**Institution: LJMU**

**Unit of Assessment: UoA26**

**a. Overview**

As a result of a 5* RAE outcome in 1996, the Research Institute for Sport and Exercise Sciences (RISES) was launched in 1997 within the School of Sport and Exercise Sciences at Liverpool John Moores University. RISES was conceived with a long-term strategic vision to promote and develop world-class "molecular to community" research across the disciplines of Sport and Exercise Science. Currently, RISES employs 53 academic staff, 6 post-doctoral fellows, 4 technical staff, 4 research officers/assistants, 3 teaching support officers, 3 administrative staff and 22 Honorary and Visiting Professors and Researchers working together in a research-led environment. This dynamic academic culture empowers staff and enables the training of postgraduate research students in world-class facilities. Excellent multi- and inter-disciplinary research networks exist within RISES and extend to world-leading national and international collaborations.

RISES is strategically organised and managed through the RISES Board and the Professors and Readers Group. Collectively RISES have revised its governance structures, such that activity is focused in 4 Research Groups; **(a)** Biomechanics, **(b)** Brain and Behaviour, **(c)** Cardiovascular Health Sciences, and **(d)** Exercise Metabolism and Adaptation. Substantial overlap on projects and postgraduate studentships facilitate collaboration within, between and beyond Research Groups. In addition to these Groups, direct end-user engagement is promoted by 2 themed "Exchanges"; **(i)** the Football Exchange (FEx), and **(ii)** the Physical Activity Exchange (PAEx). The "Exchanges" have a broad membership from all areas of RISES, external staff as well as key external stakeholders. The FEx and PAEx have a remit to produce innovative, high quality applied research outputs that are translational and have impact.

In RAE 2008 RISES received a 50% world-leading (4*) rating for its research environment. In this cycle research facilities have been significantly extended and enhanced by the provision of two new developments, the Tom Reilly Building (TRB) and the Max Perutz Building (MPB). This £35M investment markedly extends the applied and mechanistic scope of our research and has led to the recruitment of new world-class academic staff and an increase in postgraduate enrolment.

**b. Research strategy**

Within the RAE2008 document the following strategic **AIMS** were stated:

1) Further extend research activities at the highest attainable quality level,
2) Capitalise on strategic alliances in health and performance,
3) Consolidate overseas collaborations, including governments and sporting agencies,
4) Secure further external aid and enterprise projects,
5) Maintain the integrity of the three component sub-areas (chronobiology; exercise and health; human performance).

These strategic **AIMS** were underpinned by the following focused **ACTIVITIES**:

a) Develop further premises, personnel and support their activities,
b) Negotiate collaborative research projects, involving visiting Professors and Honorary Research Associates,
c) Extend the current network of activities and hosting of international conferences,
d) Increase research grant submission and acquisitions,
e) Balance post-graduate and post-doctoral activities across sub-areas and research themes.

**Reflection on Strategic Aims and Activities (2008-2013)**

The extension of high quality research activities (**AIM 1**) since 2008 include a substantial increase in total peer-reviewed publications, from 221 per year in 2007 to 342 per year in 2012. The average impact factor of research outputs has been maintained as the number of outputs per staff member has increased considerably.

To capitalise on key alliances in health and performance (**AIM 2**), RISES took the strategic decision to supplement its Research Group-focused structure with two themed "Exchanges". These themes are oriented toward areas of staff expertise, funding success, external impact and end-user translation. The FEx is a multidisciplinary group whose mission is to deliver high quality,

research-informed solutions to real-world problems in the Football industry. Examples include the tripartite partnership between NIKE, Manchester United and the FEx to develop and assess vision training in football and the secondment of 2 academic staff and recruitment of 5 PhD students at Liverpool FC covering player analysis, preparation, recovery and nutrition. The PAEx promotes innovation, research capacity and output in the field of exercise and health. The PAEx has formed collaborative projects with local government, health and industrial partners. For example, paediatric health research with key partners has targeted childhood obesity (GOALS programme; Liverpool City Council) and physical activity promotion (CHANGE! Project; Wigan Council).

RISES has made significant strides in the current REF period with respect to overseas research collaborations (**AIM 3**). New initiatives include research-based Memorandums of Understanding with elite football clubs (Real Madrid) and governing bodies (Mexican FA). RISES staff have been seconded to the Qatar FA to provide elite player support and lead the development of Sport Science services at the ASPIRE Academy in Qatar. In collaboration with the ASPETAR Sports Medicine Hospital in Qatar, we have launched a large athlete-screening programme (6000+ athletes to date) to detect cardio-respiratory pathologies.

External income generation and expenditure against all RCUK, charity, EU, industry and government funded research has markedly increased across the current REF cycle (**AIM 4**). Total research expenditure over the RAE cycle to 2008 was £2.9M and has increased over the current cycle to £6.9M in 2013, with a peak yearly income of £1.6M in 2012. This represents an increase of 138% compared with the previous RAE cycle. Within this funding cycle, a diversified approach to funding applications has also resulted in successful Knowledge Transfer Partnerships (KTP) with key industrial partners (see section D). Directly linked with the substantial rise in funding success and spending has been a significant increase in the number of submissions made to a broad range of external funding agencies (**ACTIVITY d**).

RISES continues to have a focused and strategic approach to staff recruitment, retention, mentoring, succession-planning and leadership development (**AIM 5**). We have reassessed and refocused our research sub-areas alongside the development of our thematic “Exchanges”. The activity of the Chronobiology Group has been subsumed into the Cardiovascular Health Sciences Group following the death, retirement and departure, respectively, of 3 senior Professors. As a consequence of University strategic investment in RISES as a “Beacon of Excellence”, recruitment has resulted in a more balanced staffing-base across Research Groups (**ACTIVITY a**). All groups now have a core of senior staff leading research strategies in collaboration with talented early career researchers (ECR), post-doctoral fellows and PhD students. All areas have access to technical and research officer support as well as significant investment in high quality laboratories and analysis facilities within the TRB and MPB.

A key component of our research expansion has been the development of significant collaborative research activity (**ACTIVITY b**) with a range of external collaborators. Notable successes include our EU Framework 7 projects in cardiac stem cell biology (“CAREMI” 11 partners across Europe; “EndoStem” 16 partners across Europe). The PAEx was also successful in securing EU Framework 7 funding to capacity-build a research agenda related to physical activity and nutrition (“AFRESH” 16 partners in 8 EU regions). Furthermore, all Research Groups have utilised existing and new Visiting Professors and Researchers to enhance research quality and translation.

Over the current REF cycle, RISES has significantly extended its external engagement and international conference support. In 2008 RISES organised and hosted the First World Congress of Science and Soccer, and in 2011 organised and hosted the 16$^{th}$ Annual European College of Sport Science congress. In 2012 RISES was a co-host and organiser of the International Conference of Science, Education and Medicine in Sport (ICSEMIS) (**ACTIVITY c**).

As a consequence of the increased research funding (see AIM 4), expenditure on research activity has been partially targeted at a year on year increase in PhD student recruitment and completion (see Table 1). In an effort to further increase overseas recruitment, Dual PhD agreements with the University of Malaya and Mahidol University, Thailand, have been developed (**ACTIVITY e**).

**Strategic Aims (2014-2020)**
Building on successful growth between 2008 and 2013, the focus for 2014-2020 will be to empower Research Groups and Exchanges, through financial and infrastructural resourcing, to deliver a world-class research agenda of the highest quality and currency.

Our strategic **AIMS** for 2014-2020 are therefore:

1) To further enhance the significance, quality and impact of our research OUTPUTS by using mechanistic and applied approaches to investigate real-world issues in the areas of human performance and health,
2) To increase the translational IMPACT of our work by building the activity and profile of our "Exchanges" regionally, nationally and internationally by sustaining current collaborations and developing new partnerships with key external stake holders,
3) To continue to further develop and extend our excellent research ENVIRONMENT through alignment with the current LJMU estates strategy whose mission is to promote local and regional civic partnerships including activities related to sports performance and health in our communities.

To achieve these **AIMS**, RISES will set the following **ACTIVITY** targets:

a) Promote, retain and recruit high quality staff from postdoctoral fellows, to ECRs and professors,
b) Increase UK, European and International grant funding with a specific strategic target of "Big Science" priorities and initiatives related to physical activity, exercise and health as well as elite sports performance,
c) Extend the recruitment of high quality postgraduate students, by developing Dual and International PhD awards with high profile partners,
d) Provide all staff and students with high quality support, training, development and communication opportunities in collaboration with key national and international partners. This includes the hosting of international conferences and training programmes.

**Delivering Our Research Strategy 2014-2020**
Our strategic aims for 2014-2020 will be governed through the RISES Board and will be delivered by all groups with internal and external partners. The RISES Board will meet on a quarterly basis to review progress against strategic aims and KPIs. This group will manage the overall direction and research resource (people, infrastructure) and allocate pump-prime funding that is generated from research and enterprise overheads. The RISES Professors and Readers Group will continue to report into the RISES Board and lead strategic research agendas and activities across all discipline areas. They will support the genesis and review of future REF milestones related to quality of outputs, postgraduate recruitment and completion as well as income generation. From a governance perspective, the RISES board will report directly into the Faculty Research Strategy Committee and the University Scholarship, Research and Knowledge Transfer Committee. The FEx and PAEx will benefit from the strategic direction of respective steering groups with representation from key community and industrial stakeholders.

**c. People, including:**

**i. Staffing strategy and staff development**

In 2012 RISES was identified as a "Beacon of Excellence" within the University and benefited from the University's "Inspire" strategic initiative which funded 15 new academic posts. As a consequence of this and other appointments the RISES staffing base has grown from 34 (2008) to 53 currently. The recruitment of internationally renowned scientists and associated ECRs has supported strategic direction, promoted effective team building and activity. Critical mass has been created, most notably in the Exercise Metabolism and Adaptation Research Group by attracting staff with complementary skills in nutrition, biochemistry, stem cell and molecular biology related to sport and exercise science. This group provides a mechanistic focus in high priority research areas with potential for external income generation and collaboration (physical activity, exercise and non-communicable diseases; obesity, diabetes, cardiovascular disease).

**Exercise, Metabolism and Adaptation Research Group appointments:**

- Professor Anton Wagenmakers was recruited from the University of Birmingham with 3 ECRs (Dr. Juliette Clark, Dr. Mathew Cocks, Dr. Sam Shepherd). Professor Wagenmakers has an international reputation in the field of exercise metabolism in health and disease and is leading the Exercise Metabolism and Adaptation Research Group.
- Professor Claire Stewart was recruited from Manchester Metropolitan University with 2 ECRs (Dr. Rob Erskine, Dr. Adam Sharples). Professor Stewart is an international expert in skeletal muscle stem cell biology as it pertains to health and exercise. Professor Stewart has been an Erasmus Mundus coordinator and will develop similar activity in RISES.
- Professor Jonathan Jarvis was recruited from the University of Liverpool with 2 externally-funded post-doctoral fellows. Professor Jarvis has an international reputation in the molecular biology of skeletal muscle as well as pioneering technical development in muscle electrical stimulation, micro CT scanning and the study of the rare disease alkaptonuria.
- Professor John Hawley was recruited on a fractional contract (0.4 FTE) from the Royal Melbourne Institute of Technology. Professor Hawley is a recognised world expert in the field of molecular and biochemical responses to exercise and dietary manipulations. His research work has a mechanistic focus with applied outcomes in health and disease.

**Cardiovascular Health Science Research Group appointments:**

- Professor Dick Thijssen has been recruited on a fractional contract (0.5 FTE) from Radboud University, The Netherlands, with Dr. Dave Low from Imperial College London. Professor Thijssen is a recognised international expert in vascular physiology and the impact of exercise, health and disease on the circulatory system.
- Dr David Oxborough has been recruited from the University of Leeds as a Reader in Cardiovascular Physiology. Dr Oxborough is an academic and clinical sonographer leading education and research agendas in both the UK and abroad and his research has a major impact on the cardiovascular screening of athletes.
- Dr. Paula Watson has been recruited as an ECR in physical activity and health psychology, and both Dr. Lynne Boddy and Dr. Lee Graves have been appointed as ECRs with a background in physical activity promotion and health in paediatric populations.

**Brain and Behaviour and Biomechanics Research Group appointments:**

- Professor Jeff Summers has been appointed on a fractional contract (0.5 FTE) from Tasmania University, Australia. Professor Summers is a world-leading expert in the area of motor skill learning and development. Professor Summers work spans mechanistic neuroscience topics and applied skill development.
- Professor Costis Maganaris was recruited from Manchester Metropolitan University with Dr. Tom O'Brien (Bangor University) and leads the Biomechanics group. Professor Maganaris is a recognised world leader in the adaptation of muscle, tendon and bone to ageing, exercise and disuse. His work on EU FP7 projects has provided important insights into "healthy ageing".

Moving forward, the general staffing strategy of RISES will continue to focus on the recruitment of world-leading academics with a proven track record of high quality outputs, grant successes and postgraduate student supervision as well as exceptional young scientists with significant potential. All appointments must be eligible for REF submission upon starting. The University operates a workload allocation model that has a three-tier research allowance designed to facilitate research activity. This model assesses individual outputs on an annual basis and provides relief from teaching based on quality and volume of output and income generation. All new staff receive a full allowance for research and scholarly activity during the first three years of employment. At annual performance review, individualised targets are agreed and strategically mapped to specific Groups and/or Exchanges. Staff development requirements (training, conferences, CPD) are provided through a competitive bidding process within RISES and funded strategically from research and enterprise overhead accounts. Start-up costs, minor consumables and specific pieces of capital equipment can be negotiated on a case-by-case basis with the RISES Board. New staff and ECR's are eligible to compete for Faculty funded PhD studentships (6 awarded since 2012), and the University also runs a matched funded PhD student programme that is targeted at new staff and ECR's (3 awarded this year). The University also supports ECR staff through provision of periods of study cover, travel, subsistence and some consumable costs, in order to develop

national and international collaborative partnerships. Since 2008, 8 members of RISES have been awarded University ECR Fellowships.

In relation to equality and diversity, all academic appointments and promotions to Readership and Chairs are routinely monitored (equality impact assessment) and reported in terms of equality and diversity. The University holds membership of the Athena Swan Charter. LJMU is working towards achieving the Athena Swan Bronze award by April 2014 in accordance with its Equality Objectives and Action Plan 2012-2017. Senior mentors are being introduced in 2014 to provide further support and guidance to female ECR staff.

**ii. Research students**

The RISES postgraduate research environment comprises of a large and vibrant mix of UK, EU and international students studying full or part-time in laboratory or field-based projects as well as postdoctoral fellows. An increase in enrolments (36.1 FTE in 2008/09 in to 51.9 FTE in 2012/13) and completions (9 FTE in 2008/09 to 13.5 FTE in 2012/13) has occurred across the cycle (see Table 1). The recruitment and training of exceptional postgraduate students from the UK and around the world is central to RISES philosophy. RISES recruits using the "FindaPhD portal" and overseas recruitment is driven by key partnerships and Dual and International PhD programmes (Malaysia and Thailand). Students are active in all Research Groups and Exchanges and are funded from a range of sources (industry, charity, sport as well as local, national and international Government).

**Table 1. RISES Postgraduate Research Student Summary table 2008/9 to 2012/3**

| Year | PhD FTE | PhD Headcount (FT and PT) | PhD completions |
|---|---|---|---|
| **2008/9** | 36.1 | 49 | 9 |
| **2009/10** | 33.1 | 49 | 13 |
| **2010/11** | 38.7 | 57 | 10.5 |
| **2011/12** | 36.7 | 92 | 14.5 |
| **2012/13** | 51.9 | 100 | 13.5 |

RISES research students have open plan office space in the TRB, MPB and the Centre of Excellence for Teaching and Learning. Access to desk space and computers is also supported by computer laboratories in the TRB, around the Science Faculty and in LJMU libraries. The Avril Robarts Library provides both hard and digital copies of key research resources with on- and off-campus access to on-line databases. Student support is provided through supervisory teams led by an experienced senior academic and includes ECRs through a mentoring scheme for the development of supervisory skills. Postgraduates are also supported by activities that include "journal clubs", "sandboxes", technical training, the RISES seminar series and research methods/statistical training and support. RISES supports competitive conference funding bids to aid dissemination of findings and enable postgraduate learning. There is a RISES Postgraduate Student coordinator (Deputy Head of RISES) who liaises directly with students, the Faculty Research Office and Faculty Research Degrees Committee to oversee student applications, enrolment, registration, milestones (MPhil-PhD transfer), annual monitoring review, submission, examination and completion. These individuals and groups also monitor overseas student attendance and compliance with UKBA regulations for Tier 4 visa holders.

Within the University, the Graduate School runs an annual programme of support activities and a competitive conference travel fund. Included in this is a University wide teaching development course (3i's) to promote broader academic skills for future career progression. The Graduate School also promotes external training and development (through Vitae and other bodies) and provides quality control for the entire postgraduate student process. To this end the University were awarded the European Union's HR Excellence in Research Award that acknowledges the institutional alignment with the European Charter for Researchers and Code of Conduct for their Recruitment. This also encompasses the QAA Code of Practice for Research Degree Programmes and the Concordat to Support the Career Development of Researchers. The postgraduate student body elects a representative annually, who sits on the RISES Board and Faculty Research

Degrees Committee, to provide 2-way communication between the student body and RISES/University. RISES student representatives also sit on University Ethics Committee and the University Research Degrees Committee.

**d. Income**

RISES research activity across this REF period has been facilitated by a 138% increase in external funding compared with the previous RAE cycle. Total income generation reached £6.9M over the current REF cycle and reflects a strategic approach to diversify income streams. The Cardiovascular Health Sciences Research Group acquired grants from UK charities (BHF), Research Councils UK (MRC), Industry (BUPA) the NHS (Flexibility and Sustainability) and Government agencies (UKSport). International sources of income generation included EU funding (Marie Curie; FP7) and 3 successive project grants related to the ergogenic properties of short-acting beta2-agonists (World Anti-Doping Agency). The Exercise Metabolism and Adaptation Research Group received industrial funding from Astra Zeneca, GlaxoSmithKline, Red Bull as well as BUPA Foundation and local government agencies such as the Merseyside Fire and Rescue Service. The Brain and Behaviour research groups received support from Research Councils (BBSRC; Royal Society), a multinational company (Nike) as well as sports governing bodies (English Cricket Board) and the NHS (Medical Simulations). The Biomechanics Research Group has received funding from research councils (ESRC), sports governing bodies (FIFA), industry (Li Ning; Vicon) and UK charities (The WellChild Trust), The FEx received research and innovation funding from FIFA, UEFA, the FA's of England and Wales, Premiership clubs (sequential grants from Liverpool; Manchester United; Everton; Chelsea; Hull City) and industrial partners (Nike; Prozone). The PAEx secured repeated funding across the REF cycle from the EU (FP7 Research and Technologies Development), local Government (SportLinx; GOALS; ACLASS; PEPASS; CHANGE!) as well as health agencies (NIHR - Obesity in Black and Racial Minorities; Smokefree Sports). In addition, the FEx and PAEx successfully established KTP partnerships out of long term relationships with Prozone (unique and marketable approaches to match-analysis in football and other sports, 2012, £146K) and Destination Youth (physical activity and healthy lifestyle behaviour change in young people; 2010, £142K), respectively. The School's programme of Public Engagement in Sports Science was funded by a Welcome Trust Engagement Award (2012), and a curriculum focused research programme was funded by the Higher Education Academy (£200K).

**Infrastructure**

In 2010 RISES relocated to a bespoke home in the TRB. This £25.5M investment in state-of-the-art laboratories and latest technologies was reinforced by the recent (2013; £8.5M) refurbishment of the adjacent MPB, which houses exceptional new laboratories for biomolecular and stem cell biology as well as animal facilities. The TRB and MPB house all Research Groups, and collectively allow for the investigation of the impact of exercise and activity on molecules, proteins, cells, systems and organisms in an integrated fashion. The co-location of animal and human-based laboratories allows the interrogation of the exercise response within a contained world-class infrastructure, and is unique in the domain of sport and exercise science in the UK. This provides an exciting platform from which to investigate emerging exercise and health issues and thereby sustain future world-leading scholarship. We maintain a presence in the Centre of Excellence for Teaching and Learning (CETL) building which facilitates the applied work of the FEx and PAEx, including performance and health and fitness gymnasia, a physiotherapy suite, a match analysis room and meeting space. This enables translational activity with high performance athletes and exercise and health interventions for the community.

RISES staff and students are supported by 2 administrators in the RISES office (grant submission, travel, student registrations and finance support). Research training within RISES is managed through a dedicated Research Methods and Statistics Support Group that is mandated to advise and review research proposals, grant applications and submissions, paper writing and conference presentations. This group is led by a Fellow of the Royal Statistical Society and supported by internal experts in quantitative and qualitative methods. Postgraduate students can access taught Master's modules including: Research Methods, Statistics, subject-specific Technical Training and Current Issues. Within RISES there is an ECR Mentorship Coordinator offering support packages for postgraduate students nearing completion and ECR staff members seeking guidance as they begin their career. A vibrant research culture is facilitated by a weekly series of seminars that

invites postgraduate students, staff, internal University collaborators and external experts to present cutting edge research. This series is advertised campus-wide and showcases the world-leading research performed within RISES as well as with collaborators outside the institution. Scientific, technical and philosophical insights are also developed and shared across the research community and facilitated by discipline and exchange related "journal club" meetings.

RISES liaises with the Faculty Research Office which monitors postgraduate student milestones, runs the Faculty Research Degrees Committee and hosts a PGR Research Day with prizes to support research activity or external conference attendance. This group communicates directly with the University Research Degrees Committee and the Graduate School. The RISES Board works with the Associate Dean (Science) for Research, Scholarship and Knowledge Transfer who convenes the Faculty Research Strategy Committee that develops the Faculty's research strategic plan. RISES strategic aims both inform and reflect Faculty strategy. Likewise, RISES strategic aims encompass the Universities Strategic Plan and feed directly into institutional discussion and development via the University Research Strategy Committee.

**Facilities**

Within the TRB, MPB, the Centre of Excellence for Teaching and Learning (CETL) and also externally where applied research occurs in the field (Match Analysis at Liverpool FC; the BASES accredited and FEx-quality assured Human Performance Laboratory at Manchester United FC), RISES has an array of research facilities. Generic research space includes: two large general exercise physiology laboratories (with multiple ergometers and metabolic analysis systems), a muscle function laboratory (muscle stimulation and dynamometry), 2 environmental chambers (-20 to 50$^{o}$C with normobaric hypoxia capability to simulate an altitude of 4500 m), a body composition laboratory (skinfold, impedance and DEXA) a recovery laboratory (hot and cold water immersion) and a range of small clinical rooms (blood sampling, biopsy). Research Groups and Exchanges also manage and quality control scholarly activity in bespoke facilities.

**Biomechanics Research Group Laboratories:** The biomechanics research laboratories are equipped for the study of fundamental, sport and clinical human biomechanics from the muscle-tendon level, *in vivo*, to whole body locomotion. Two large research laboratories and a 70 m runway are equipped with optoelectronic motion capture systems with multiple cameras and force platforms, plantar pressure measurement systems, wireless electromyography and Xsens inertial sensors to allow complex movement analysis. A further laboratory houses a CAREN virtual reality system including a large display screen, a computer driven motion platform with integrated Kistler force plate, a Vicon MX system and EMG. This laboratory also has a unique custom-made staircase instrumented with independent Kistler force plates. These tools are integrated to study posture and balance in the context of cerebral palsy, as well as falls and accidents on stairs. The mechanical and geometric properties of the human musculoskeletal system are also examined using dynamometry and ultrasound imaging.

**Brain Behaviour Research Group Laboratories:** The 3 co-located purpose-built Brain and Behaviour laboratories allow for studies of: **i)** gait and balance, interceptive actions and perception-action using life-size projected displays with full-body kinematic data collection (Qualisys QTM) and visual search technologies (Mobile Eye or Eye-TRAC eye movement devices), as well as Nike Inc. SPARQ Sensory Station with Vapor Strobe Eyewear providing visual assessments for high performance sport, **ii)** oculomotor control using a full black-out facility and control room with 2-way mirror integrated with eye movement analysis by video-oculography (Eyelink100) integrated with motion analysis systems (Vicon Nexus or Ascension trakSTAR), **iii)** sensorimotor neuroscience and neural plasticity using transcranial magnetic stimulation (Magstim BiStim) and electrical (tDCS) stimulation integrated with motor evoked potentials (DelSys Bagnoli) and limb kinematics (Optotrak Investigator) to investigate neural control of limb movement, **iv)** observational learning via a suite containing computers with linked displays, digitising tablets for upper limb movements and stereoscopic stimuli for 3D presentation using LCD glasses.

**Cardiovascular Health Sciences Research Group Laboratories:** The Cardiovascular Health Sciences Group acquire and analyse real-time images related to blood vessel and cardiac

structure and function. Five state-of-the-art echocardiographic systems provide 2D, M-mode, Doppler, tissue-Doppler and strain imaging capacity (GE Ltd; Echopac) with additional software for coronary flow assessment and left ventricular opacification. A further 5 vascular ultrasound machines (Siemens; Terason) provide 2D and Doppler imaging of intima media thickness, diameter, flow, shear stress and endothelium (in)dependent dilation in blood vessels. Laser Doppler assessment of (skin)microvascular function can be combined with microdialysis of vasoactive substances, and trans-cranial Doppler assessment of cerebral perfusion. Electrocardiography (ECG) and finometry allow assessment of heart and vascular function. Data are acquired in 3 temperature-controlled ultrasound laboratories complemented by an analysis room with dedicated, encrypted image and data server and workstations that include automated, validated and observer-independent vascular and cardiac analysis software.

**Exercise Metabolism and Adaptation Research Group Laboratories:** Bespoke integrated laboratories in the TRB provide ample space for treadmills and ergometers (cycle, rowing, arm and others) to investigate a wide range of acute exercise and training interventions in health and disease., State-of-the art equipment is used to measure functional outcome measures that include $VO_{2max}$, time-trial performance, muscle strength (various dynanometers ), as well as body and muscle morphology (DEXA and ultrasound). State-of-the-art analytical facilities are used to measure blood and tissue metabolites and muscle proteomics (MALDI & ESA mass spectrometers). The MPB provides brand new world-class research suites and analytical facilities. These include the latest rodent facilities with individually ventilated cages and surgical theatres. This facility allows RISES researchers to complement their strength in human muscle metabolism research with studies in unique transgenic rodent models imported from world-leading rodent laboratories. Mechanistic, cellular and molecular physiology research is supported in the MPB by; **i)** an imaging suite (confocal and wide-field fluorescence microscopy; inverted light microscopy; transmission electron microscopy) for visualisation of life cells and sections of muscle (heart and skeletal), tendon, bone, adipose tissue, vascular endothelium and smooth muscle cell layers; **ii)** a cell culture suite; **iii)** molecular biology and biochemistry laboratories for mRNA, DNA and protein analyses (RT-PCR, DNA methylation and polymorphism analyses, Western blotting, ELISA and FLOW cytometric analyses); **iv)** an HTA-approved LJMU human tissue bank, **v)** an HPLC suite, and **vi)** a DNA/RNA suite with extensive PCR facilities.

**Facilities for the Football Exchange and the Physical Activity Exchange:** The PAEx accesses exercise space and technical equipment in the TRB and CETL. Physical activity and/or sedentary behaviour are assessed using uni- and tri-axial Actigraph accelerometers, GENEActivs devices (Actihearts), as well as portable heart rate, pedometer and indirect calorimetry systems. The preparation and analysis of physical activity data occurs in a dedicated laboratory that also includes 'exergaming' equipment as well as video playback facilities to assess fundamental movement skills and systematic observational analysis. A paediatric exercise testing laboratory is used for the assessment of physiological function in children (peak $VO_2$). The FEx can access laboratory space in the TRB and CETL to link fundamental and applied work as well as having a dedicated match analysis suite (16 workstations) in the CETL. The FEx also have extensive access to training and science facilities at a range of football clubs (Liverpool, Manchester United) as well as at St. George's Park (FA) in order to collect specific training and match play data.

**e. Collaboration or contribution to the discipline or research base**

As previously noted, RISES staff collaborate locally, nationally and around the globe with academic and industrial partners to provide world-leading knowledge and impact. Examples of significant research programmes already noted and that feature important national and global collaborations are; **1)** the EUFP7 projects CAREMI (2008-2012; £524K; 11 partners) and EndoStem (2010-2013; £212; 16 partners) pursuing world leading research in cardiac stem cell biology; **2)** EUFP7 capacity building project AFRESH (2010-2013; £155K; 8 Regions; 16 Partners) creating strategic partnerships and activities in exercise, physical activity and diet; **3)** KTP projects building industrial relationships and impact under the auspices of the Football Exchange (partner-Prozone Ltd; 2012-present; £146K) and the Physical Activity Exchange (partner-destination Youth; 2010-present; £142K); **4)** long-term collaborative partnerships with local government and health agencies (with Liverpool City Council - 1996-2012, SportsLinx, £1.4M; 2006-2013, GOALS, £631K) to develop interventions that change policy relating to health inequalities in Liverpool Schoolchildren; **5)**

comprehensive partnerships within elite football clubs and Associations (2008-present; Liverpool; Manchester United; Everton; £468K) where the generation of new research knowledge in relation to fitness, training, nutrition and visual training provide both empirical data to push forward scientific boundaries as well as a joint "academia-industry" approach to problem solving for the football industry.

Staff and research groups produce shared outputs with scientists from all five continents, and collaborative grant activity has occurred in multiple European countries as well as USA, Canada, South Africa, Australia, New Zealand, China, Saudi Arabia and Qatar. The global recognition of RISES staff and their activity is apparent in various academic formats; **a)** international peer-review journal editorial roles (24 RISES staff have undertaken 53 Journal editorial roles between 2008 and 2013), **b)** invited international conference keynote talks (38 RISES staff have completed 180 Keynote and Invited conference presentations), **c)** home and international requests for grant reviewing (30 RISES staff have completed 85 requests) and **d)** multiple national and international PhD examinations and other academic activity.

Fifty RISES staff have completed 150+ professional service roles including peer-review journal paper scrutiny, professional group support (BASES workshop delivery and accreditation, UKAD steering group member, ECSS Scientific Board Chair, President-Elect of ECSS, Past-President North American Society for the Psychology of Sport, Dean of the Institute of Sport and Exercise Medicine, Secretary to the World Commission of Sport Sciences), and individual secondments/consultancies and contracts with industry (Nike, Everton FC, Liverpool FC, Manchester United FC, Munster RUFC, the FA, Prozone, Qualsys). RISES staff have been recognised for a range of individual and groups awards between 2008-2013 that include; Young Investigator Awards at the European College of Sport Science and other conference (BASES, Physiological Society, Paediatric Work Physiology, UK Endocrine Society) a WellChild Trust Research Award (2010; Dr. Gabor Barton), the Louis Bonduelle Award for Research Against Childhood Obesity from the European Childhood Obesity Group (2011; SportsLinx project; Physical Activity Exchange), the President's Medal from the Human Factors and Ergonomics Society (2008; RISES Chronobiology Research), Silver Podium Award (2012; Exceptional Research Contribution for work with the British Shooting Team prior to London 2012; Dr. Joe Causer), Get Set Award (2012; Inspiring Outstanding Learning via the Face-2-Face with Sport Science programme; Dr. Zoe Knowles), RARE Champions of Hope Award for Collaboration in Science (2013; The Global Genes Project; Professor Jonathan Jarvis), the Suden/Hellbrandt Professional Opportunity Award (2008; the American Physiological Society; Dr. David Low), as well as the bestowing of various Fellowships (e.g. BASES, ECSS, University Fellowships).

In 2008 RISES hosted the 1st World Congress on Science and Soccer (300 delegates from 14 countries) to showcase football research and integrate the science within the football industry. In 2011 we organised and hosted the 16th ECSS congress with 2000 delegates from 44 countries), the largest sport science conference in the World. We also simultaneously hosted satellite symposia in football, physical activity and cardiovascular topics. In 2012, RISES co-organised the ICSEMIS conference that was endorsed by the IOC. In 2013 we hosted a pan-European conference on physical activity, diet and health under the auspices of the AFRESH initiative to promote translation of basic science and inform European health policy. RISES host and deliver a number of technical and skill-based training courses including a summer school programme in "Ultrasound Applications in the Sport and Exercise Sciences". To date this has provided practical and theoretical support to over 200 cardiovascular scientists from 20+ countries and in 2010 this course was run in Canada at the request of the University of British Columbia. Other CPD courses are delivered in conjunction with Prozone Ltd, delivering state-of-the-art training in performance and match analysis, as well as with Qualsys Ltd in developing high quality biomechanical skills.

The research philosophy of RISES has produced a vibrant and dynamic research culture that is enthused by an empowered team of people working in a world-class environment. This combination of people, infrastructure and leadership has produced significant individual and group successes whose impact is felt within and beyond academia.