Institution: University of Bristol
Unit of Assessment: 24: Sport, Exercise Sciences, Leisure and Tourism
1. Unit context and structure, research and impact strategy

1.1 Overview

The Centre for Exercise, Nutrition and Health Sciences (ENHS) comprises the UoA24 submission within the University of Bristol. ENHS is a vibrant and dynamic research group which focuses on conducting innovative and methodologically robust research to both advance scientific understanding and inform changes in clinical and public health policy in relation to physical activity, nutrition, sedentary and eating behaviour. A unique aspect of our work has been to combine physical activity and nutrition research to identify the dual impact of changing both physical activity and nutrition behaviours on health outcomes. We are located within the School for Policy Studies at the University of Bristol, which provides a culture and ethos that supports our strategic aim of conducting research to impact on health policy and improve health in clinical and public health settings across the lifespan. An example of how we have impacted on policy is our leadership of the Chief Medical Officers' physical activity guidelines in 2019. This work was informed by our research and is an example of how our setting within a policy-focused school enables us to translate our research into policy and practice (see impact case study for details).

The Centre has been led by members of this submission since 2012 (Cooper 2012 - 2015; Jago 2016 - 2019; and Foster 2019 - present). We are a highly collaborative team who draw on the unique strengths of each member to conduct innovative research, evidenced by our shared authorship of papers and collaboration on research grants. Members of staff within the Centre have made major contributions to the running of the School via leadership roles, such as Impact Director (Jago/Page), Postgraduate Research Director (Foster/Papadaki), Research Director (Page), and Section Head (Jago), and have therefore been able to forge relationships with other areas of the School for Policy Studies (UoA20) to address policy-relevant research questions. We have also made major contributions to leading streams of work with National Institute of Health Research (NIHR) funding infrastructure at Bristol. For example, Cooper's leadership of the sedentary behaviour and diabetes theme within the NIHR Biomedical Research Unit in Nutrition, Diet and Lifestyle (2012 to 2017) and Jago's leadership of Public Health research within NIHR Applied Research Centre West (2019 – Present) and its successor CLAHRC West (2017-2019). Our staff size has remained broadly consistent across the last three REF cycles with an increase from 7.0 to 9.4FTE staff from REF2014 to REF2021. This has been achieved with promotion and external recruitment ensuring an excellent seniority and gender balance of the Unit's profile. Further to the 9.4 REF eligible staff we have additional expertise and capacity from externally funded research staff and PGR students. A key feature of our work is collaboration with colleagues across the institution in computer science, engineering, public health, social sciences, and medicine, via University-wide strategic investments as outlined in our institutional environment statement (REF5a).

1.2 Achievements since REF 2014

Three strategic aims were outlined in REF2014: 1) developing the aetiological understanding of how physical activity, nutrition, sedentary and eating behaviour are associated with chronic disease; 2) understanding the factors that affect physical activity, nutrition, sedentary and eating behaviours; and 3) developing and evaluating complex interventions to change physical activity,

nutrition, and eating behaviours. Below we summarise our achievements against these aims.

1. Aetiology of chronic disease

We have advanced the understanding of how physical activity, nutrition, sedentary and eating behaviour are associated with health outcomes. For example, Armstrong used the Million Women Study to explore the association between physical activity among middle-aged women and vascular disease (Armstrong et al, Circulation, 2015). This study was based on data from over one million women followed for nine years and found that, overall, the lowest risks in vascular disease were observed among women undertaking moderate activity.

Our work is at the forefront of the field, and in terms of methodologies includes integrating traditional epidemiology with state-of-the art measurement approaches (metabolomics, continuous glucose monitoring, GPS mapping) and analysis (longitudinal modelling of within-person variation). A key focus of our work is understanding how diet and physical activity behaviours interact with each other in terms of their influences on health outcomes. For example, Johnson, Toumpakari and Papadaki have used the National Diet and Nutrition Survey to identify an obesogenic dietary pattern and explored how this pattern is associated with physical activity. Key findings, such as the top five food groups that are most likely to increase risk of obesity, informed the 2nd chapter of the UK Childhood Obesity Strategy via written and oral evidence. We also specialise in synthesising evidence across different behavioural domains, such as Johnson's work on the causal associations of saturated fat and coronary heart disease, which prompted a re-evaluation of the UK Government's Scientific Advisory Committee on Nutrition national guidelines in 2019.

2. Understanding physical activity, nutrition, and sedentary behaviour

Our work on understanding behaviours has centred around families and the exploration of novel research designs and analyses. We have been central in both the academic and policy arenas in arguing for an approach to help children be more physically active that recognises the critical importance of parents in child behaviours and vice versa. We established the B-Proact1V cohort of ~2,000 children and their parents who have been followed from Year 1 to Year 6 of primary school. This study is unique in providing key reference data on accelerometer-measured physical activity on children and parents during primary school in the UK. In addition, we led the collection of accelerometer measured physical activity data in international cohorts, such as 16,000 families in the Europe-wide I.Family study. These datasets have provided novel insights about how parents' influence on their children's behaviour is predominantly via support rather than co-participation.

We have enhanced the evidence base on the influence of sedentary behaviour and diet on health, particularly in clinical groups, where our work has facilitated a greater understanding of the consequences of sedentary time in adults with type 2 diabetes and described the role of the Mediterranean diet in heart failure incidence among adults. We have also extended methodological boundaries with innovative work using open-source, machine-learning methods to automatically identify travel mode from GPS data.

We have a strong track record of applying innovative analyses to understand complex associations. For example, we have used multilevel models to account for within-person meal-to-meal variation in food intake. We have broken new ground by applying latent class analysis to identify common physical activity motivation profiles amongst adults and explored how these are associated with physical activity (Emm-Collison et al, Psychology of Sport and Exercise, 2020).

A key strength of the Unit's research lies in our ability to apply methods from public health nutrition to the physical activity field and vice versa. As an example, we have applied methods typically used in dietary pattern analysis to physical activity data to identify patterns in the type, location, and timing of adolescent activity. This allowed us to identify common physical activity patterns that are linked to disease mechanisms and create a priority list of targets for intervention development.

3. Development and evaluation of complex interventions

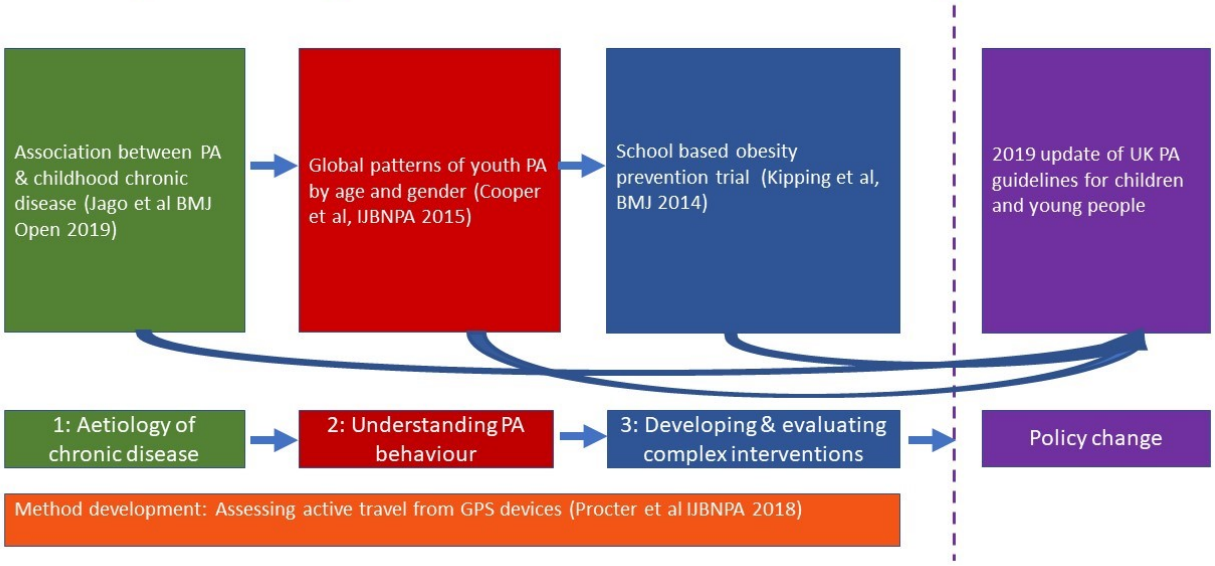
A major contribution of our work in this REF cycle has been the development and evaluation of complex interventions to change young people's physical activity. Examples include: i) the Action 3:30 studies, which examined the feasibility of training Teaching Assistants to deliver after-school physical activity (funded by Medical Research Council (MRC) and NIHR); ii) the Bristol Girls Dance Project, which evaluated after-school dance sessions for adolescent girls (NIHR); and iii) PLAN-A, which provided communication training to influential peers with the aim of increasing physical activity in Year 9 girls (NIHR). Li's work extends our contribution in this area by developing and evaluating a highly cost-effective obesity prevention programme in China (Li et al, Plos Medicine, 2019). Cooper and Page have led a programme of work within the NIHR Biomedical Research Unit in Nutrition, Diet and Lifestyle (to 2017), and its successor as a workstream within the Bristol Biomedical Research Unit to develop diet and physical activity interventions for clinical groups. A key product of this work has been interventions such as the use of e-bikes to increase physical activity for adults with diabetes, and the team are now extending this work to cancer survivors. We have also worked with colleagues in Population Health Sciences within Bristol Medical School (submitted to UoA2 in REF2021), to adapt the American Nutrition And Physical Activity Self-Assessment in ChildCare (NAPSACC) programme, which makes changes to the diet and physical activity policies in nurseries, for use in UK settings via two NIHR grants.

Our expertise in GPS and accelerometry has been used within innovative multi-site interventions that have been evaluated in: i) schools, where children were taught to use the technology to foster greater use of the physical environment; ii) worksites, involving peer-led schemes to increase walking to work; and iii) flagship natural experiments, such as the ENABLE London study, which explored the impact on physical activity of moving to a more walkable environment. Use of this technology has been extended to novel interventions for clinical groups. For example, our work to overcome barriers to physical activity faced by people with type 2 diabetes by using e-bikes achieved substantial improvements in cardiorespiratory health and reduced medication load in those cycling regularly.

Integration across strategic aims to improve population health and achieve impact

An essential feature of our work is the dynamic integration of findings across our three strategic aims. Figure 1 provides an example of how our strategic research aims are informed by, and build upon, each other to inform changes in national policy in relation to children's physical activity.

Figure 1: Integration of childhood PA across strategic aims

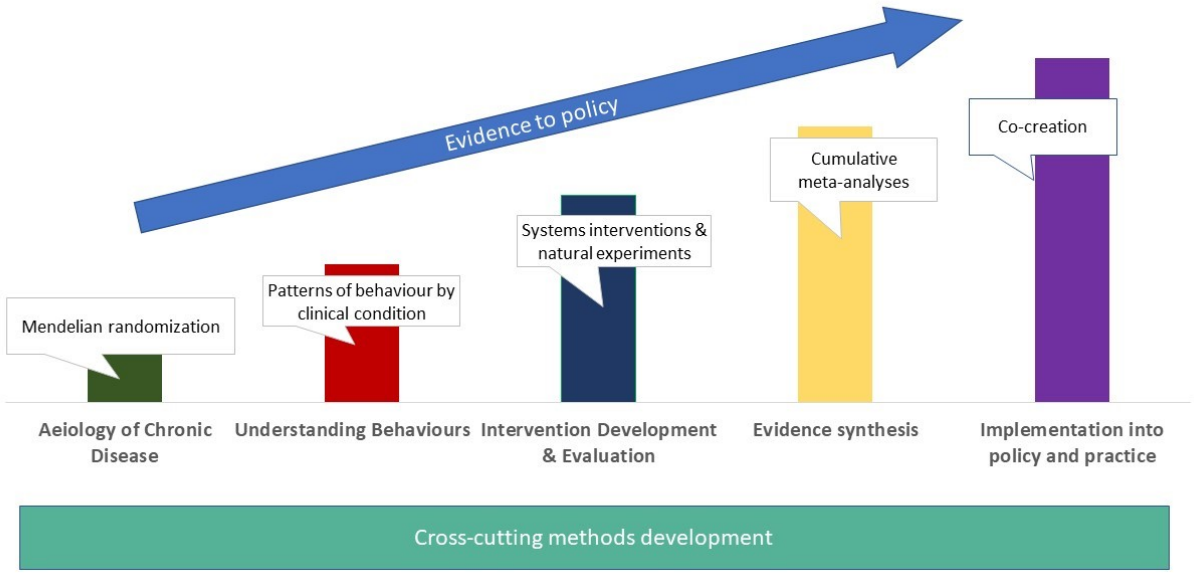


Aim 1 (green box) illustrates our work on chronic disease aetiology, investigating the links between the type and volume of physical activity with health in children. Aim 2 (red box) complements aim 1 to show how physical activity varies globally by age and gender. Aim 3 (blue) provides an example of a large cluster randomised trial to increase physical activity. Underpinning our work are methodological developments (Orange), such as pattern recognition of GPS data to automatically identify active travel. Collectively, our research directly changed policy via the UK physical activity guidelines (purple box), as shown in one of our impact case studies. We facilitate the integration of work across aims by sharing emerging research findings at our bi-weekly seminar meetings in which we focus on interpreting findings, identifying implications for future research and how we can translate evidence into practice. This iterative process enables us to learn and share as the work is conducted and is mindful that the process is not always linear and can be bi-directional with, for example, trials informing our understanding of behaviour and vice versa.

1.3 Future strategic aims

Our goal for the next REF cycle is to build on our academic success while also extending the reach and impact of our research. We will strengthen the impact of our work by further developing research on optimising implementation, thereby accelerating the translation of evidence into effective practice. Future work will encompass five areas (illustrated in Figure 2 and described below), which provide a broad structure for future research but can adapt to allow us to address new or policy relevant research questions as they arise.

Figure 2: Pathways of evidence to implementation



1. Aetiology of chronic disease

We will advance our understanding of how physical activity, nutrition, sedentary and eating behaviours are associated with the development of non-communicable diseases, with a focus on causal factors that could be targets of specific interventions. In collaboration with our colleagues in the University of Bristol MRC-funded Integrative Epidemiology Unit (IEU) – submitted to UoA2 in REF2021 – we will apply Mendelian Randomisation and cross-context comparisons to longitudinal datasets to understand the causal pathways from behaviour to disease.

2. Understanding physical activity, nutrition, and sedentary behaviour

We will apply advanced statistical analyses that extend standard techniques to understand complex patterns of behaviours, such as latent transition analyses, to dissect the determinants of behaviour change within individuals over time. We will utilise the latest technological advancements, such as passive data capture of diet and machine learning to identify physical activity behaviours. We will also adopt a systems lens to understand the processes and stakeholders that influence behaviours to identify key leverage points for intervention.

3. Development and evaluation of complex interventions

We will continue to translate our aetiological and behavioural research into the design and evaluation of complex interventions. This will include new group-level (e.g. school) and individual-level interventions (e.g. e-bikes for cancer survivors), as well as a novel focus on system-level interventions. We will conduct evaluations of policies via the use of natural experiments. Li will extend this work to low- and middle-income countries (LMICs).

4. Evidence synthesis

Inconsistencies in evidence are still a significant barrier to effective intervention and implementation, so evidence synthesis will remain a major component of our work. This will include conducting scoping reviews, systematic reviews, and meta-analyses to provide accurate summaries of the current evidence base. We will also embrace more advanced review methodologies, such as individual patient data analysis, cumulative meta-analysis, network meta-

analyses and triangulating evidence from diverse study designs.

5. Implementation – translating evidence into policy and practice to achieve impact

The implementation of our work into policy and practice is critical to improve public health. A central aim over the next REF cycle is therefore to reduce the time that it takes from the creation of evidence to the implementation of findings into policy. This will be achieved via advancing research into effective implementation as well as working with local, regional, national, and international stakeholders to translate evidence into policy and practice.

We will expand the scope and scale of our implementation work by extending our collaborations within and outside academia to co-create solutions to key challenges. This is an area where we aim to drive national and international impact by working with communities and both local and national governments to change behaviour. One example of how we will do this is by building on ongoing work evaluating the physical activity strategy for Gloucestershire County Council (Foster/Jago). In this project we are working in collaboration with the Council and our colleagues in NIHR Applied Research Collaboration (ARC) West to evaluate a whole-system approach to physical activity within the county. This work uses an embedded researcher to capture all the decisions that are being made in relation to physical activity. Internationally, Li leads an MRC-funded project to co-design systems-based interventions to reduce both under and over nutrition in 12 Southeast Asian countries with policy makers from diverse authorities (e.g., Environmental Protection/Climate Change, Transportation, Agriculture and City Planning). This systems-based approach will allow research and policy making to take place simultaneously in a co-creation process.

We will continue to draw on University-wide infrastructure, such as the Elizabeth Blackwell Institute for Health Research (EBI), to work collaboratively with colleagues from across the institution and local area to translate findings into policy. We will work closely with PolicyBristol, the University of Bristol's core funded dissemination and knowledge mobilisation team, to increase the frequency and reach of our policy briefings. We already have well-established collaborations with the Department of Health, Sport England, and Public Health England, but we will build on these networks to forge stronger collaborations with local, national, and international policy makers (e.g., the World Health Organization). We will achieve this by forming strategic alliances, via placements and advisory roles within these groups. We will hold an annual policy-focused event that brings together academics, policy makers and stakeholders.

Research integrity and open science

Research integrity is critical to our work. All staff undergo mandatory research integrity, data safety and ethics training. Our projects receive ethical review and are governed by the University's research governance procedures. We embrace open-science principles and have played a major role in this area by calling for the advancement of rigorous open science in publishing. For example, when Jago was Editor in Chief of International Journal of Behavioural Nutrition & Physical Activity (IJBNPA), he mandated the pre-registration of all trials and systematic reviews as well as stipulating the use of the CONSORT, PRISMA, STROBE and TIDIER reporting guidelines. He has also worked with the current editor to publicly call for a greater adoption of open-science principles for all work published in the journal. Similarly, Johnson was part of the Diet@Net consortium that developed best practice guidelines for dietary assessment to improve rigour and produced a website with validated data collection instruments https://www.nutritools.org/. We demonstrated leadership by providing code for our analyses, registering our trials on ISCTRN and

our review protocols on PROSPERO, and making our data publicly available. We have been supported in these efforts by the University's open data policy, which provides guidance and support on the responsibilities of the University and its staff in managing and preserving data. This includes the Research Data Storage Facility (RDSF), which provides long-term research data storage.

2. People

2.1 Staffing strategy

Our overall staffing strategy is to combine a core funded group of academic staff with a much larger group of externally funded research staff, collaboration with colleagues within the School for Policy Studies (UoA20), Bristol Medical School (UoA1 and 2) and large infrastructure investments across the University of Bristol. This strategic approach has enabled us to leverage specialist methodological expertise, thereby allowing us to sustain high impact interdisciplinary research.

The overall number of core funded REF-eligible staff members has increased since REF2014 (7.0 in 2014 to 9.4 in 2021). Prof Cooper reduced to 0.2 FTE in 2017 but remains actively involved in research. Dr Sebire reduced to 0.2 FTE in 2018 to take on a new role as the Chief Executive of the Health Improvement Commission for Guernsey and Alderney, a third sector organisation with responsibility for implementing the Healthy Weight Strategy. This innovative arrangement has enabled us to draw on Sebire's insights from front-line public health work and identify direct pathways to implement research.

We appointed four new core-funded colleagues with an exceptional upward trajectory to maintain the quality of our existing research. Foster was appointed as Senior Lecturer in 2017 with a focus on leading the implementation of evidence into policy. Armstrong was appointed as Lecturer in 2017, extending our expertise in large-scale epidemiology and the aetiology of chronic disease in adults. Toumpakari was appointed as Lecturer in 2018 to strengthen our work in changing both diet and physical activity behaviours. Li was appointed as a Lecturer in 2019 to lead on our work in applying methods from systems science to change physical activity and nutrition behaviours in LMICs. Emm-Collison secured her own funding from the Wellcome Trust and joined the team as an Independent Researcher in 2019. Emm-Collison's research uses innovative methods to capture children's views on physical activity and co-create behaviour change programmes and is aligned with our strategic aim to develop novel interventions.

We have a good gender mix among our team. Our submission comprises seven female and two male full-time members of staff with two male part-time colleagues. Full-time staff include one female and two male Professors, one female Associate Professor, a female Senior Lecturer, three female Lecturers and our independent researcher is also female. In this REF cycle, there have been seven promotions for five people, three of which were female team members.

All new staff are supported when they join the School via a mentor to help them become familiar with School processes and provide an additional point of contact. Newly appointed staff have a reduction of 15% time in their allocated workload in their first year of appointment and 7.5% in their second year to provide time to acclimatise and devote time to building networks and collaborations across the institution. Staff are recruited in accordance with the University's policy on fair and effective recruitment, which focuses on protection from discrimination in the job-specification,

short-listing, and interviewing stages. Staff are required to undertake training in these areas before contributing to recruitment.

We continue to maintain a vibrant group of externally funded research staff who build our capacity and sustain many projects. These include Project Managers, Post-Doctoral Fellows, Statisticians, Research Associates, Fieldworkers and Administrators. All research staff are fully integrated into the Centre, providing input into the Centre's strategy.

Our research capacity is considerably enhanced by our leadership in several externally funded University-wide research infrastructure projects that facilitate the sharing of methodological skills and expertise. For example, experts in statistics and health economics from the Bristol Trials Centre (submitted to UoAs 1 and 2 in REF2021) provide core support for designing and running our large trials. This collaboration has been key to securing substantial MRC and NIHR funding and has enabled us to conduct trials using robust methodologies with specialist support in research governance, database, dissemination, statistical and economic analyses. We also collaborate with colleagues in the IEU which has helped us to embed novel methods for dietary assessment within new cohorts and advance our statistical modelling to include within-person trajectory modelling, latent transition analysis and Mendelian randomisation. Our collaboration with NIHR ARC West has facilitated the translation of research evidence into practice, such as work providing relatable examples of physical activity for the updated national physical activity guidelines. The Bristol Biomedical Research Centre has supported work in relation to e-bikes for clinical groups and expertise from the NIHR School of Public Health Research is informing our natural experiment and system science work.

2.2 Staff development

Staff professional development is critical to the Centre. We encourage participation in the many leadership and development programmes run by the University, encompassing online courses, face-to-face training, and residential career development courses. For example, Academic Staff Development provide courses to support teaching (e.g. the CREATE scheme), grant development, as well as specialised training in academic leadership which all staff are provided with a time allowance to attend. The CREATE scheme led to Armstrong (2018), Johnson (2014), Papadaki (2014) and Sebire (2014) becoming Higher Education Academy Fellows during this REF cycle.

We encourage all staff to attend at least one academic conference per year, with £1,000 contribution from school funds to supplement research grants. We encourage participation in external career development schemes, such as Papadaki's attendance at the GW4 Southwest Crucible training programme for mid-career researchers and Johnson's attendance at the European Nutrition Leadership Platform. We have also supported periods of study leave for Page (2018 – EU collaborators), Papadaki (2019 – Harvard Medical School, USA) and Johnson (2020 – Deakin University, Australia), which have facilitated international collaborations and extended the impact of our research.

All new staff are mentored to balance teaching, research, and administrative activities, and to develop grant applications. This process has worked well, evidenced by all academic staff holding research grants during the current REF cycle and a series of promotions: Page was promoted to Professor in 2015; Foster to Associate Professor in 2018 and Professor in 2020, and Johnson to Senior Lecturer (2017) and then Associate Professor (2020) with Papadaki (2016) and Sebire (2015) promoted to Senior Lecturer. In addition, Toumpakari completed her PhD in the Centre in

2016, was appointed as a Research Associate in 2017 and secured a Lectureship in 2018. Similarly, Emm-Collison was employed as a Research Associate in 2017 and used this experience to secure a Wellcome Trust-funded personal fellowship. Promotions at Bristol are assessed via criteria that assess teaching, research, administration, and citizenship.

The Centre places a strong emphasis on staff well-being, recognising the potential stresses and strains of an academic career, by taking practical steps to promote physical and mental health. We create a positive working culture encouraging open and honest communication though line management, informal support, and team meetings. Before the COVID-19 pandemic we built in regular breaks in our working day to meet informally and socialise over coffee. We also arrange social events, including team-building exercises to nurture a positive group dynamic. We have sustained these practices via Zoom during the pandemic to ensure that all staff feel connected while working from home. These local practices are reinforced by increased University-wide provision of a Staff Well-being Service, as well as online and face-to-face staff counselling programmes and staff training from Bristol Mind. The University has also supported the training of Mental Health Champions to signpost staff to support within the University. Our School Mental Health Champion (Byron Tibbitts) is an ENHS Project Manager. Tibbitts has led the school-wide provision of mental health support and this role is an example of how we have supported the broad career development of our research staff.

2.3 Training and supervision of PGR students

PhD student training is a major focus of our work and 11.45 students have completed in this REF cycle with 10 students continuing. Completions (which include fractions for cross-school supervision; no professional doctorates awarded) are shown below.

2013/2014	2014/2015	2015/2016	2016/2017	2017/2018	2018/2019	2019/2020
0	2	2.75	3	0.2	2.5	1

PhD student training is managed by the Bristol Doctoral College, a University-wide programme that focuses on providing a supportive and rigorous training environment. The Doctoral College provides career development sessions, workshops, seminars, and online resources for students. There are also annual events, such as “Research Without Borders” where all students are encouraged to share their research with other students and staff across the University, thereby facilitating interaction across disciplines, methods, and countries. We are currently members of, and have secured competitive funding for students from, two RCUK doctoral training programmes (the ESRC-funded Southwest Doctoral Training Partnership and the MRC GW4 Biomed Doctoral Training Partnership), as well as the NIHR School for Public Health doctoral training scheme. We have supervised several students who have been funded by the Conacyt schemes in Mexico and Chile (Hermosillo-Gallardo, Vega-Salas, Ortega, Valerino-Perea, Chavez-Ugalde, Ibacache). Foster and Toumpakari are supervising a PhD student who is funded via the University of Bristol’s Cotutelle scheme, whereby a student spends half their time in Bristol and half at the University of Cape Town. We actively support career progression for students on our MSc in Nutrition, Physical Activity & Public Health with approximately 10% of students continuing to PhD study.

Our research students are located within the same building as academic and research staff, and are provided with a desk, computer, storage, and a communal space that facilitates social interaction with fellow students and staff. All students have at least two supervisors, with expertise

drawn from across the institution and wider training networks to provide the best support. All PhD students attend and contribute to our bi-weekly research group meetings, a forum for sharing research and fostering a centre-wide collaborative approach and are encouraged to attend the Centre's social events and team-building exercises. They are also provided with opportunities to gain teaching experience by giving guest lectures in their specialist area on our MSc in Nutrition, Physical Activity & Public Health. PhD students have set up a fortnightly journal club to help develop critical analysis skills.

In this REF cycle, PhD students have been funded by the British Heart Foundation (Zahra), Bristol Primary Care Trust (Bentley), Conacyt in Mexico (Hermosillo-Gallardo, Ortega, Valerino-Perea), Conacyt in Chile (Vega-Salas), ESRC (Lloyd, Carroll), MRC (Begum, Garbutt, Magklis, Dias), NIHR Doctoral Clinical Training Scheme (England), NIHR Biomedical Research Unit / Centre in Nutrition, Diet and Lifestyle (Brocklebank, Bourne), NIHR School for Public Health Research (Porter, Chavez-Ugalde), DECIPHer Public Health Research Centre of Excellence (Harding) and Saudi Arabian Cultural Bureau (Alharbi), along with two self-funded students (Toumpakari, Khodabakhsh).

2.4 Equality, diversity, and inclusion

Equality, Diversity, and Inclusion (EDI) are essential components of the University's staffing strategy. The University of Bristol has developed a joint policy with the local union on tackling the gender pay gap and has a policy on EDI. The University is also a member of the Stonewall Diversity Champions programme, which provides support for all lesbian, gay, bi and trans (LGBT) staff and the University sponsors the Bristol Pride festival. The School for Policy Studies has played leading roles in the creation of University-wide EDI strategies and we have been fortunate to draw on the expertise of colleagues in other areas of the School in relation to equalities provision (Prof Marianne Hester), gender pay gap (Prof Esther Dermott) and disability issues (Dr Beth Tarleton) who are all submitted to UoA20 in REF2021.

Within the School, an EDI committee has been established to oversee EDI activities and monitor progress. The EDI committee reports to the Senior Management Team, who have an action register of EDI tasks. These issues are cascaded to all School staff via email and School-wide meetings, and all new staff undertake EDI training as part of the induction process. In 2020 we were awarded Athena Swan Bronze and that application enabled us to analyse all aspects of our research support and processes in relation to EDI issues via a panel of assessors representing the variety of members of the School involved in research. The self-assessment team included staff at different grades, representing a mixture of research- and teaching-focused pathways, as well as professional services staff and PhD students. We have introduced a new workload model to ensure that all tasks are allocated equitably and the workloads of different categories of staff can be monitored against EDI criteria. We will build on this work to secure at least Athena Swan Silver over the next REF cycle.

The University of Bristol and the School for Policy Studies creates a supportive working environment that allows colleagues to work in a way that is most productive and can be adjusted for different life circumstances. For example, staff who return from maternity leave are given a lighter teaching load to allow time to readjust to work. We have encouraged staff to utilise the University's carers' return-to-work scheme to support career development after parental leave.

We have considered EDI issues in the REF process in compliance with the University's code of practice. All staff were encouraged to declare any personal circumstance that may have affected their ability to produce outputs to a University-wide committee that had no other involvement in the REF process. A long list of possible outputs for submission was then produced and reviewed by the gender balanced School's REF sub-committee, which focused on the quality of the outputs, regardless of authorship. Final output selection decisions followed University policy when selecting between outputs of the same awarded grade, to ensure equity across all staff members.

3. Income, infrastructure and facilities

We are a focused group of core funded staff supported by externally funded research staff who are integral to all our work. We are also part of University-wide research structures and research institutes that provide additional support to maximise the scale and impact of our work. In the sections below we outline our research income and University-wide support for our work.

3.1 Income

The table below highlights that we have secured nearly £4 million in grant income to the Centre over the current REF cycle, which is an average of £419,140 per FTE or ~£60K per FTE per year. The table also highlights that this has been secured from diverse sources including research councils, EU, government agencies, such as the National Institute of Health Research, and leading charities, such as the British Heart Foundation.

	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	Total
Research Councils	300,655	29,091	7,442	51,380	108,041	50,156	38,250	585,015
EU	54,124	88,476	28,586	20,992				192,179
UK govt	341,493	392,269	312,740	249,506	235,624	379,849	358,599	2,270,080
UK Industry		23,631	46,969					70,600
Charities	110,860	113,804	164,447	127,851	146,454	103,921	54,702	822,040
							Total	**3,939,914**

A unique feature of our group within UoA24 is our leadership of physical activity and nutrition research in population and clinical settings via senior roles within externally funded infrastructure grants. These major grants (>£50 million) include the NIHR-funded Biomedical Research Unit (Cooper was one of four co-applicants and led the sedentary behaviour theme in the BRU), NIHR-funded Bristol Biomedical Research Centre (Cooper and Page), NIHR School for Public Health Research (Jago), NIHR CLAHRC West and its successor NIHR ARC West (Jago as Public Health theme lead), the MRC/Wellcome Trust core support for the Avon Longitudinal Study of Parents and Children (Jago), as well as the EPSRC-funded SPHERE (a Sensor Platform for HEalthcare in Residential Environment; Cooper), Cancer Research UK Integrative Cancer Epidemiology Programme (Page and Armstrong) and the UKCRC-funded DECIPHer Public Health Research Centre of Excellence, for which Cooper, Jago and Page were all collaborators. Jago is also the lead for England for the recently funded Bristol-Cardiff NIHR funded Public Health Intervention Response Team (PHIRST). These strategic awards facilitate research capacity but are not included in the direct income figures above, as they are based primarily in the Faculties of Health Sciences or Engineering.

3.2 Research infrastructure and facilities

As highlighted in our plan for the next REF cycle, we aim to embed research into policy and practice to achieve meaningful impact on population health. Our location within the School for Policy Studies is particularly advantageous in this regard, as we can draw on broader School expertise in policy processes, such as our collaborative teaching on global public health policy, to guide the translation of research. The School has a Research Manager who helps to coordinate grant submissions and an Impact Director who provides guidance on how to maximise the policy and practice impacts from our research.

Central University support and infrastructure are critical to our research success. Research and Enterprise Development (RED) provide core support in grant development, design and dissemination, which has facilitated the development and running of our many research projects. RED's specialists in research governance provide advice and sponsorship for projects. This support is particularly helpful for NHS-focused research, such as our work with adults with type 2 diabetes, where RED helped to navigate the complicated Health Research Authority ethics system. RED also support intellectual property and commercialisation. For example, the PLAN-A study uses previous intellectual property (IP) on how to identify influential peers that was developed as part of the ASSIST smoking cessation programme, led by Professor Rona Campbell (UoA2); RED negotiated the IP agreement. This core support is integral to our success.

University support has helped team members to disseminate evidence to drive changes in policy and practice. The Centre has benefited from support for Knowledge Exchange and impact acceleration from a range of staff and structures housed within RED. As an example, we have received an ESRC Impact Acceleration Award (to develop an after-school diet and physical activity award scheme) and Business Development support (to explore funding mechanisms to accelerate the uptake of e-bikes in clinical groups). Critical in these efforts has been PolicyBristol, a University-wide service, which disseminates evidence to policy makers and helps academics to widely share findings. PolicyBristol have helped us draft policy briefings on food provision in vending machines, evaluation of a local healthy eating award scheme, and have then disseminated these briefings to MPs and elected representatives in the devolved assemblies to provide timely information to key decision makers. PolicyBristol have also provided guidance on submitting evidence to government committees, such as our oral contribution to the Health and Social Care Select Committee inquiry into childhood obesity and our evidence submitted to the Welsh government on their physical activity strategy (see impact case study).

Data are central to our research, with several of our projects requiring analysis of large and complex datasets. The University provides the RDSF a long-term storage facility. We are also able to use the University's High-Performance Computing facility that enables us to process high volumes of data, such as Armstrong's analysis of the physical activity and health data of ~100K participants in UK BioBank, and Johnson's work on diet and disease in ~500K participants in the European Prospective Investigation of Cancer (EPIC).

A major benefit of working in a diverse, research-focused institution is the ability to interact with colleagues from a range of disciplines to share expertise. At Bristol, there are five University Research Institutes that facilitate these interactions (see REF5a). We have particularly strong links with the EBI and the Jean Golding Institute for Data Science (JGI). EBI provided catalyst funding for a project developing a crowd-sourcing platform for assessing dietary intake, led by Johnson.

This project included engineers, computer programmers, epidemiologists, and dietary experts, and typifies how University structures support collaborative interdisciplinary research. The EBI has also administered the Wellcome Trust funding that supports Emm-Collison. Foster is part of the Steering Committee for the new Global Public Health strand within the EBI, which coordinates global health research across the University. JGI provides training in statistics such as the use of R, which has been attended by Centre staff and PGR students. JGI also facilitates links with the Alan Turing Institute, such as Toumpakari's JGI-funded project to automate large-scale analysis of food purchase databases.

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

Collaboration is a central focus of all our work, as we believe that we can have the greatest impact on public health by working in partnership with policy makers and academics across the globe. In the sections below we have highlighted our research collaborators, networks, beneficiaries as well as our wider contribution to the research base, economy, and society.

4.1 Research collaborators

We focus on building long-term partnerships with collaborators and colleagues in local and national health roles to sustain relationships that transcend individual research projects. For example, for all our randomised trials we have Trial Steering Committees composed of diverse groups of leading academics and practitioners who provide valuable collaboration, oversight, and governance. Below we provide examples of how we collaborate with national and international colleagues.

Nationally, Foster chairs the UK Chief Medical Officers' advisory group for physical activity. Via this role he provides guidance to the four Chief Medical Officers twice per year and leads strategic initiatives, including the update of the National Physical Activity Guidelines and the guidance on how to be active during the COVID-19 epidemic. Foster also provides regular guidance to the physical activity officers in the Department of Health and the physical activity leads in Public Health England (with Jago leading advice on children and young people). The Centre is part of the NIHR School of Public Health Research, with Jago a member of the Bristol Executive team. We were also part of DECIPHer, a UKCRC Public Health Research Centre of Excellence, with Cardiff and Swansea between 2008 and 2018, which helped to facilitate the Bristol Girls Dance Project, Action 3:30 and PLAN-A trials. Toumpakari collaborates with the Global Food Security Program to synthesise evidence around choice architecture interventions across the food system.

Internationally, we are part of the leadership group of the International Children's Accelerometer Database and the EU-funded I-Family study. Foster collaborates with the USA and Canadian physical activity national academic committees, Papadaki has an ongoing collaboration with the PREDIMED Consortium (Europe and Harvard) and global consortia on Meals on Wheels led by Brown University (USA), Johnson collaborates with European consortia (EPIC and NutriProgram) as well as Deakin University (Australia), Pennington Biomedical Research Centre (USA), the University of Malaya and Monash University in Malaysia. Li collaborates with Auckland University (New Zealand), Deakin University (Australia), University of Sherbrooke (Canada), Shanghai Jiao Tong University and Guangxi Medical University (China) on multinational research programmes.

4.2 Networks and partnerships

Central to our mission to improve population health are our partnerships with local, national, and international government and non-government agencies. For example, Foster is on the Board of the Global Observatory for Physical Activity (GoPA!). This network has evaluated the national physical activity policies and surveillance actions for over 160 countries and will expand to include sedentary behaviour over the next few years. Li has strategic partnerships with public health leads in local and national governments in China and Sri Lanka, the World Obesity Federation and the WHO Regional Offices for Europe and China. In addition, Johnson is a member of the Diet@NET partnership providing best-practice guidelines for dietary assessment. Johnson and Papadaki are part of the cross-Council funded UKPRP Genius network, which is focused on generating excellent nutrition in schools. Jago was part of the global group that produced the WHO updated physical activity guidelines in 2020.

4.3 Beneficiaries

Involving beneficiaries and policy makers, such as key staff from local authorities as well as national groups, throughout the research process from conception to dissemination, is crucial to our success. We have built and maintained close working relationships with many different non-academic partners including community groups (Bristol Diabetes Network), local authority staff (Bristol City Council, South Gloucestershire Council), third sector groups (Active Gloucestershire, Sustain), and policy makers (Department of Health, Sport England), and sustained these relationships across multiple grant awards. All our research studies include a Local Advisory Group, which provides a direct link to the voice of participants and stakeholders.

In our work with clinical populations, participants are engaged throughout the project. For example, in our NIHR-funded work with adults with type 2 diabetes, regular meetings are held with participants who advise on study design, recruitment, data collection and the dissemination of study results. Additionally, we have established strong links with Bristol, North Somerset and South Gloucestershire's (BNSSG) dietitians and diabetes specialist nurses and with local patient-led Diabetes UK support groups, who advise on which issues are of high importance to patients and practitioners, such as the practicalities of recruitment and introducing interventions into practice.

We hold dissemination events on the completion of major projects, which are attended by partners from government, academia, third sector and national organisations, including Sport England and Women in Sport. We also share our research by regularly writing blogs, contributing to press releases, radio, and TV programmes, participating in public engagement events (Pint of Science, Creative Reactions) and via seminars for local authority and clinical commissioning groups.

4.4 Wider contribution to the research base, economy, and society

We actively encourage staff to take on roles within strategic national and international committees that influence policy, and these tasks are recognised in our workload allocation. For example, Foster led the development of updated National Physical Activity Guidelines and communication materials for all age groups. Cooper led the Sedentary Behaviour Update and Jago led the update for Children and Young People. Page and Cooper were guest editors for the Global Matrix 2.0 Report Card on the Physical Activity of Children and Youth, which compared physical activity in 38 countries. Johnson presented oral evidence to the Health and Social Care Select Committee inquiry into the Childhood Obesity Strategy (May 2018) based on the Centre's research, which was subsequently cited in the report. She was also an expert adviser to the British Nutrition Foundation on the development of guidance on portion sizes for adults (2017-2018).

We encourage staff members to contribute to professional societies. Foster was President of the International Society of Physical Activity & Health (ISPAH) between 2016 and 2018 and was Scientific Chair of the 2018 ISPAH Congress with >1,200 delegates from over 60 countries. Jago was a member of the International Society of Behavioural Nutrition & Physical Activity Executive Committee and Chair of the Finance Group (2012-2015). Armstrong has been the continuing professional development lead for the Physical Activity and Health section of the British Association of Sport and Exercise Sciences (BASES) since 2016, where she has coordinated the provision of training courses and webinars. Johnson is a UK representative in the Federation of European Nutrition Societies working group on improving standards in the science of nutrition.

Contributions to society have been recognized by an OBE to Foster in the 2019 New Year's Honours list for services to physical activity policy. Fellowships from the Faculty of Public Health by Distinction (Foster 2017 and Jago 2018) and the International Society of Behavioural Nutrition and Physical Activity (Jago 2017) illustrate significant contributions to the fields of physical activity and public health. Locally, we provide strategic advice to Bristol City Council (Papadaki), public health teams in South Gloucestershire Council (Emm-Collison) and Wiltshire Council (Papadaki), and Public Health England South West (Jago and Johnson).

Academic citizenship within the discipline is a priority for us and we have made significant contributions to journal editing, grant reviewing, research strategy development for funding bodies and invited keynote lectures. For example, Cooper is a member of World Cancer Research Fund's Board of Trustees, where he provides strategic guidance on grant funding, such as the new focus on diet and physical activity for cancer survivorship. Jago was Editor in Chief of the International Journal of Behavioural Nutrition & Physical Activity between 2015 and 2018. In this role he led a re-focus of the journal on publishing the highest quality research demonstrating rigour and innovation which resulted in a 50% increase in the number of submissions over the period. We are also keen to expand our influence on research in LMICs and Li is advancing this work by advising on the expansion of the WHO European Childhood Obesity Surveillance Initiative (currently 36 European member states) to LMICs.

In terms of research funding and scientific leadership, Jago has been a member of the NIHR Public Health Funding Board since 2014 and became Deputy Chair in 2019. We regularly provide invited talks to academic and non-academic audiences, including Foster's keynote lectures at the Association of Obesity, Scotland Physical Activity Conference and Portugal Sports Medicine Congress and Jago's invited presentations at the ukactive National Summit (2018) and the British Association of Sport and Exercise Medicine (2019). We provide support to our local partners, such as Papadaki's presentations to the Bristol Diabetes Support Network in 2017 and 2018 and regular contributions to Public Health England South West conferences (Sebire, Papadaki and Jago).

We consider it essential that research evidence is shared with wider society and so we have made Public Engagement integral to all our work. To facilitate these efforts, we include engagement activities into all our research grant applications and discuss engagement activities and plans at our monthly centre meetings. A key public engagement activity has been the delivery of FAB Kids, a diet and physical activity outreach programme for primary school children that has been delivered to >1,500 children in the past three years, for which we were supported by the University's Public Engagement Team and the Widening Participation Office. We have held centre-wide public engagement sessions in the Galleries Shopping Centre (2014), delivered nutrition-

based education sessions in the Einstein Garden's programme at the Green Man Festival (2014) and in local public houses via the "Pint of Science" scheme (2017), and had art created based on our research in the "Creative Reactions" collaboration (2018).

Concluding remarks

The Centre for Exercise, Nutrition & Health Sciences at the University of Bristol is an ambitious and highly successful research group which focuses on the clinical and public health aspects of physical activity, sedentary and eating behaviours. We have made major advances in research, provided research leadership via professional societies, and informed changes to national policy. We have been joined in these endeavours by a diverse team of research staff and PhD students, as well as University-wide infrastructure grants, which provide a unique environment in which to conduct high quality and impactful research.