochemical laboratory (with 2 dedicated staff) analysing traditional and novel biomarkers. We also work with the UoL Precision Medicine Institute Multiomics Facility, in collaboration with Ng and Suzuki [UoA1] and Jones [UoA5], assessing targeted and untargeted metabolomic and proteomic responses to physical activity, with targeted responses focused on trimethylamine N-oxide and zinc-alpha-2-glycoprotein.

**Lung function:** At Glenfield Hospital we have specialist facilities for undertaking oscillometry testing and Sulphur hexafluoride (SF<sub>6</sub>) analysis allowing gold standard measures of lung function within rehabilitation research.

**Imaging:** We run two DEXA scanners for body composition and bone density quantification. We have developed ultrasound imaging protocols to access muscle area and quality, and we work closely with McCann [UoA 1] to include cardiac MRI outcomes within our research

investigating whether exercise training can reverse the functional and structural cardiac abnormalities observed in chronic disease.

**Muscle function:** We deploy a wide range of techniques and facilities for the *in vivo* and *in vitro* assessment of muscle function and underlying intramuscular metabolic and mechanistic pathways. *In vivo* assessments include the use of ultrasound for muscle size and quality with validation of this method against MRI; infrared spectroscopy for muscle oxygen saturation kinetics; muscle elasticity; and isokinetic dynamometry. Our close collaboration with molecular biology colleagues in CLS allows *in vitro* investigation of muscle dysfunction using muscle biopsies and a range of advanced cellular, molecular, biochemical, immunoassay and imaging techniques, and primary culture of biopsy-derived muscle cells, including bespoke cell stretch facilities to mimic exercise.

**Computing and statistics:** Our work is supported by the RWEU with access to 7 statisticians and data analysts. This has ensured our research is underpinned by statistical excellence. We also utilise ALICE, a £2M High Performance Computing (HPC) cluster that is one of UoL's research strengths.

#### **National Centre for Sport and Exercise Medicine East Midlands (NCSEM-EM)**

NCSEM-EM is a partnership between the universities of Loughborough, Leicester and Nottingham and three NHS Trusts, hosted at Loughborough University (30 minutes from UoL). It manages a wide range of clinical research facilities including biopsy rooms, exercise physiology laboratories, whole body and wheelchair ergometry facilities, functional analysis rehabilitation laboratory, DEXA machines, 3T MR imaging and musculoskeletal and cardiac ultrasound equipment. Access for our staff is facilitated through the NIHR Leicester BRC (see section 4).

### **4. Collaboration and contribution to the research base, economy and society**

#### **COLLABORATIONS AND CONTRIBUTION TO THE RESEARCH BASE**

We place a high value on collaboration which enables us to both learn from and provide value to the research community. We are an emerging team, but our diverse range of collaborations reflects our position and reputation.

#### **International collaborations**

During the REF period we were awarded 7 major grants and published 45% of our articles with international collaborators. **Yates** is the UK Principal Investigator on an MRC UK-Canada Diabetes grant (UK funding £339k), a collaboration with Imperial College London, McGill University and University of Alberta working to translate exercise and dietary protocols developed by our group into an international context. **Singh** is the Principal Investigator for a NIHR Global Health Group grant (£1.9M), with partners in India, Kirgizstan, Sri Lanka and Uganda, where work conducted in Leicester is used to develop rehabilitation pathways in low and middle income countries. **Smith** was the UK chief investigator for the international (Australia, USA, Canada, Mexico, Italy and the UK) SONG study which validated a new outcome measure for fatigue in haemodialysis patients, recruiting 60% of the total study cohort globally (Feb-July 2019). **Harrington** worked within the MRC funded (£230k) EXTEND collaboration (2017-2018) providing a sustainable pathway for diabetes self-management within Malawi and Mozambique. **Edwardson** and **Harrington** were investigators on the UoL



led PRE-START project, funded by the European Commission (€1M) with partners in Portugal, Germany, Spain and Greece developing a family-based lifestyle programme for adolescents at risk of diabetes. **Greening** is a founding member of the European Respiratory Society Clinical Research Collaboration, a pan-European multi-centre network dedicated to improving the management of COPD exacerbations (€1.5M). **Edwardson** is the principal investigator (£0.9M NIHR Public Health Research) for a collaboration with Australian-based researchers developing and evaluating a sedentary behavior reduction intervention in the workplace which has resulted in impact through the freely available online programme *SMART Work and Life* (ICS1).

### National collaborations

We collaborate with >20 Higher Educations Institutions. During the REF period, 11 of our major external grants over £100k and 93% of our publications have involved collaborators from other UK institutions. Our national leadership and collaborative networks are exemplified by the national PHOSP-COVID study (£8.4M <https://www.phosp.org/>) examining the longer-term sequela of COVID-19 across 40 NHS hospital Trusts involving 22 academic institutions where **Evans** plays a leading role, **Edwardson** as physical activity measurement lead and **Singh** as co-lead for the rehabilitation working group. **Edwardson** and **Yates** led the measurement and analysis of objective physical activity within the PROPELS trial (n=1366) (£2M NIHR HTA grant between UoL, Universitys of Cambridge, East Anglia and Sheffield). **Harrington** and **Edwardson** led the Girls Active NIHR PHR funded study (£600k), a collaboration with Universities of Inverness, Bangor and Loughborough. **Smith** is a key investigator on the £1.4M Muscle and Iron study led by Kings College Hospital, London.

Our closest collaborators (geographically and academically) are Loughborough University. This collaboration was formalised through the NCSEM-EM and the NIHR Leicester-Loughborough BRU and NIHR Leicester BRC, where Loughborough University are a sub-contracted partner. During the REF period our researchers have been co-investigators on the Loughborough led 'Snackitivity' project (NIHR programme grant £2.2M; **Edwardson, Yates**), SHIFT trial (NIHR Public Health Research grant £800k; **Edwardson, Yates**), Stand Out in Class trial (NIHR Public Health Research grant £400k; **Edwardson**), and a Heart Research UK Translational Research Project Grant (£150k; **Smith**). Conversely, Loughborough University researchers are co-investigators on UoL led projects such as SMART Work and Life (NIHR Public Health Research grant £0.9M; **Edwardson** lead), and the EMBER project (ESPRC/MRC molecular pathology node £2.5M) of which **Greening** is a deputy theme lead. **Smith, Singh, Evans** and **Edwardson** have co-supervised 7 Loughborough University PGRs facilitated through the NCSEM and Leicester BRC. Overall, during the REF period we have had 7 successful major grant awards and 88 coauthored publications with Loughborough University colleagues.

### Improving physical activity quality research through standardisation and harmonisation

**Yates** and **Smith** are involved with the Diet, Activity and Obesity Research Translation (DART) partnership involving lifestyle researchers from the Universities of Leicester, Loughborough, Cambridge, Oxford, Southampton, Manchester, Newcastle, Imperial College, and University College London, aimed at driving a step change in the in nutrition and physical activity research capacity and capability. The Department of Health formally recognised this partnership through the creation of a new translational research partnership. **Smith, Yates** and **Greening** are also part of the Midlands Health Alliance working across the Universities of Loughborough, Warwick, Birmingham, Nottingham and Leicester which includes a focus on

sarcopenia. **Edwardson** and **Yates** are members of the newly formed International Workplace Intervention Network (IWIN) consortium (involving researchers from Australia, USA and UK) to foster international knowledge exchange for occupational interventions to reduce sitting time and support pooled data analysis. **Edwardson** and **Rowlands** collaborate with the international Prospective Physical Activity and Sleep Consortium (ProPASS) harmonising and pooling thigh-worn accelerometer data. **Rowlands** is a member of the expert group, led by the University of Granada, convened to generate a consensus statement of analytical approaches to physical activity measurement, along with collaborating with the National Norwegian Accelerometer database (University of Agder, Norway), the Childhood Overweight BioRepository of Australia (COBRA) cohort study and the Child Health CheckPoint, undertaking Longitudinal assessment of Australian Children (University of Melbourne). **Harrington** collaborates with researchers within Amsterdam University Medical Center developing a Core Outcome Set for school-based obesity trials.

### **OTHER CONTRIBUTIONS TO THE RESEARCH BASE AND MEASURES OF ESTEEM**

We actively participate in the peer-review process; on average we each peer-review around 15 articles and 4 grant applications per annum. Category A staff in the unit have acted as Chief Editor for Chronic Respiratory Disease (**Singh** 2003 – 2019), Associate Editors for Physiotherapy (**Singh** 2009-2020; now international editor), Clinical Respiratory Journal (**Singh** 2017 -), BMC Public Health (**Edwardson** 2015-, **Harrington** 2017-), Frontiers in Sports and Active Living (**Edwardson** 2020 -), Journal for the Measurement of Physical Behaviour (**Rowlands** 2017-), Pediatric Exercise Science (**Rowlands** 2014-) Chronic Respiratory Disease (**Evans & Greening** 2019-) and Guest Editors (**Edwardson** 2015, **Rowlands** 2013, 2015) for the International Congress of Ambulatory Monitoring and Physical Activity Measurement: Focus Issue in Physiological Measurement.

Our researchers give between 10-20 invited keynote and plenary lectures per annum. **Rowlands** and **Edwardson** sit on the Scientific Committee of International Society for the Measurement of Physical Behaviour which organises the International Conference on Ambulatory Monitoring of Physical Activity and Movement annual conference.

**Edwardson** and **Rowlands** and several of our postdocs deliver the 'MEASURE' workshop which trains researchers from across the UK and Europe in accelerometer data processing (two delivered with ~50 attendees).

Our researchers have had visiting positions at Loughborough University (**Singh, Smith**), University of Cambridge (**Dempsey**), Swinburne University of Technology, Australia (**Dempsey**), University of South Australia (**Rowlands**), Baker Heart and Diabetes Institute, Australia, (**Dempsey**), and Pennington Biomedical Research Centre, USA (**Harrington**).

**Evans** received the 2020 American Thoracic Society Pulmonary Rehabilitation Early Career Achievement award. **Yates** and co-authors were awarded the most cited observational article in the International Journal of Behavioral Nutrition and Physical Activity for 2016 and **Greening** and co-authors were voted to have conducted one of the top 20 most significant physiotherapy trials of all time by PEDro (Physiotherapy Evidence Database) for an article published in the British Medical Journal (2014). **Singh** was presented with the prestigious lifetime membership award by the European Respiratory Society (2020). **Smith** received the Honorable Mention Award (AAP Excellence in Research Writing Award) for best paper published in the American Journal of Physical Medicine and Rehabilitation (2018).

**CONTRIBUTIONS TO SOCIETY****Public Health Guidelines**

Our researchers ensure wide societal and clinical impact through translating our research into public health and clinical guidelines.

Following work contributing to the American Diabetes Association Position Statement on Exercise/Physical Activity (2016), **Dempsey** went on, through membership of the Guideline Development Group (2019-2020), to help update World Health Organization physical activity guidelines (published 2020). **Yates** was part of an expert group who published the first expert consensus statement on sedentary behaviour levels in the workplace (2015) and a member of the sedentary behaviour expert working group to update the Chief Medical Officer (CMO) physical activity guidelines (2019). **Harrington** was an expert group member for translating the CMO physical activity guidelines for children and young people into infographics for healthcare professionals (2015). **Harrington** also led the development of Ireland's Physical Activity Report Card in 2014 (a global physical activity advocacy tool for raising awareness and influencing policies for childhood physical activity), launched alongside 14 other countries, and was Chair of the working group for the second version alongside 37 other countries through the Active Healthy Kids Global Alliance.

**Clinical Guidelines, Tools and Engagement**

**Singh, Greening, and Evans** were involved in developing new guidelines, quality standards and surveillance tools for the British Thoracic Society (BTS), American Thoracic Society (ATS) on Skeletal Muscle Dysfunction in COPD, joint ATS/European Respiratory Society (ERS) Statement on pulmonary rehabilitation (**Singh** as Chair), the ERS/ATS technical standard for field walking tests in chronic respiratory disease, the ERS statement on nutritional assessment and therapy in COPD and the Pulmonary rehabilitation Quality Improvement Advisory Group, BTS (**Singh** as inaugural Chair). **Singh** is also a member of the WHO Rehabilitation in COPD working group and is the incoming chair for the ATS Pulmonary Rehabilitation Assembly. **Smith** is a member of the Global Renal Exercise group and the NHS England/UK Renal Registry and contributed to the UK Renal Association Guidelines for Exercise and Lifestyle in Chronic Kidney Disease. **Smith** is a member of the UK Renal Association Clinical Studies Group (Exercise and Lifestyle committee) and **Yates** of the Diabetes UK Research Steering Group (Treatments and Prevention) advising on national research priorities.

**Health Care Professional Training/Engagement**

**Singh** founded the BTS short course for pulmonary rehabilitation, with **Evans** and **Greening** also having leadership positions on pulmonary rehabilitation courses, including a BTS course on Fundamentals of Pulmonary Rehabilitation and online patient tools. **Singh** is the NIHR lead national advocate for physiotherapy and **Evans** was the ATS pulmonary rehabilitation web-director (2016-2020) leading international podcasts, journal clubs, quarterly bites and website content. **Dempsey** is a contributor on the #MovementForMovement undergraduate medical curriculum resources and guidance on physical activity for health practitioners. **Yates** and **Edwardson** deliver training on physical activity, including for the award winning Leicester developed 'Effective Diabetes Education Now' (EDEN) programme which has trained >5000 health care professionals since 2014. We work with national charities and their regional groups such as Kidney Research UK, the National Kidney Federation and Kidney Care UK and Diabetes UK to provide seminars and talks to both health care professionals and patient groups (~10 per year).

**Public engagement and resources**

Our research is underpinned by an active public involvement and engagement (PPI/E) infrastructure to ensure our research is relevant to targeted populations. This is supported by a PPI/E officer funded through the NIHR Leicester BRC. Along with embedding PPI/E at the centre of our research, we work to disseminate our research findings to patients and public; over the REF period the NIHR Leicester BRC organised 50 physical activity and lifestyle themed public lectures and 88 wider public engagement events, including physical activity tasters and research fairs.

More widely, our Leicester CCD initiative involved Faith Centres, Schools and the City Council with the first Global City Sporting Pledge signed by the City Mayor and all four of Leicester's professional sports clubs. **Yates** joined BBC presenters at the Cheltenham Science Festival (2016) discussing the importance of physical activity for health. We regularly appear as experts on national and regional media outlets. **Harrington** is a monthly guest on BBC Radio Leicester 'Table Talk' to discuss research findings. Our research on walking pace was developed into the 'Being a brisk walker could save your life' BBC3 mini-feature. We worked with the BBC Radio 4 documentary 'Are you Sitting Comfortably', as well as working with the New Scientist on their feature 'Workouts are no antidote to death by desk job' and the Naked Scientist Podcast 'The science of sitting down'.

We also design and disseminate infographics and information resources for patients and the public, including the content of the freely available e-Learning module *Get Moving, Get Healthy* from the Virtual College promoting the importance of physical activity; the module has been completed by >5000 users.

**CONTRIBUTIONS TO THE ECONOMY**

We contribute to the health care economy through evaluating and implementing nationally commissioned lifestyle and rehabilitation programmes. **Yates** and **Edwardson**, through their work within the framework for *Healthier You: the NHS Diabetes Prevention Programme* (ICS) have helped generate significant health service income for the UHL NHS Trust totaling over £1.7M over the REF period. Overall *Healthier You* has also been estimated to provide an undiscounted economic net benefit of £1.2bn, driven by a reduced demand for future NHS resources over a 20-year horizon (NHS England), to which we directly contribute through commissioning our diabetes prevention programme. The commissioning of our rehabilitation programmes generates an additional >£60k per annum in health service income for UHL.

**SUMMARY STATEMENT**

We are committed to undertaking high quality research developing physical activity as an evidence-based therapy in the prevention and management of chronic disease. With strategic support from CLS, and our NHS partner Trust we have developed a thriving group of high-profile researchers and infrastructure that have successfully generated substantial grant income and outputs, informed physical activity guidelines and policy, and translated physical activity research into tools and interventions that are delivered globally.