

<p>Institution: The University of Leeds</p>
<p>Unit of Assessment: UoA26 Sport and Exercise Sciences, Leisure and Tourism</p>
<p>a. Overview</p> <p>Sport and Exercise Sciences (SES) is located within the School of Biomedical Sciences, Faculty of Biological Sciences (FBS). With a strategic focus on exercise, health and rehabilitation, SES includes interdisciplinary researchers who are affiliated to one of two groups: Cardiovascular and Exercise Physiology (CEP), or Motor Control and Exercise Psychology (MCEP). In 2012, SES relocated to purpose-built facilities adjacent to the Leeds General Infirmary (LGI), the Leeds Institute of Genetics Health and Therapeutics (LIGHT), and the University Sports Centre. This improved patient access, promoted cross faculty collaborations and provided new facilities, including 2 movement analysis laboratories, 3 exercise physiology laboratories, and an environmental chamber. Combined with 7 appointments since 2008, strategic investment in this state-of-the-art environment (>£2M) ensures effective cross fertilisation between core SES research and cognate areas of expertise, including physiology, neuroscience and medicine.</p> <p>The overarching aim of SES research is to better understand the relationships between physical activity patterns, health, and predisposition to chronic conditions including vascular, cardiac and pulmonary diseases, diabetes and cancer. This extends from translational cell-to-system research, to the amelioration of the consequences of physical inactivity or the rehabilitation of patients. During the REF period, SES were involved in grants awarded to the value of £7.2M and increased research income considerably (£4.6M), published >200 research articles and received >2,500 article citations.</p>
<p>b. Research strategy</p> <p>i) Meeting national and international priorities in SES research</p> <p>National and international concerns regarding the role of inactivity and ageing in the development of chronic diseases underpin the group's research strategy to improve health and promote healthy ageing, via a better understanding of physiological responses and limitations to exercise, exercise-based rehabilitation, and exercise adherence. Members of SES form a buoyant, collegiate team linked by common interests in research with the following aims:</p> <ol style="list-style-type: none"> 1: To integrate basic and applied research to elucidate the role of exercise in health, disease and rehabilitation 2: To improve understanding of the integrated systems biology of exercise, from youth to senescence, in health, disease or injury, where exercise tolerance or movement is limited <p>The first report on the robustness and translation of SES in the UK from the House of Lords Science and Technology Select Committee (<i>Sport and exercise science and medicine: building on the Olympic legacy to improve the nation's health</i>, 2012) highlighted the ability for “research by sports and exercise scientists to benefit health” and the need to “inform development of new interventions based on knowledge of physiological responses”. Equally, the World Health Organisation stresses the importance of exercise and activity in all ages for prevention and treatment, especially in obesity and heart disease. The Leeds SES research strategy – developed in 2008 – is in direct accordance with these views, and aims to provide sustainable delivery of high-quality translational research outcomes that are built on a foundation of basic science, research in physiology, neuroscience and medicine.</p> <p>ii) Research development strategy</p> <p>To achieve these aims, SES has markedly increased its world-class research activity, and the number of research outputs and citations. This was achieved via a strategy which promotes a vibrant research culture by:</p> <ul style="list-style-type: none"> • Facilitating external funding success through a grant development forum, internal peer review, dissemination of successful applications, and active mentoring <ul style="list-style-type: none"> - Research income has increased from £1.0M to £4.6M (see REF4b) in the REF period • Stimulating University-wide engagement in cross-cutting, interdisciplinary, research via seminars, meetings, journal clubs and road shows, with Medicine, Engineering, Psychology, and the Leeds Teaching Hospitals Trust (LTHT) <ul style="list-style-type: none"> - 10 out of 48 grants awarded in the REF period were interdisciplinary or cross-faculty • Building research capacity through new appointments and external collaborations <ul style="list-style-type: none"> - There were 7 new SES appointments during the REF period - A BBSRC-supported conference in Leeds in 2012 drew delegates from 12 countries

Environment template (REF5)

- Collaborative grants with institutions in UK, USA, France, and Japan (Dr Harry Rossiter, Dr Andrea Utley, Dr Olivier Bernus, Professor Ed White)
- Providing a nurturing environment for new appointees by protecting teaching requirements in early years, providing financial support for grant development, active mentoring by successful researchers, and supporting postgraduate and postdoctoral research students
 - 6 out of 48 grants awarded in the REF period were to new investigators
- Increase translation of research findings through knowledge transfer activities to stakeholders and end users, and through public engagement
 - SES members are increasingly active in international professional scientific organisations addressing exercise and health

These activities have enhanced the research culture within SES and facilitated translational links, allowing the group to deliver a distinctive combination of systems-based research with cellular and molecular biological sciences. This strategy has significantly improved delivery of our research aims via two research groups:

iii) Research groups

The Research Leader (Professor Stuart Egginton) is a new position to support the SES research strategy and provide strategic leadership. The Research Leader represents SES interests on the School Management Committee and the Faculty Research and Innovation Committee.

Group 1 - Cardiovascular and Exercise Physiology (CEP), 8.5 FTE: Leader, Professor Ed White (EW). Group members: Dr Graham Askew (GA), Dr Alan Benson (AB), Dr Olivier Bernus (OB), Dr Karen Birch (KB), Dr Sarah Calaghan (SCa), Professor Stuart Egginton (SE), Dr Carrie Ferguson (CF), Dr Harry Rossiter (HR), Professor Derek Steele (DS), Dr Klaus Witte (KW). The SES research development strategy led to the rapid expansion of SES-focused physiological research (GA,AB,OB,SCa,SE,CF,DS,KW), and to development of the major new CEP research theme. In addition, the promotion of senior returnees (Reader (KB); Associate Professor (GA,SCa)) and appointment of a new University Leadership Chair (SE) recognizes the research excellence of the group and strategic investment in CEP.

The strategic vision is for a cell-to-system approach to provide increased knowledge of (a) the systemic and molecular mechanisms supporting and limiting physical activity, and (b) the development of exercise-based interventional strategies for improving physical function, activities-of-daily-living, and quality-of-life. To achieve this, CEP brings together expertise on molecular, cellular, organ, *in vivo* animal, human and patient based methodologies to study acute and chronic exercise responses. Within this, the focus is on cardiovascular risk, heart failure, and limited oxygen delivery, which aligns well with national and international priorities for amelioration of chronic disease through physical activity (e.g. House of Lords Science and Technology Select Committee; UK and US Departments of Health; World Health Organisation). As such, CEP has been successful in attracting research funding from research councils and major charities (MRC, NIHR, BBSRC, BHF, EPSRC, Wellcome Trust). CEP has expertise and facilities to study mitochondrial function *in situ* (see outputs [HR:1,4]), single muscle fibre biomechanics and energetics [GA:2-4, HR:3], muscle cell Ca²⁺ dynamics using confocal imaging [DS:1-4, EW:2, OB:1], sarcoplasmic reticulum function using mechanical skinning of animal and human muscle fibres [DS:3], and the regulation of skeletal muscle vascularity and angiogenesis [SE:1-4]. In animals we study myocardial function *in vivo* using telemetry and echocardiography [EW:2], and have established optical imaging of electrical activity in the perfused heart [OB:1-4, EW:2,3]. Complementary approaches allow isolated skeletal muscle functional and adaptive responses to be assessed [HR:1; SE:1], and are strongly supported by computational biology [OB:1-4, AB:1]. In the past 5 years the group has also developed and characterised a monocrotaline model of right heart failure [EW:2,3], an aortic banding model of left heart failure (SCa,DS), cold-induced cardiac hypertrophy (SE) and a model of voluntary exercise induced cardiac hypertrophy in rats [EW:1,4]. Our human research continues to be internationally leading in non-invasive techniques for analysis of exercise response dynamics in health and disease [KB:2,3, CF:1-4, HR:4, KW:3] and imaging assessments of cardiac and cardiovascular function and reactivity in athletes and high-risk patient groups [KB:2, KW:1,4].

The development of strong interdisciplinary and clinical links is evidenced by outputs with greater

translational relevance. Examples of this include: (i) human exercise-induced circulating progenitor cell mobilization is nitric oxide oxide-dependent and is blunted in south Asian men [KB:1]; (ii) overload-induced angiogenesis is primarily a mechanical response, and graded according to stimulus intensity [SE:1]; (iii) exercise-induced hypertrophy occurs to a greater extent in the left ventricle than in total lean body mass after correcting for uneven growth rates (KB); (iv) the intramuscular contribution to the slowed dynamics of oxidative energy transfer during exercise in chronic heart failure is related to the severity of the condition (HR); (v) cardiac output does not limit submaximal exercise capacity in patients with chronic heart failure [KW:2]. This work has been facilitated by major awards from the British Heart Foundation (BHF:KB,OB,SCa,SE,DS,EW), the MRC (OB,SCa,HR,DS,EW,KW), BBSRC (GA,OB,HR), the Wellcome Trust (DS), NIHR (KB,SB,HR) and the Dunhill Medical Trust (KB). Notably, this includes the recent award of a 5-year BHF Programme Grant to study β -adrenergic dysfunction in heart failure (DS,SCa) and a Wellcome Trust Equipment grant providing state-of-the-art high speed confocal imaging facilities and nanometre resolution topographical imaging of skeletal and cardiac muscle (scanning ion conductance microscopy, DS).

CEP has hosted prestigious personal research awards (3 MRC, 1 ORSAS), and a total of 42 international visiting researchers (from USA, Netherlands, Belgium, Italy, Switzerland, France, Finland, Brazil, Canada, Japan, and Australia). Strong collaborative links form a major part of the CEP strategy to produce internationally leading research. During the REF period, funded links (BBSRC, British Council, Physiological Society, American Physiological Society) with a total of 25 international institutions contributed to outputs from the CEP group.

Research highlights from the CEP research group include:

1. The first observation that voluntary exercise reduces the β_2 -adrenergic responsiveness of the heart, an effect opposite to that seen in heart failure [EW:4]
2. A major international collaboration showing that the class 1c antiarrhythmic agent flecainide can prevent a form of inherited exercise-induced arrhythmia *via* a novel mechanism of action on the type-2 ryanodine receptor [DS:2]
3. Evidence that caveolar invaginations of the sarcolemma compartmentalize the β -adrenergic second messenger cAMP in adult cardiac myocytes [SCa:1]
4. The first demonstration that osmotic stress of skeletal muscle (a common outcome of exercise) leads to major alterations in subcellular Ca^{2+} signalling [DS:4]
5. The first demonstration of allosteric control of skeletal muscle O_2 consumption *in situ* [HR:1]
6. Identification of pro-arrhythmic mechanisms associated with monocrotaline-induced right heart failure [EW:2,3]
7. First-in-human demonstration of the nitric oxide dependence of exercise-induced endothelial progenitor cell mobilisation [KB:1]
8. Mechanotransduction through CD31 plays a role in the shear-stress related sensitivity of some genes and in neutrophil recruitment, providing novel therapeutic targets for the manipulation of angiogenesis or inflammation [SE:4]
9. The first demonstration that environmental levels of carbon monoxide are proarrhythmic, particularly when there is increased β -adrenergic drive to the heart during activity. Activation of the late sodium current and a novel therapeutic approach were identified [DS:1]

Group 2 - Motor Control and Exercise Psychology (MCEP), 4.0 FTE: Leader, Dr Ronaldo Ichiyama (RI). Group members: Dr Shaunna Burke (SB), Dr Samit Chakrabarty (SCh), Dr Andrea Utley (AU). A targeted investment in MCEP has led to the recruitment of two new early-career staff (SB, SCh), and created one of the only centres in the UK housing a critical mass of staff with interdisciplinary expertise in the psychology and neuroscience of motor control. This is specifically aligned to research in rehabilitation and clinical populations. In addition, the promotion of senior returnees (Reader (AU); Associate Professor (RI)) recognizes the research excellence and strategic investment in MCEP.

The strategic vision is to bring this critical mass of research expertise together with local health delivery (Leeds General Infirmary; Chapel Allerton Hospital; Pinderfields Hospital) in order to improve understanding of the control of movement following injury, disease, trauma and aetiologies affecting movement. The ultimate goal of this research is to improve rehabilitation outcomes and

maximise functional recovery. To achieve these objectives MCEP use a diverse range of approaches for mechanistic investigation of, and to develop new treatment strategies for, motor dysfunction in cerebral palsy, developmental coordination disorder (DCD), and spinal cord injuries. Psychological and behavioural approaches are embedded in MCEP research, extending to the psychological benefits of exercise for cancer patients and survivors. The approaches used by MCEP span cellular physiology and morphology, to whole organism behaviours, and psychological interviews. Facilities and equipment are now in place to study three-dimensional control of movement using surface (AU,RI) and indwelling [RI:1-4] electromyography. Central nervous system physiology, morphology, and pharmacology [RI:1-4, SCh:1-4] is assessed in humans and animals with a range of neurological disorders. The group also applies these approaches to investigate the use of robotic devices to aid recovery of motor function (RI), and clinical populations [SB:2].

The MCEP group has significantly increased its extramural funding to support research activities from The International Spinal Research Trust (RI), Royal Society (RI), International Foundation for Research in Paraplegia (RI), Craig Neilsen Foundation (SCh), The White Rose Health Innovation Partnership (AU), Action Medical Research (AU), NIHR (SB,HR), and Alexander Hospital Foundation (SB,AU). Examples of major new findings stemming from these awards include: (i) demonstration of interfering effects of combining anti-Nogo-A antibody and locomotor training after an incomplete spinal cord injury [RI:1]; (ii) the use of sound during exercise to assist development of children with and without movement disorders [AU:4]; and (iii) the use of motor behaviour during an early critical period to restore skilled movement after corticospinal damage [SCh:1]

Research highlights from the MCEP research group include:

1. The development of a combined electrical stimulation, pharmacological and exercise training intervention to recover locomotion after severe spinal cord injury published in *Nature Neuroscience* [RI:1] [impact case study 1]
2. Identification of key elements in control of bimanual coordination in children with DCD [AU:2]
3. Contributions to understanding of key neurodevelopmental mechanisms associated with control of arm movement [SCh:3]
4. The first demonstration that two independently positive strategies on functional recovery (locomotor training and anti-Nogo-A antibody) have detrimental effects when delivered simultaneously [RI:2]
5. The first demonstration that segmental corticospinal tract development regulates ontogenic motor function controlled by corticospinal tract [SCh:2]
6. The consensus statement for the definition of DCD (AU) [impact case study 2]
7. The role of exercise in reducing pain in breast cancer survivors and its link to mental health was first explored by the group [SB:3]

iv) Sustainability of SES research

The SES research development strategy is embedded with aims to ensure sustainability. The ever-increasing awareness of the therapeutic benefits of physical activity, coupled with the Olympic legacy in the UK, make SES ideally placed to enhance delivery of exercise-related research for health benefit. In so doing SES maximizes protection of its members against funding challenges, by building on current successes in securing NIHR, RCUK, and BHF funding. SES aims to develop these strengths, with strategic direction provided by the Research Leader and members holding positions on national and international, governmental and non-governmental advisory panels. For example, GA and HR are members of BBSRC research committees, and SE is a panel member for the Danish Council for Independent Research, Medical Sciences. Also, HR is a member of the European Respiratory Society's Task Force for *Exercise as an Outcome for Therapeutic Interventions*. This Task Force contributes to setting international standards for the testing of pharmaceutical and device interventions using exercise, and therefore engages industry to increase use of physiological, neurological and psychological responses to exercise. It is expected that this will be an area for further development given that Leeds SES has well-established links between clinical and exercise sciences (KB,SCa,CF,SE,DS,KW).

c. People, including:

i. Staffing strategy and staff development

The SES Research Group has fully embraced University facilities and policies that provide support

to staff. This includes the provision of a supportive and professional working environment, through embedded practices supporting equality, diversity, protected characteristics, disabilities and flexible working. The University strongly supports the development of women's careers in Science, Technology, Engineering, and Mathematical disciplines as recognized by an Athena SWAN Bronze award. At the heart of staff development is the Staff Review and Development Scheme (SRDS). SRDS helps staff achieve their full potential through the 2-way review of progress, identification of key objectives, constructive feedback, recognition of success, support for improvement and the identification of development needs. In addition, the Staff and Departmental Development Unit (SDDU) provide training and development services including courses on mentoring, attracting research income, applying for funding, partnership with industry, leadership, commercialisation, and the University's 'Next Generation Researcher' programme. In December 2010, Leeds was awarded the HR Excellence in Research Award by the European Commission in recognition of commitment to good working conditions and career development for researchers. The University is fully supportive of The Concordat to Support the career development of researchers and has an established policy to implement this approach. Within Faculties there are research training and development 'Hubs' whose remit is the development of skills training activities for researchers, including those on fixed term contracts.

Each school has an academic and financial plan agreed with the central University and reviewed on an annual basis. This takes into account staff recruitment and alignment to research and teaching. All new appointments of full-time SES staff during the REF period are research-active and fulfil the strategic aim to expand inter-disciplinary research. These appointments, in both CEP and MCEP research areas, ensure critical mass for delivery of internationally-leading translational exercise research and enhance the quality of the SES research environment and outputs. A new professorial appointment (SE), made as part of the University's 'academic leadership recruitment scheme', provides strategic leadership within SES and support to recently appointed staff. SES is a collaborative and collegiate team that provides an attractive and fertile environment for current and future staff. Weekly research group meetings for data dissemination and the development of research plans have engendered a nurturing research culture, with interdisciplinarity at its core. The active peer-review system within SES offers feedback on grant development, and promotes good practice in research for staff at all levels. New staff are assigned a mentor in their research area who advises on grant writing and assists in development of a strategic plan. The mentor also works with the Head of School to monitor attainment. New staff have a reduction in teaching and administration to ~1/3 of the average. Regular individual and research group meetings on a monthly basis support these activities.

ii. Research students

Postgraduate research training is managed through the Faculty Graduate School, via the Director of the Graduate School and the Graduate School Committee. Elected postgraduate representatives sit on the School Graduate Committee, and periodic anonymous questionnaires provide an additional route for student feedback. FBS follows the University Code of Practice on Research Student supervision and training, and the Faculty Graduate School ensures that all students receive appropriate and consistent induction, training, assessment and supervision. The Faculty is committed to the principles of the Researcher Development Framework, 2010.

Postgraduate students (MSc by research, and PhD) are embedded within research themes where they have daily interactions with other postgraduates, post-doctoral fellows, technical and academic staff. A large purpose-designed research office provides work and computing space for 24 postgraduates and post-doctoral researchers. Table 1 demonstrates that PhD student enrolment throughout the REF period maximises the current capacity in SES; an expansion of which has begun, with 18.17 FTE enrolled in 2013/14. This open and cross-discipline facility has helped to develop a nurturing and collegiate work environment for students transitioning from undergraduate to those preparing to compete for faculty appointments. All postgraduates have a primary supervisor responsible for the research, a co-supervisor who also has academic input, an advisor, and an independent assessor, who meet formally with the student to review progress at defined time points. Formal meetings include evaluation of a grant proposal or literature review in the first 4 months, the transfer viva within the first year (examined by written report and *viva voce*),

Environment template (REF5)

a manuscript in publication format and thesis plan at the end of the second year. This process has produced effective development for postgraduate researchers with 40 of over 200 SES outputs in the REF period being co-authored by a postgraduate researcher (45% as first author). All PhD students complete at least 30 days of transferable-skills training. A wide range of opportunities for subject specific research skills, career skills, and enterprise and innovation skills is offered, to support the management of the research project, professional development, and to enhance employability. External conference presentations are an expectation, and the Faculty Postgraduate Symposium, which attracts over 250 staff and postgraduates, provides preparation for this. At the symposium second year students present posters and final year students give talks. SES research students made over 40 presentations at national and international conferences during the REF period. The SES peer review process extends to students to improve publication and external funding application rates.

Table 1 - SES postgraduate PhD student enrolment by year (FTE, HESA statistics)

	2008/9	2009/10	2010/11	2011/12	2012/13	Total
CEP	4.75	4.80	6.37	4.75	7.49	28.16
MCEP	2.21	1.53	2.28	1.34	3.29	10.65
Total	6.96	6.33	8.65	6.09	10.78	38.81

These processes and support structures have benefited SES PhD and post-doctoral researchers entering academic careers, with 40% securing post-doctoral or faculty appointments, far exceeding national averages. SES students have received international awards for their research (Physiological Society, American College of Sports Medicine), and secured faculty appointments in the UK and USA, or prestigious international posts or fellowships (e.g. Brown University USA, Vrije University, Netherlands), and a Personal Fellowship (Humboldt Foundation Germany).

d. Income, infrastructure and facilities

i) Income - SES research benefited from 48 successful funding applications exceeding £7M in the REF period. Research income of £4.6M in the period represents a 360% increase since RAE08: 58% of this research income came from Research Councils (e.g. BBSRC, ESRC, MRC), 36% from charities (e.g. Wellcome Trust, BHF), and 6% from other sources. Support for research grant applications and the management of existing awards is provided through the Faculty Research Office, and the University Research and Innovation Service.

ii) Infrastructure - The Faculty has recently concentrated its research activities in the Astbury, Garstang, Miall, and Manton buildings. These facilities are in close proximity containing laboratory and office space that enables and promotes collaborations and facility sharing. These buildings are physically adjacent to: 1) Leeds Institute of Genetics Health and Therapeutics providing state of the art laboratory facilities focusing on laboratory, clinical and applied biomedical research into common chronic disorders and non-communicable disease; 2) Leeds General Infirmary – providing unparalleled access to patients and clinical expertise; 3) the newly-developed University Sports Centre. We have excellent central library and IT facilities with SES holdings including electronic access to a wide range of journals.

iii) Facilities - The Faculty maintains one of the largest life-sciences focused research infrastructures, providing an unparalleled environment for research from molecular to organismal behaviour. These facilities enhance the ability to translate basic sciences research to human and patient benefit. Facilities specifically used by SES include: **Bio-imaging**, which comprises five **TEM** and **SEM electron microscopes**, 8 **confocal** imaging systems (including fast spinning disk and swept field modalities), a 'Delta Vision' widefield **deconvolution** microscope, a **phase contrast** imaging system combined with **microinjection**; a **scanning ion conductance microscope (SCIM)**, which allows super resolution (~10nm) topographical scanning of live cells. The **Human Performance** facility, which comprises an **environment chamber**, 2 Kistler **force plates**, 2 x **3D motion analysis** systems (10 and 13 camera systems), **electromyography**, automated **eye tracking** equipment, **cardiopulmonary exercise testing** with breath-by-breath determination of gas exchange and ventilation, **near-infrared spectroscopy** for tissue oxygenation, blood gas, electrolyte and acid-base **blood analysis**, a range of blood lactate analysis equipment, **Doppler ultrasound**, a range of **ergometry** equipment including 3 Lode Excalibur Sport electromagnetically-braked cycle ergometers, **Biodex and Lode** isokinetic dynamometry systems, recumbent ergometry, and arm cranking dynamometry. Many of these new facilities were supported by grant awards within the REF period (HR,KB,RI,AU,DS). The University

has two state of the art animal units for use by FBS researchers. One unit completed in 2008 (£9M) is a high-health status mouse-only facility, the other unit, completed in 2012 (£5M), is a multi-species facility. Each unit has highly equipped surgical suites, rooms for behavioural analyses and Category II work, underpinning aspects of SES research that involve *in vivo* models of exercise, heart failure, diabetes, spinal cord injury, and related cellular studies.

e. Collaboration or contribution to the discipline or research base

i) Collaboration

The SES group has a wide range of national and international collaborations reflecting our position within the wider research community. Examples include: (i) NIHR-funded project with the University of Southampton (HR,SB) to determine the role of exercise training to improve surgical and oncological outcomes in lower gastrointestinal cancer; (ii) peripheral consequences of heart failure and chronic obstructive pulmonary disease, with Aberdeen and Liverpool (SE); (iii) investigating coupling in cerebral palsy with the University of Nijmegen The Netherlands (AU); (iv) recovery of control of locomotion after spinal cord injury with the University of California Los Angeles USA (RI); (v) mechanisms of arrhythmia during low level carbon monoxide exposure (e.g. due to traffic pollution), with the University of Montpellier, France (DS); (vi) identification of a novel drug mechanism to treat a form of inherited exercise-induced arrhythmia with the Universities of Vanderbilt, USA and Newcastle, Australia (DS); (vii) a project with the University of Nevada, USA (SCa) to study compartmentalization of the second messenger cAMP during the physiological β -adrenergic response of the heart to exercise or stress; (viii) the role of exercise in cancer survivors with McGill University, Canada (SB); (ix) the role of perineuronal nets on activity-dependent plasticity after spinal cord injury, University of Cambridge (RI); (x) combinatorial interventions for recovery of function after spinal cord injury with Swiss Institute of Technology (ETH), Zurich, Switzerland (RI); and (xi) the role of mechanical forces in generating therapeutic angiogenesis with the Institute of Sports Medicine, Copenhagen (SE). SES holds BBSRC-grants in collaboration with the University of Liverpool to make use of the facilities and expertise of the Magnetic Resonance and Image Analysis Research Centre (MARIARC). SES members (SB,HR) are part of the *Fitness for Surgery* consortium, a UK-wide research group translating University-based research into NHS practice. Also SES (RI, AU) currently works with the Yorkshire Regional Spinal Injuries Centre at the NHS Trust at Pinderfields Hospital with direct exchange with consultants, occupational and physical therapists. DS and SCa have a BHF Programme Grant, with collaborators in Bern, Switzerland and Nevada, USA.

ii) Contribution to the discipline

Members of the group make a range of contributions to the discipline and the research base. This includes reviewing for broad-scope and discipline-specific national and international journals. SES members act on editorial boards including: Journal of Applied Physiology (HR); Experimental Physiology (SE); European Journal of Applied Physiology (HR); Frontiers in Exercise Physiology (RI,HR,GA,AU); Microcirculation (SE); Adapted Physical Activity Quarterly (AU); Journal of Molecular and Cellular Cardiology (SCa); Frontiers in Skeletal Muscle Physiology (DS); Frontiers in Vascular Physiology (SE); Frontiers in Integrative Physiology (SE). SES members review grants for a range of national and international funding agencies including BBSRC, NIHR, MRC, Action Research, Wellcome Trust, BHF, National Institute for Social Care and Health Research Wales, Research Foundation Flanders Belgium, Association Francaise Contre les Myopathies France, Natural Sciences and Engineering Research Council of Canada, and NIH USA. SE was a member of the Council of the Physiological Society, and is the current president of the British Microcirculation Society. SES staff also act on expert panels including: BBSRC (HR,GA), NIHR (KB,AU,SA), Stroke Association (AU), Action Medical Research (AU), Heart Research UK (SCa), BHF (SCa). We provide expert advice for a number of organisations such as the GB Athletes with learning difficulties, Football Association, American College of Sports Medicine, Council of Europe, Cyclists Fighting Cancer (AU, SB) and the European Respiratory Society. SES members are active in professional scientific organisations such as the International Society for Motor Control, National Association Sport Physical Education, and the Physiological Society, as well as maintaining a wide range of knowledge transfer activities, such as with Yorkshire Water, NHS, Novartis, White Rose Health, and New York Institute of Technology. Specific highlights include the delivery of workshops for the European Union, The Council of Europe, and the UK Sports Council on pedagogy for learning motor skills (AU).