UNIVERSITY OF COPENHAGEN
CENTER FOR HEALTHY AGING

CENTER FOR HEALTHY AGING

Annual Report 2019

Facts of Center for Healthy Aging in brief

External grants	>DKK 576m (EUR 77m) in addition to the Nordea-fonden grant
Publications	2009-2018: 1688 2019: 142
PhD projects (completed)	2009-2018: 172 2019: 9
Post-doctoral projects	2009-2018: 102 2019: 30
Visiting professors	2010: 5 2011: 9 2012: 9 2013: 8 2014: 7 2015: 6 2016: 6 2017: 6 2018: 5 2019: 1
Recruitment	Nationally and internationally recognized senior researchers: 9 New group leaders: 10
International summer schools	2011-2019: IARU Summer School Interdisciplinary Aspects of Healthy Aging 2016-2018: Innovating Solutions for Aging Populations – innovative solutions to aging related challenges, including Massive Online Open Course (MOOC)
International networks (selected)	IARU EIT Health Alliance for Healthy Aging
Communication and outreach (selected)	2015-2019: People's Political Festival 2017-2019: Culture Night at SUND 2017-2019: Keep Your Brain Healthy 2019: Dissemination Conference: Physical activity and aging – from research to practice
Awards	Center of Excellence Grant (Danish Research Council/Grundforskningsfonden) University of Copenhagen Excellence projects: 4 awards Global Excellence Awards: 2 awards ERC Advanced Grant Novo Nordisk Foundation Challenge Grant Lundbeckfonden's Research Prize for Young Scientists KFJ-prize

EXECUTIVE SUMMARY

Research close to practice

Wherever you go, it seems that there are more middle-age and elderly people than in the past, and every nation is or will soon be facing the challenge of population aging. As a result, it is more critical than ever that we understand how to promote healthy aging. As "healthy aging" is the main focus of our Center, what we do here at the University of Copenhagen's Center for Healthy Aging is also more important than ever. On 1 January 2019, we entered a new 5 year period of funding from the Danish Nordea-fonden. This funding and our ongoing relationship with Nordea-fonden provides essential support for our research, which is playing a critical role in addressing one of today's most pressing societal challenges.

The complexity of aging

Aging is a complex, multidimensional process, that challenges Center for Healthy Aging to develop a sophisticated interdisciplinary toolbox, as we attempt to understand the many different facets of human aging. The more angles we examine, the better will be our ability to promote individual and societal health and well-being, as population demographics continue to change over time. The Center pursues basic research at the tissue, cell and molecular level, and also pursues studies grounded in social science disciplines, including anthropology, epidemiology, sociology, psychology and economics.

Here at Center for Healthy Aging, we emphasize and promote collaborative research involving diverse disciplines/departments, public/private partnerships, and scientists from different countries and cultures. A new collaboration this year involves the Faculty of Health and Medical Sciences at the University of Copenhagen and the Faculty of Medical Sciences at the University of Groningen. This partnership includes research and education activities, as well as a student exchange program. Other new or strengthened collaborations involve the University of Birmingham, The Alliance for Healthy Aging: Mayo Clinic, the University of Groningen Medical Center and Newcastle University.

The Center is recognized internationally for the high quality of its research and its impressive publication record, including over 1800 articles in top tier peer-reviewed journals over the last 11 years. Our research findings form the foundation of our effort to address the societal challenge of population and individual aging.

The work conducted in Professor Vilhelm Bohr's group is one example of the outstanding research being performed at the Center. Professor Bohr who recently showed that NAD+ (a derivative of vitamin B3) increases lifespan and improves healthspan in animal models of Werner Syndrome. These results pave the way for clinical trials to test the therapeutic value of NAD+ or an NAD+-related compound for treating age-related diseases.

Another example of The Center's outstanding research is from Professor Rikke Lund's group. Professor Lund showed that individuals who experience four or more periods of living below the poverty threshold during their adult life develop age-related pathology significantly earlier/faster than control groups.

Because of the quality of the Center's research, our researchers receive generous external funding and frequently win prestigious scientific awards. In 2019, Professor Simon Bekker-Jensen received an ERC Consolidator Grant as well as the Lundbeck Foundation's Young Investigator Prize for his research on the basic mechanisms of aging and cellular stress. In addition, Professor Michael Kjær received the prestigious KFJ Award for excellent research on the health benefits of physical activity.

Enabling change in society

Educating the next generation of aging researchers and health sector professionals is one of the Center's top priorities. For example, the Center was instrumental in developing the educational campus component of the EIT Health Initiative, whose focus is healthy living and active aging, and which is now part of a new EIT Health PhD Programme with courses on innovation and entrepreneurship. The Center has a large portfolio of educational offerings, including undergraduate, Master's and PhD programs, an international summer school, and Massive Open Online Courses (MOOC) on the Coursera platform. The Center's Network for Young Scholars (NYS) organizes career seminars and networking events that bring together students and young researchers and the PhD Academy for Interdisciplinary Aging Research (PAIAR) develops and organizes PhD level courses.

Center for Healthy Aging emphasizes a citizen-centric and impact-oriented approach in order to engage key stakeholders, including citizens and health professionals, in our effort to create

a strong framework for healthy aging. For example, in collaboration with the University of Copenhagen's Center for Team Sports and Health, the Center organized a conference entitled *Physical activity and aging – from research to practice*, at which researchers presented 20 recommendations on how authorities, municipalities and sports organizations can promote the health and well-being of elderly individuals through physical activity. The recommendations were developed by 26 of the world's leading researchers on this topic. Participants representing Center for Healthy Aging included Professors Michael Kjær, Flemming Dela, Jørn Wulff Helge and Erik Lykke Mortensen, Associate Professors Astrid Pernille Jespersen and Abigail Mackey and Postdoctoral Fellow Aske Juul Lassen.

Center for Healthy Aging researchers, including Associate Professor Nete Schwennesen and Professor Karsten Vrangbæk, also contributed to The National Health Authority's National Action Plan on Good Elderly Living, and in July 2019, The Science Advice for Policy by European Academies issued a report entitled *Transforming the Future of Ageing*. The report was prepared for the new European Commissioners with contribution from Professor Lene Juel Rasmussen.

Center for Healthy Aging researchers are leaders of two newly established research collaborations, which we believe will make it possible for ground-breaking new research to benefit patients more quickly. The collaborations are called Clinical Academic Groups (CAGs); the goal of one CAG is to determine whether regular physical activity is useful for prevention and treatment of chronic diseases, treatment and rehabilitation after trauma and injury, and prevention of musculoskeletal injury/disorder. The second CAG aims to improve acute treatment of elderly and fragile patients during or in association with acute hospital admissions, and to optimize healthcare for the elderly in Denmark.

In addition, the Center has embarked on a series of collaborative projects in local communities. An example is a collaboration with three municipalities on the transition from working life to retirement. Another example is an initiative, known as the Copenhagen Center for Clinical Age Research (CopenAge) led by Professor Flemming Dela in collaboration with Professor Charlotte Suetta (Department of Clinical Medicine) on rehabilitating the elderly. In November 2019, they hosted a workshop for representatives from 19 municipalities on rehabilitation of the elderly. The purpose was to identify the areas where health professionals at the rehabilitation centers lack knowledge and could benefit from additional support.

Summing up, the above paragraphs mention only a few highlights of the Center's current and ongoing activities. After another successful year at Center for Healthy Aging, we look forward to a prosperous and productive future, building on our strong foundation for many years to come. We hope and are always working diligently to ensure that our research is of great benefit to the citizens of Denmark and other countries around the world.

Lene Juel Rasmussen

Professor Lene Juel Rasmussen, Executive Director

TACKLING CHALLENGES IN AGING RESEARCH

Major demographic changes are occurring across the globe: most notably, the proportion of elderly individuals has been and continues to increase in virtually all countries and human populations. It is predicted that 16 percent of the global population will be older than 65 years of age by 2050, and that the number of people over the age of 80 will have tripled[1]. In developed countries of the world, the average human lifespan increased more than twofold during the 20th century, and it is estimated that average life expectancy of newborns will gradually increase to close to 100 years during the 21st century. These trends are associated with significant economic, cultural, medical, social, and public health challenges, that will affect individuals, communities, and entire nations, and whose implications are only just beginning to be fully understood and appreciated. Aging itself is a leading risk factor for nearly all major chronic diseases, which increase co-morbidity and drive increases in healthcare costs[2]. In Denmark, the latest population projections estimate that the proportion of the population over the age of 65 will increase from 18 percent in 2018 to 24 percent in 2042, after which it will decline slightly (source: Statistics Denmark). Consequently, population aging is considered by many to be one of the most urgent societal challenges of the coming decades; therefore, better tools for promoting 'healthy aging' are urgently needed[3].

From an individual perspective, longer life can be seen as a good thing, if a person's quality-of-life is maintained for a longer period of time. In that case, population aging will not necessarily be or become a societal burden, as many of us fear it will be on a personal level. Rather, high-functioning elderly individuals could be an asset and a new societal resource, contributing to the workforce or to civil society as retirees and volunteers.

Center for Healthy Aging's vision and mission

Since its inception, Center for Healthy Aging has consistently improved our understanding of aging at the cellular, individual and societal level, brought together researchers with diverse disciplinary backgrounds, trained many doctoral and post-doctoral students, and promoted healthy aging by engaging with a wide range of stakeholders. Extensive epidemiological, imaging, and physical exercise studies have made it possible for researchers at the Center to identify health-promoting interventions. Furthermore, our communication and outreach efforts have engaged lay audiences and increased awareness of the importance and value of healthy lifestyle choices.

Center for Healthy Aging is now embedded within the University of Copenhagen, an arrangement that brings numerous mutual benefits. The university provides substantial financial support, including salaries of senior faculty and staff, co-financing of PhD scholarships, and state-of-the-art research facilities for the Center's interdisciplinary research, involving members of the Faculty of Health and Medical Sciences and the Faculty of Social Sciences.

VISION AND MISSION

The Center's vision is to discover and understand biological, social, psychological, and cultural processes of aging and learn how to translate our research findings into preventive action.

Our mission is to conduct leading-edge research on major aspects of aging, to train young scientists in aging and aging-related research, and to develop health promotion tools for preventing age-related decline and disease; all of which is aimed at improving the health and quality of life for citizens of Denmark and beyond.

Center for Healthy Aging's strategic goals:

- to undertake cutting-edge, multidisciplinary research to better understand the aging process;
- to devise a new understanding of aging at both the individual and societal levels;
- to challenge the negative discourse of aging, frailty, and dependency by focusing instead on energy, resilience, intrinsic capacity and (psychosocial) functional abilities;
- to communicate policy-relevant research and concrete recommendations to the relevant stakeholders in government and other sectors in Denmark and beyond;
- to contribute to the public discourse on aging by undertaking innovative outreach activities.

Furthermore, the location of the Center within the University of Copenhagen optimizes the opportunity for synergistic interactions between Center researchers with distinct background, exper-

tise and training, whether in Health / Medical or Social Science disciplines. Center scientists have access to extensive resources, including the Novo Nordisk Foundation Center for Protein Research (http://www.cpr.ku.dk/); the Novo Nordisk Foundation Center for Basic Metabolic Research (http://metabol.ku.dk/); the Copenhagen Center for Health Research in the Humanities (https://core.ku.dk/); the Center for Health Economics and Policy (https://chep.ku.dk/); and the Center for Chromosome Stability (https://ccs.ku.dk). Furthermore, Center for Healthy Aging provides educational and training in aging research (e.g. PhD dissertations, PhD courses, master level activities; see "Education activities", pp. 35) to the entire University community. Thus, we are grateful for and continue to take advantage of many synergies between the Center and larger University of Copenhagen academic community.

NOTES

1 Population Division, DESA, United Nations: https://www.un.org/en/development/desa/population/publications/pdf/ageing/WorldPopulationAgeing2019-Report.pdf

2 Global status report on non-communicable diseases 2010, WHO: https://www.who.int/nmh/publications/ncd_report_full_en.pdf

3 Horizon 2020 Societal Challenges 1: Health, Demographic Change and Wellbeing and Strategic Foresight which acknowledges the demographic trend of aging is reiterated as putting increased pressure on health systems

CENTER FOR HEALTHY AGING'S UNIQUE APPROACH

The following characteristics (see Fig. 1) highlight the uniqueness of this Center:

Interdisciplinarity

The Center for Health Aging conducts interdisciplinary research on the highly complex process of aging, drawing on the expertise of our professional staff in multiple disciplines. We take this approach because human aging encompasses challenges and problems that belong to the realms of biology, health, medicine, psychology, sociology, economics, and many other scientific and non-scientific disciplines.

Researchers from Center for Healthy Aging study the impact of genetic factors, social class, lifestyle, and education on aging, as individual factors or in combination with each other. The number of publications co-authored by the Center's researchers continues to increase, as does the number of collaborative research projects between the Center's scientists and their national and international colleagues. These collaborations are critical, because they stimulate creativity, productivity and faster progress by promoting synergy between participating groups.

The Center emphasizes interdisciplinary collaborations among the Center's scientists and with their national and international colleagues because we understand that collaboration stimulates creativity and growth, leading to synergy between the participating groups. We hope that this approach will hasten progress and allow each researcher to accomplish more than he or she could accomplish working independently.

Taken together, the strong infrastructure provided by Center for Healthy Aging embedded in the University of Copenhagen, the strong leadership team and the many established international collaborations (see "International and national collaboration", pp. 32 for more details), it is clear that the success of our interdisciplinary research Center is virtually ensured.

Holistic approach

Center for Healthy Aging seeks to understand all aspects of aging – biological, social, psychological, and cultural – at all levels, from the cell to the individual to the population level. This approach to understanding aging is quite unique and only a few institutions around the world take this type of approach.

Scientific excellence

We promote rigorous and innovative research on aging by bringing together top international scientists to address important questions from multiple perspectives. A common conceptual framework for all researchers at the Center, regardless of discipline, ensures that we stay focused on our main priorities and are successful in translating our findings into innovative health-promotion interventions to promote healthy aging.

Capacity building

We train the next generation of aging researchers via our high-quality educational programs, with an emphasis on a holistic approach. We also emphasize excellent communication and outreach, whose goal is to educate and engage the media, citizens, and stakeholders.

Outreach

We engage a wide range of stakeholders including the Danish public, policymakers, municipalities, and businesses. Our goal is to communicate our research in a clear and effective manner, and ultimately, we want to facilitate implementation of interventions and policies that promote healthy aging.

Evolving norms and challenging stereotypes

Center for Healthy Aging views itself as a dynamic entity. This means that we are open to adapting and responding to an evolving landscape, dominated by ever-changing scientific and social issues. The Center is committed to educating citizens, health professionals and all stakeholders, and to challenging intentional and unintentional "agism". While the habitual view of the human life course is built on the assumption that dependence and disability in late life is inevitable, we feel that now more than ever, as societal norms evolve, this assumption needs to be questioned and challenged.

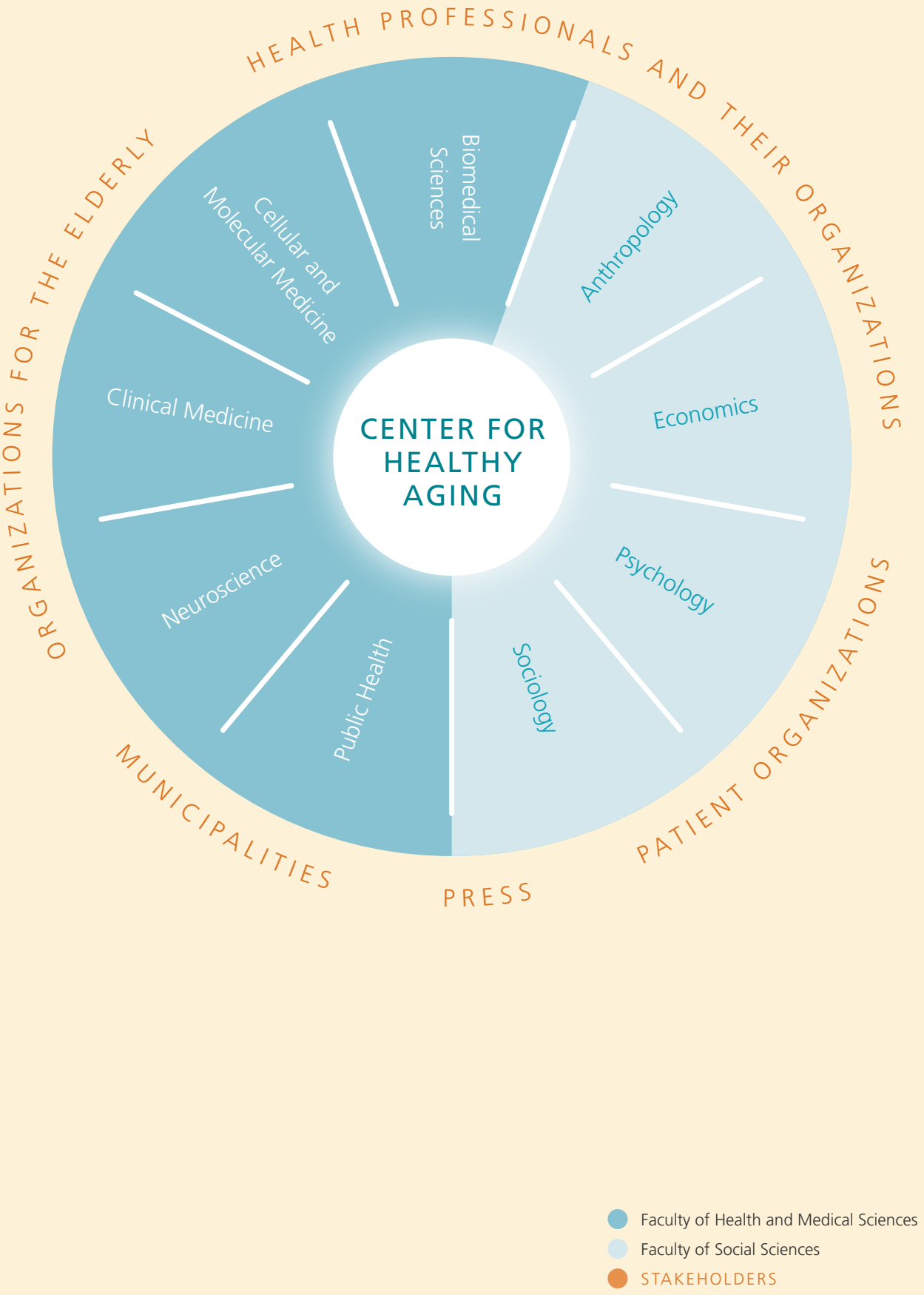

Figure 1. Center for Healthy Aging's approach is interdisciplinary and holistic, and focuses on engaging with multiple stakeholders through impactful communication and outreach.

ORGANIZATION, MANAGEMENT, AND INTERNATIONAL RECRUITMENT

Organization

Center for Healthy Aging conducts research assigned to three multidisciplinary research tracks (I-III). Research also spans eight departments within two University of Copenhagen Faculties (Social Sciences and Health and Medical Sciences) and three hospitals in the Greater Copenhagen Area (Amager and Hvidovre Hospital, Rigshospitalet – Glostrup, and Bispebjerg and Frederiksberg Hospital). Biomedical researchers, including the secretariat, occupy a 'centralized' workspace on the 2nd and 3rd floors of the Mærsk Tower, a new state-of-the-art building offering world class research facilities as well as spare offices and conference/meeting rooms of all sizes. While Center researchers who are members of the Department of Public Health, Faculty of Social Sciences and clinicians who work primarily at area hospitals do not have primary workspace in the Mærsk Tower, these scientists interact regularly with their Center colleagues in the Center's focal hub at the Mærsk Tower.

Management and Advisory Board

The administrative duties of Center for Healthy Aging are carried out by the Executive Director, a Steering Committee and Administrative Staff. The Executive Director Lene Juel Rasmussen, Deputy Director Rudi Westendorp and Outreach Director Anéh Hajdu report to the Dean of the Faculty of Health and Medical Sciences, Dean Ulla Wewer, who is the grant owner. The Center is embedded within the Department of Cellular and Molecular Medicine, Faculty of Health and Medical Sciences. Operational tasks at the Center, including strategic planning and development, and coordination between tracks, are executed by the Executive Director. The administrative staff manage logistics and help coordinate research activities and programs, working closely together with the Communication and Outreach staff.

The main oversight committee for Center for Healthy Aging is the Steering Committee. The committee members include group leaders of each of the three research tracks, as well as the Outreach Director (see "Appendices" for list of members, pp. 10). The Steering Committee provides oversight for research activities, strategic planning, and outreach. The Chair of the Steering Committee is the Executive Director and the Co-Chair is the Deputy Director.

Center for Healthy Aging's management is supported by an International Advisory Board, which reports to the Dean. It includes eleven distinguished scientists, representing broad scientific expertise relevant to the Center's research (see "Appendices" for list of members, pp. 10). The role of the Advisory Board is to advise on the strategic direction and development of the Center; including recruitment, feasibility, progress, and development of the scientific and outreach program in order to maximize Center for Healthy Aging's performance. Furthermore, the Advisory Board serves as inspirator for the Center's development, playing an active role in facilitating opportunities for networking and collaboration within the international aging research community. The Board advises on scientific goals to ensure that the research programs are of the highest international standard and achieve optimal scientific impact.

The Steering Committee meets approximately eight times a year, while the Center's management and staff meet with the Advisory Board once a year in connection with the annual Advisory Board meetings.

Staff

As of 31 December 2019, Center for Healthy Aging had 52 full and part-time employees (funded by the Nordea-fonden grant) plus 194 employees paid by external funding (non-Nordea-fonden funding), including staff paid by the University of Copenhagen. In total, there were 246 staff, which i.a. were distributed between 56 senior researchers; 31 postdocs; 8 guest researchers; 49 PhD students; 14 research assistants; 53 bachelor/master/pregraduate research students; and 9 lab technicians. 9 PhD projects were completed in the Center (2019). Among the research and research support staff, 119 were from Track I, 60 were from Track II, and 61 were from Track III.

International recruitment

In 2019, two internationally renowned Professors in the field of aging were recruited as Affiliated Professor and Guest Professor at Center for Healthy Aging.

Professor and Vice Dean for Research Erik Boddeke from University Medical Center Groningen University was recruited as Affiliated Professor in Molecular Aging at Department of Cellular and Molecular Medicine, which has further strengthened the

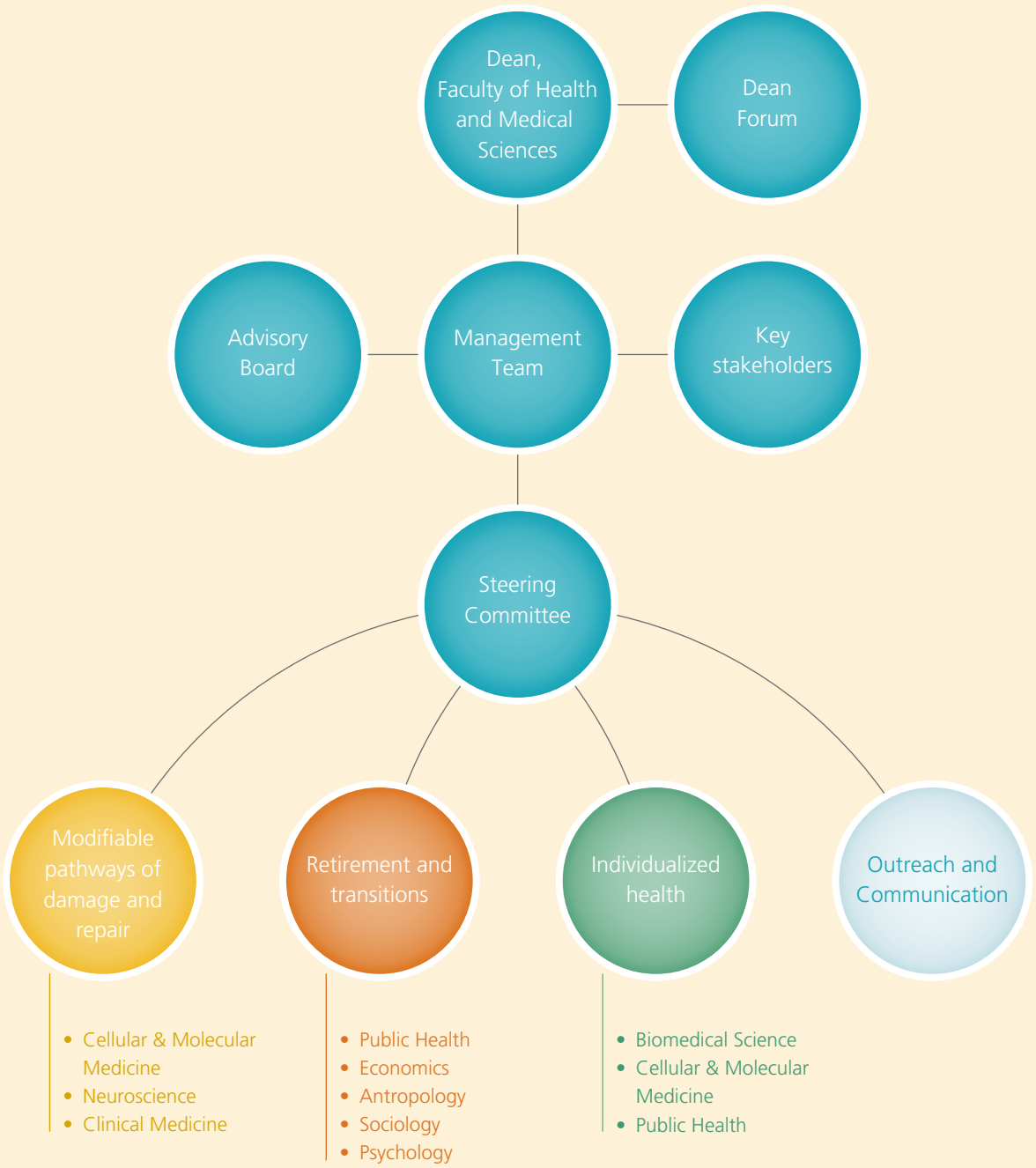

Figure 2. Center for Healthy Aging's organization. Departments associated with a track are listed below the respective track.

existing collaboration between Center for Healthy Aging and the University Medical Center Groningen. Professor Erik Boddeke knows the Center very well as he has collaborated with the Center's researchers for many years and has been part of the Center's Advisory Board since 2014.

Professor of Gerontology and Director of the Oxford Institute of Population Ageing, University of Oxford, Sarah Harper was recruited as Guest Professor joining a collaborative project between Center for Healthy Aging, Oxford Institute of Population Ageing and the Department of Public Health at the University of Copenhagen. The project explores the impact of life-long policies framing women's decisions to work full or part-time or take on full-time domestic care responsibilities, and the impact this has on late life well-being including mental health and depression. This collaboration initiates a comparative study of women's affiliation to the labour market in UK and Denmark and an investigation of the impact of differences in family life and social welfare policies on women's health. The results of this research will assist policymakers in UK and Denmark in developing evidence-based strategies relevant to women's health, mental health, aging and population aging. Sarah Harper is one of the founding members of the IARU ALH network.

RESEARCH

Center for Healthy Aging focuses on promoting healthy and successful aging through interdisciplinary research on all levels, from cells to organisms to populations. The Center acquires evidence-based knowledge and understanding of human aging as the basis for developing preventive and health promotion activities that benefit elderly individuals, their families and their communities.

RESEARCH IN NUMBERS

Number of publications: 142
PhD students (completed): 9
Media mentions: 136
External funding (excluding the Nordea-fonden grant): 76,451,822 DKK

RESEARCH TRACK I

MODIFIABLE PATHWAYS OF DAMAGE AND REPAIR IN AGING

GROUP LEADERS

Michael Kjær, Department of Clinical Medicine, Faculty of Health and Medical Sciences
Discipline: Skeletal muscle and tendon tissue, aging, physical activity, injury

Simon Holst Bekker-Jensen, Department of Cellular and Molecular Medicine, Faculty of Health and Medical Sciences
Discipline: Cell stress responses, signal transduction, MAP kinases, DNA damage response, aging

Ian Hickson, Department of Cellular and Molecular Medicine, Faculty of Health and Medical Sciences
Discipline: Aging, chromosome stability, DNA repair, age-associated disease

Martin Lauritzen, Department of Neuroscience and Pharmacology, Faculty of Health and Medical Sciences and Department of Clinical Neurophysiology, Rigshospitalet, Glostrup, Denmark
Discipline: Aging, human brain function and neurodegenerative disorders

Andres Lopez-Contreras, Department of Cellular and Molecular Medicine, Faculty of Health and Medical Sciences
Discipline: DNA damage, replication stress, mouse models, cancer

Lene Juel Rasmussen, Department of Cellular and Molecular Medicine, Faculty of Health and Medical Sciences
Discipline: Aging, human molecular biology, mitochondrial biology, DNA repair and genomic stability, nucleotide metabolism

Morten Scheibye-Knudsen, Department of Cellular and Molecular Medicine, Faculty of Health and Medical Sciences
Discipline: Aging, accelerated aging, aging interventions

Rationale, focus, and aims

In Center for Healthy Aging Track I, the Hickson Group focuses on how dietary folic acid deficiency leads to damage to chromosomes in human cells. The group is currently mapping several regions of the human genome that are unusually susceptible to [breakage under conditions of] folate deficiency. Moreover, they are defining the identity of the proteins that are recruited to these susceptible loci following folate deprivation using both cell imaging and unbiased proteomic screening methods. In addition, the Lopez-Contreras Group has performed proteomic studies to identify novel regulators of chromosomal fragile sites that are implicated in cancer and aging.

Every day, our bodies experience cycles of tissue breakdown, damage, or trauma followed by subsequent regeneration, recovery, or repair to re-establish homeostasis. Within this research track, we will investigate the effect of aging on these processes; specifically, how they change with age.

Any damage requires adequate repair to maintain optimal body function. Since the response to damage is physiological, it occurs daily, with possible cross-talk between the brain and tissues, and involving stem cells, sophisticated molecular regulators, and the circadian clock.

We will explore the link between increased damage with age, overloading of the existing repair mechanisms, their exhaustion, and medical disability and disease. We will focus on understanding the modifiable pathways of damage and repair in aging and explore the possibilities of positively influencing these.

Organizational developments

The organization and personnel working in Track I have not changed (since last report).

Key achievements

Track I researchers completed a 1-year intervention study, the LISA Project (see "Intervention project on physical activity – LISA Project", pp. 24). The LISA project included a physical training intervention and reported a very low drop-out rate as well as good compliance.

Overview of key research achievements

- Sites of chromosome instability associated with folate deprivation were identified at low resolution; one new PhD student was recruited to the project;
- The tumor suppressor ATRX was identified as an important regulator of the stability of chromosomal common fragile sites;
- In elderly individuals, pre-activation of satellite cells prior to resistance training increased the number of satellite cells but did not increase hypertrophy more that resistance training alone. This suggests that one or more factors other than the number of satellite cells limit the capacity for muscle hypertrophy in the elderly;
- In the elderly, denervated muscle fibers display an embryonic configuration, a phenomenon that can be used as a marker for evaluating interventions that target age-related muscle fiber denervation;
- Protein supplementation in well-nourished elderly, does not improve muscle mass, size or function *per se*. In contrast, strength training improved the muscle strength and volume in elderly individuals, and also led to a reduction in abdominal and whole body fat.

Selected publications

Holdgaard SG, Cianfanelli V, Pupo E, Lambrughi M, Lubas M, Nielsen JC, Eibes S, Maiani E, Harder LM, Wesch N, Foged MM, Maeda K, Nazio F, de la Ballina LR, Dötsch V, Brech A, Frankel LB, Jäättelä M, Locatelli F, Barisic M, Andersen JS, Bekker-Jensen S, Lund AH, Rogov VV, Papaleo E, Lanzetti L, De Zio D, Cecconi F. Selective autophagy maintains centrosome integrity and accurate mitosis by turnover of centriolar satellites. *Nat Commun.* 10: 4176, 2019.

Tollenaere MAX, Tiedje C, Rasmussen S, Nielsen JC, Vind AC, Blasius M, Batth TS, Mailand N, Olsen JV, Gaestel M, Bekker-Jensen S. GIGYF1/2-Driven Cooperation between ZNF598 and TTP in Posttranscriptional Regulation of Inflammatory Signalling. *Cell Rep.* 26: 3511-3521, 2019.

Aman Y, Frank J, Lautrup SH, Matysek A, Niu Z, Yang G, Shi L, Bergersen LH, Storm-Mathisen J, Rasmussen LJ, Bohr VA, Nilsen H, Fang EF. The NAD+-mitophagy axis in healthy longevity and in artificial intelligence-based clinical applications. *Mech. Aging Dev*. Dec 5:111194. doi: 10.1016/j.mad.2019.111194. 2019.

Bizard AH, Allemand J-F, Hassenkam T, Paramasivam M, Sarlós K, Singh MI, Hickson ID. PICH and TOP3A cooperate to induce positive DNA supercoiling. *Nature Struct. Molec. Biol.* 26: 267-274, 2019. Featured in a 'News & Views' article in *Nature Struct. Molec. Biol.* 26, 252-253.

Bechshøft CJL, Jensen SM, Schjerling P, Andersen JL, Svensson RB, Eriksen CS, Mkumbuzi NS, Kjaer M, Mackey AL. Age and prior exercise in vivo determine the subsequent in vitro molecular profile of myoblasts and nonmyogenic cells derived from human skeletal muscle. American Journal of Physiology: *Cell Physiology* 316: C898-912, 2019.

Karlsen A, Bechshøft RL, Malmgaard-Clausen NM, Andersen JL, Schjerling P, Kjaer M, Mackey AL. Lack of muscle fibre hypertrophy, myonuclear addition, and satellite cell pool expansion with resistance training in 83-94-year-old men and women. *Acta Physiologica* 227:e13271, 2019.

Grubb S, Lauritzen M. Brain waves drive fluid flow during deep sleep. Invited perspective paper. *Science*. Nov 1;366(6465):572-573. doi: 10.1126/science.aaz5191, 2019.

Fordsmann JC, Murmu RP, Cai C, Brazhe A, Thomsen KJ, Zambach SA, Lønstrup M, Lind BL, Lauritzen M. Spontaneous astrocytic Ca2+ activity abounds in electrically suppressed ischemic penumbra of aged mice. *Glia*. Jan;67(1):37-52, 2019.

Bakula D, Ablasser A, Aguzzi A, Antebi A, Barzilai N, Bittner MI, Jensen MB, Calkhoven CF, Chen D, Grey ADNJ, Feige JN, Georgievskaya A, Gladyshev VN, Golato T, Gudkov AV, Hoppe T, Kaeberlein M, Katajisto P, Kennedy BK, Lal U, Martin-Villalba A, Moskalev AA, Ozerov I, Petr MA, Reason, Rubinsztein DC, Tyshkovskiy A, Vanhaelen Q, Zhavoronkov A, Scheibye-Knudsen M. Latest advances in aging research and drug discovery. *Aging (Albany NY)*. Nov 21;11(22):9971-9981, 2019.

Pladevall-Morera D, Munk S, Ingham A, Garribba L, Albers E, Ying Liu, Olsen JV, Lopez-Contreras AJ. Proteomics characterization of Chromosomal Common Fragile Site (CFS) – associated proteins uncovers ATRX as a regulator of CFS stability. *Nucleic Acid Res,* 47:8004-8018. 2019.

PhD dissertations completed in 2019

Shunlei Duan: "Identification of novel RECQL4 interacting proteins in maintenance of genomic stability".

Antonis Giannopoulos: "Cell-matrix interaction in tendon constructs".

Cecilie Jæger Leidesdorff Bechshøft: "The role of ageing in the interplay between satellite cells and interstitial cells in skeletal muscle at rest and in response to exercise".

Grith Stougaard Højfeldt: "Fate of nutrient-derived amino acids: influence of habituated levels of daily dietary intake on protein utilization".

Rikke Beyer: "Achilles tendinopathy. The effect of loading on clinical outcome and intratendinuous sliding at the fascicle level".

Nelly Richard: 'Neurophysiological correlates of cognitive decline. An EEG and EEG-fMRI study on cognitive aging".

Eliene Albers: "Generation and characterization of a PICH-deficient mouse model".

RESEARCH TRACK II

RETIREMENT AND TRANSITIONS

GROUP LEADERS

Karsten Vrangbæk, Department of Public Health, Faculty of Health and Medical Sciences
Discipline: Health policy and health economics

Marco Piovesan, Department of Economics, Faculty of Social Sciences
Discipline: Social preferences, self-control problems, unethical behavior, peer effects, and behavioral contract theory

Rikke Lund, Department of Public Health, Faculty of Health and Medical Sciences
Discipline: Social epidemiology, public health and life course

Stine Møllegaard, Department of Sociology, Faculty of Social Sciences
Discipline: Life course perspectives, social demography, genetics

Paul Conway, Department of Psychology, Faculty of Social Sciences
Discipline: Occupational health psychology (OHP), including workplace bullying, work-related stress, sickness presenteeism, aging at work, mental health at work, and work motivation

Line Hillersdal, Department of Anthropology, Faculty of Social Sciences
Disciplines: Obesity, cancer, aging, food and eating, welfare technology, personalised medicine, interdisciplinarity, cultures of science, the body in biomedical contexts, prevention and complex intervention research

Nete Schwennesen, Department of Anthropology, Faculty of Social Sciences
Discipline: Anthropology of life and health, aging, technologies, community studies

Maria Kristiansen, Department of Public Health, Faculty of Health and Medical Sciences
Discipline: Health services research, mixed-methods, intervention studies, personcentred care, and inequality

Rationale, focus, and aims

Retirement is a critical life transition that can have profound consequences for an individual's health and well-being. The aim of this research track is to analyze how behavior and social contexts interact in shaping successful responses to critical transitions in later life. We will use retirement as a key example, but will extend the analysis to include other aging-associated transitions such as onset of disease, bereavement, functional decline or change of living conditions. This will enable us to gain a broader understanding of the antecedents, dynamics, and consequences of these transitions. Such knowledge is critical for developing deeper insight into aging as a process that reflects constant interaction between social and biological stress factors, as well as social and biological factors that support resilience and damage repair. Based on the results of these explorations, we will collaboratively develop interventions and outreach projects that support coping with transitions in later life.

Organizational developments

Lisbeth Trille Loft has left UCPH. – The funding for her project is re-allocated to Stine Møllegaard, but Loft remains affiliated with Department of Sociology and the project.

Erik Lykke Mortensen has retired. Psycho-social aspects of retirement are now covered in Paul Conway's group.
Staff has been hired, hereof i.a. an Associate Professor and a PhD student. Furthermore, several PhD students, Postdocs, and one Assistant Professor were recruited in 2019 and they are expected to start in the beginning of 2020.

Key achievements

Key achievements in 2019 include the start of many new projects and groups that have not previously been part of Center for Healthy Aging. The individual groups have been developing project frameworks, specific strategies and focus areas. Recruitment of skilled research staff is another key achievement for the new groups.

Other key achievements include the development of internal management and coordination structures as well as engaging with external project partners. Track II researchers have success-

fully applied for supplementary funding (see "Overview of key research achievements", pp. 17).

These activities have established a firm platform for specific research projects and groups and fieldwork and data collection has already begun, in collaboration with research partners.

Furthermore, we have been actively engaged in communicating with a wide range of societal stakeholders, in an effort to strengthen the societal impact of our work.

Overview of key research achievements

- Track II researchers Karsten Vrangbæk and Maria Kristiansen are a part of and contributed to the successful application for the ACUTE CAG, granted by the Capital Region;
- Karsten Vrangbæk, Nete Schwennesen and Henriette Langstrup obtained a grant from the Danish Agency for Science and Higher Education within the International Network Programme. – "Technology assisted healthy aging in Denmark and Japan";
- Karsten Vrangbæk and Rikke Lund participated in the European Region Congress of the International Association of Gerontology and Geriatrics in Gothenburg in May 2019;
- Nete Schwennesen obtained a grant from the Danish Alzheimer Association for her PhD project 'Surveillance and care in dementia';
- Nete Schwennesen obtained two grants from the Copenhagen Healthtech Solutions (CACHET) for two PhD projects in collaboration with DTU (Associate Professor Philip Cash & Associate Professor Jaap Dalhuizen;
- Nete Schwennesen obtained an international Visiting Fellowship, to host Associate Professor Daniel Lopez Gometz, University of Catalonia, the Department of Anthropology, KU;
- Line Hillersdal hosted the Association for Interdisciplinary Studies international seminar on innovative games and tools for collaboration: CoNavigator (with Postdoc Katrine Lindvig and Designer David Earle), Amsterdam Oct 2019;
- Line Hillersdal hosted the international seminar: Silent Rationing and New Collectives (with Professor Mette Nordahl Svendsen, Associate Professor Jeanette Knox, Postdoc Laura Navne), Copenhagen Oct 2019;
- Line Hillersdal hosted the international workshop: Training for trainers: Navigating contexts and collaborations, Leicester Institute for Advanced Studies, UK (with Postdoc Katrine Lindvig and designer David Earle) June 2019;
- Line Hillersdal hosted a seminar on patient participation and healthcare teams: Canada, Denmark, Sweden & US (with PhD fellow Kelly Kilgour, Assistant Professor Katri Manninen, Assistant Professor Renée K. Nicholson), Amsterdam Oct 2019;
- Maria Kristiansen obtained funding for an intervention project in collaboration with the Ophthalmology Department, University Hospital Roskilde, Region Zealand;
- Maria Kristiansen enrolled two industrial PhD students in collaboration with the Danish Heart foundation;
- Maria Kristiansen obtained additional funding for the study on person-centered care for older patients with multi-morbidity, which has been initiated in close collaboration with the Nephrology Department at Rigshospitalet, the Capital Region;
- Maria Kristiansen received a grant to establish a longer-term program with leading researchers in the Knowledge Translation Unit at the Mayo Clinic, Minnesota, the US;
- Maria Kristiansen obtained three grants under the EIT Health Campus programme focusing on citizen and patient engagement, and collaborations between academia, industry and society;
- Maria Kristiansen obtained a grant for a study on person-centered care for Parkinson Disease patients and their relatives;
- Maria Kristiansen obtained a network programme grant from the Nordic research council to establish seminars with Norwegian and Finnish university partners and external stakeholders;
- In collaboration with Statistics Denmark, Region Zealand and a scholarship student, Anna Vera Jørring Pallesen, Maria Kristiansen completed a study on inequality in colorectal cancer screening among older patients funded by an external grant;
- Maria Kristiansen was selected for UCPH Forward: Talent Programme for Excellence in Research", University of Copenhagen.

Selected publications

Kousgaard, MB, Scheele, CE & Vrangbæk, K 2019, 'Inter-Sectoral Collaboration in Municipal Health Centres: A Multi-Site Qualitative Study of Supporting Organizational Elements and Individual Drivers. International Journal of Integrated Care', *International Journal of Integrated Care*, bind 19, nr. 2, s. 1-11. https://doi.org/10.5334/ijic.4196.

Scheele, CE, Vrangbæk, K & Kriegbaum, M 2019, 'Volunteer Association Perceptions of Municipal Policy Strategies to Promote Co-production of Healthy Ageing Services', *Ageing & Society*, bind 39, nr. 6, s. 1152-1171. https://doi.org/10.1017/S0144686X17001453.

Schwennesen, N. In between Bricolage and repair: Digital Entanglements and fragile connections in dementia care work in Denmark, in Alexander Peine, Louis Neven, Wendy Martin, Barbara Marshall (eds) *Socio-Gerontechnology : Interdisciplinary critical studies of ageing and technology*. Routledge (forthcoming).

Mikkelsen HH, Schwennesen N & Lassen AJ (eds) Introduction: Energy and Aging in the Danish Welfare State: Ethnographic Explorations of an Omnipresent but Forgotten Concept. *Anthropology and Ageing*, Special issue on ageing in the Danish Welfare State, 2019.

Hillersdal, L., Jespersen, A. P., Oxlund, B. & Bruun, B., (2019) Affects and Effects in Two Interdisciplinary Projects on Obesity and Cholesterol Lowering Medicine at the University of Copenhagen Science & Technology Studies. Online ahead of print.

Lund R, Christensen U, Mathisen J, Sørensen KS, Srivarathan A, Molbo M, Halby K, Kristiansen M. Health, well-being and social relations in a changing neighbourhood: protocol for a prospective, multi-methods study of the consequences of large structural changes in an ethnic diverse social housing area in Denmark. BMJ Open,9(6):e030936, 2019.

Srivarathan A, Nedergaard Jensen A, Norredam M, Kristiansen M. Community-based interventions to enhance healthy aging in disadvantaged areas: perceptions of older adults and health care professionals. BMC Health Services Research, 19: 1-9, 2019.

Mikkelsen ASB, Dragsted AC, Kristiansen M. Social interventions targeting social relations among older people at nursing homes: a qualitative synthesized systematic review. INQUIRY: The Journal of Health Care Organization, Provision, and Financing, 56:46958018823929, 2019.

Foverskov E, Petersen GL, Petersen JLM, Mortensen EL, Rod NH, Lund R. Economic hardship over twenty-two consecutive years of adult life and markers of ageing: physical capability, cognitive function and inflammation. Accepted for publication in Eur J Aging June 2019.

Kriegbaum M, Andersen I, Brønnum-Hansen H, Hougaard C, Lund R. A life course analysis on income and incident AMI: a Danish register based cohort. 2019 Epub ahead of print, doi:10.1136/jech2018-212043.

PhD dissertations completed in 2019

Gitte Lindved Petersen: "Socioeconomic position across the life course and physical capability in late-middle age". Spring 2019.

RESEARCH TRACK III

INDIVIDUALIZED HEALTH

GROUP LEADERS

Flemming Dela, Department of Biomedical Sciences, Faculty of Health and Medical Sciences
Discipline: Diabetes, metabolism, physical activity, exercise, cardio-vascular diseases, mitochondrial physiology

Rudi Westendorp, Department of Public Health, Faculty of Health and Medical Sciences
Discipline: Geriatric medicine and all disciplines related to aging research

Jørn Wulff Helge, Department of Biomedical Sciences, Faculty of Health and Medical Sciences
Discipline: Aging, training, insulin resistance, metabolism, inactivity

Vilhelm Bohr, Department of Cellular and Molecular Medicine, Faculty of Health and Medical Sciences
Discipline: Aging, DNA repair, neuroscience, metabolism, neurodegeneration

Rationale, focus, and aims

Individualized health entails focusing on individual responses to interventions and life-course trajectories, i.e., zooming in on the biological, psychological, and social factors that determine individual characteristics, such as those resulting in "responders" and "non-responders". In this research track, we will broaden the understanding of the phenotypic characteristics that render every individual unique. We will also explore how the classic determinants of age—chronological or biological in nature—may be different from an individual's understanding and experience of age. The findings will offer explanations for different outcomes among individuals exposed to the same intervention. In the future, average values for groups will be less important than individual responses, and individualized health will have a major impact on how trajectories of aging and life-course exposures are understood.

Organizational developments

Associate Professor (Julien Ochala, PhD, from Kings College, London) has been recruited to Xlab, effective April 2020.

The Westendorp Group, which runs the project CHALLENGE on big data, makes a joint investment combining the strengths of the Danish data repositories, computational analysis, and research into aging (see "CHALLENGE – Big data", pp. 27).

Key achievements

We work with human healthy aging and diseases associated with aging. This is directly relevant to the societal challenges associated with population aging. For example, Xlab has fruitful scientific collaborations with clinical geriatric departments in Regions H and S, such as CopenAge (https://copenage.ku.dk/). CopenAge is a research center for clinical studies on aging by both basic and clinical research scientists.

Concerning CHALLENGE, the Westendorp Group is collaborating with Leibniz Institute for Prevention Research and Epidemiology and Copenhagen Municipality to develop machine learning algorithms to predict which older persons are at greatest risk of declining health. The Westendorp Group coordinates the project, gathers the data, and performs the scientific analyses. Using registry data, they analyze how patterns of health, socioeconomic, and environmental status change over time, in order to develop self-learning predictive algorithms.

Overview of key research achievements

- Statin studies in humans: no interference with exercise training ability; Q10 supplements do not affect mitochondrial function; delineating the history of statin use as a treatment in Denmark;
- The ability to combust lipids is of major importance for performance in long-term endurance exercise;
- High intensity interval training is tolerable and improves insulin sensitivity in patients with type 2 diabetes;
- Teamsports, such as handball and football, elicit favorable health effects among elderly people;
- Mitochondrial function in skeletal muscle, adipose tissue is of importance in cardiovascular diseases, such as ischemic heart

disease. However, it is not involved in the acute phase of cardiac arrest;
- NAD+ supplements may influence mitochondrial function in liver;
- Antioxidant supplements may affect insulin sensitivity in elderly individuals;
- Description of age-related macular degeneration as the consequence of age-related random accumulation of molecular damage in the eye/retina and the systemic inflammatory response to that damage;
- Description of interactions between hormones from interlinked as well as different hypothalamic-pituitary-target gland axes in healthy older individuals;
- Demonstration that senescence occurs at different levels in different human tissues/organs from the same individual, as previously observed in animal models;
- A 1 year treatment with levothyroxine had no effect on bone health in older adults with sublinical hypothyroidism;
- The impact of (I)ADL disabilities on life satisfaction in community-dwelling older people decreases with age and these associations are not affected by psychosocial factors;
- In adults aged 80 years and older with subclinical hypothyroidism, treatment with levothyroxine, compared with placebo, was not significantly associated with improvement in hypothyroid symptoms or fatigue;
- Empirical support for evaluating the effect of perceived stress on the risk of dementia in old age;
- Demonstration that neither night shift work nor long working hours increases dementia risk;
- Observation of limited evidence for a link between senescence in skin and in immune system cells in individual patients.

Selected publications

Morville T, Dohlmann T, Kuhlman AB, Monberg T, Torp M, Hartmann B, Holst JJ, Larsen S, Helge JW, & Dela F (2019). Glucose homeostasis in statin users-The LIFESTAT study. Diabetes Metab Res Rev 35, e3110.

Halling JF, Jessen H, Nøhr-Meldgaard J, Buch BT, Christensen NM, Gudiksen A, Ringholm S, Neufer PD, Prats C, Pilegaard H. PGC-1α regulates mitochondrial properties beyond biogenesis with aging and exercise training. *Am J Physiol Endocrinol Metab*. Sep 1;317(3):E513-E525, 2019.

Larsen S, Dandanell S, Kristensen KB, Jorgensen SD, Dela F and Helge JW. Influence of exercise amount and intensity on long-term weight loss maintenance and skeletal muscle mitochondrial ROS production in humans. *Appl Physiol Nutr Metab* 44: 958-964, 2019.

Sogaard D, Baranowski M, Larsen S, Taulo LM, Munk SC, Vestergaard AC, Greve DS, Dela F and Wulff HJ. Muscle-Saturated Bioactive Lipids Are Increased with Aging and Influenced by High-Intensity Interval Training. *Int J Mol Sci* 20(5), 2019.

Morville T, Lovsø Dohlmann T, Birk Kuhlman A, Eg Sahl R, Kriegbaum M, Larsen S, Dela F, Wulff Helge J. Aerobic exercise performance and muscle strength in statin users – the LIFESTAT study. *Medicine and Science in Sports and Exercise*, 51(7):1429-1437, 2019.

Rozing MP, Durhuus JA, Krogh Nielsen M, Subhi Y, Kirkwood TB, Westendorp RG, Sørensen TL. Age-related macular degeneration: A two-level model hypothesis. Prog Retin Eye Res. 2019 Dec 30:100825.

van der Spoel E, Roelfsema F, Akintola AA, Jansen SW, Slagboom PE, Westendorp RGJ, Blauw GJ, Pijl H, van Heemst D. Interrelationships between pituitary hormones as assessed from 24-h serum concentrations in healthy older subjects. J Clin Endocrinol Metab. 2019 Dec 19. pii: dgz253.

Puvill T, Kusumastuti S, Lund R, Mortensen EL, Slaets J, Lindenberg J, Westendorp RGJ. Do psychosocial factors modify the negative association between disability and life satisfaction in old age? *PLoS One.* 2019 Oct 31;14(10):e0224421.

Nabe-Nielsen K, Hansen ÅM, Ishtiak-Ahmed K, Grynderup MB, Gyntelberg F, Islamoska S, Mortensen EL, Phung TKT, Rod NH, Waldemar G, Westendorp RGJ, Garde AH. Night shift work, long working hours and dementia: a longitudinal study of the Danish Work Environment Cohort Study. *BMJ Open*. 2019 May 24;9(5):e027027.

Fang EF, Hou Y, Palikaras K, Adriaanse BA, Kerr JS, Yang B, Lautrup S, Hasan-Olive MM, Caponio D, Dan X, Rocktäschel P, Croteau DL, Akbari M, Greig NH, Fladby T, Nilsen H, Cader MZ, Mattson MP, Tavernarakis N, Bohr VA (2019). Mitophagy inhibits amyloid-β and tau pathology and reverses cognitive deficits in models of Alzheimer's disease. *Nature Neuroscience.* 22 (3), 401-412, 2019.

PhD dissertations completed in 2019

Stine Dam Søndergård: "The production of reactive oxygen species in response to glutathione supplementation and acute exercise in patients with type 2 diabetes". 1 April 2019.

Shunlei Duan (Bohr and Rasmussen): "Identification of novel RECQL4 interacting proteins in maintenance of genome stability". PhD defense 6 December 2019.

INTERVENTION STUDIES AND INTERDISCIPLINARY PROJECTS

Identification of predictors for cognitive function

KEY RESEARCHERS

- Martin Lauritzen, Professor (PI, Track I)
- Erik Lykke Mortensen, Professor (Track II)
- Lene Juel Rasmussen, Professor (Track I)
- Merete Osler, Professor (Not affiliated with the Center)
- Rikke Lund, Associate Professor (Track II)
- Egill Rostrup, Associate Professor (Track I)
- Krisztina Benedek, Consultant (Track I)

What impact will this proposed research have on human health?

The proposed research is expected to 1) improve understanding of human aging, including aging-related neurological disease, AD and other dementias, 2) facilitate the search for effective, personalized anti-aging interventions, and 3) provide tools that enable individuals to live healthier lives. The potential impact of this project on human health is very high, in that it directly addresses societal concerns and challenges related to worldwide population aging.

This research program explores the cumulative effect of morbidity on brain function at different life stages in a Danish Birth Cohort, Danish men born in 1953. The primary aim is to identify factors that influence or predict cognitive function, especially as relevant to cognitive decline in middle or late life.

Methods: Cognitive test scores at a single point in time in midlife reflect individual differences in age-related decline, as well as inherent individual differences in cognitive ability/potential throughout life. Members of the Copenhagen Metropolit Cohort were cognitively-assessed as young adults at time of conscription. A subset of this cohort was also tested for cognitive function in midlife (i.e., CAMB 2009). These data and new data collected since 2010 at the National Hospital (Rigshospitalet) in Copenhagen include structural and functional MRI studies, cerebral rhythmic activity (EEG) patterns, evidence of inflammation, sleep data and molecular and genetic data that shed light on the contributions of genetic risk factors for cognitive decline. The project involves a collaboration with other groups in the Center for Healthy Aging, other Institutions in the Capital region of Denmark and nationally, and research groups in other countries including but not limited to Oxford University. Several predictive markers for aging-associated cognitive decline have been identified. The findings from the human studies have been replicated in rodents, and provide important mechanistic information on brain aging.

Progress and results: We have examined cognitive performance of more than 520 males from our birth cohort one or more times. The test-persons were without evidence of differences in IQ when cognitive function was assessed at draft board examination (baseline), but with important differences when they were 58 years old, and at age 61-63. All the participants have now been re-invited to one more follow-up study, which will include the comprehensive test battery described above in the Methods section. These follow-up examinations began in 2018 and will be complete by 2021. In addition to the follow-up examinations, we have enlarged the cohort of test-persons to 319 individuals. These and other data were analyzed, revealing differences in sleep quality, mitochondrial function, nucleotide metabolism, telomere length and structural and functional MRI when test-persons were stratified according to higher or lower cognitive performance. In addition, we have shown that EEG correlates of visual short-term memory in older age vary with adult lifespan cognitive development and provide a clinical tool that can be used to examine cognitive status in old age. In animal model systems, we have identified unique features of brain repair mechanisms in astrocytes linked to aging and dysregulation of interneurons during normal aging. Our rodent data also show decreased activity of the mitochondrial complex 1 and increased mitochondrial size heterogeneity; these observations suggest that lower mitochondrial quality may be an early sign of brain aging. Most recently we have provided evidence of increases in activity in of brain astrocytes in aged rodents, which may be of key importance for an understanding of brain frailty in older individuals.

Conclusions: We have identified potential markers of middle and late life cognitive decline in a birth cohort of Danish men. Additional studies are underway to confirm the results, demonstrate reproducibility and to increase sensitivity and specificity of biomarker assays. Ultimately, we envision that these novel findings will lead to novel strategies or tools for diagnosing and preventing brain aging, thus promoting healthier late life years for the elderly.

Intervention project on physical activity – LISA Project

KEY RESEARCHERS
- Michael Kjær, Professor (PI, Track I)
- Erik Lykke Mortensen, Professor (Track II)

The study has significant societal importance, in that it evaluates and could in future predict the long-term effects of interventions based on physical strength training in elderly individuals at or near retirement age.

In this multidisciplinary randomized controlled trial (clinicaltrials.gov: NCT02123641), a blinded assessor allocated the participants to either a) supervised, heavy resistance training (HRT, n=149, 3/wk), b) moderate intensity resistance training (MIT, n=154, 3/wk) or c) non-exercise activities (CON, n=148). 451 participants were randomized (62-70 yrs, women 61%, ≈80% with a chronic medical disease) and 419 were included in the intention-to-treat analysis (n=143, 144 and 132; HRT, MIT and CON). Changes in muscle power (primary outcome), strength and size, physical function, body composition, hippocampus volume and physical/mental well-being were analysed.

In the LISA intervention study, all have completed a 1-year intervention (only 6% drop out rate) with 83% of the subjects involved in training intervention completing at least 2/wk (=66% of all training sessions). All subjects have now completed 2-year tests (1 year after intervention) and 60% of subjects have completed 4-year test.

Leg extensor power (primary outcome) was unchanged in all groups and no effect of training was found. However, strength training had positive effects on several secondary outcomes including isometric knee extensor strength and muscle mass, whereas an increased cross-sectional area of vastus lateralis muscle, a decreased whole-body fat percentage and visceral fat content occurred in HRT only. Further, chair-stand performance and 400 m walking time improved in all groups. Hippocampus volume decreased in all groups over time with no influence of strength training, whereas mental health (SF-36) improved more in HRT than MIT.

Conclusions: Together, the results indicate that leg extensor power did not change in response to long-term supervised strength training; however, this type of training can be implemented in both healthy and chronically-diseased elderly individuals, and with good compliance, induces consistent changes in physiological parameters of muscle strength, muscle mass and abdominal fat.

Social relations and healthcare utilization among middle-aged and older people: an implementation and registry-based study in Denmark

KEY RESEARCHERS
- Anne Sophie Bech Mikkelsen, PhD Student (Track II)
- Maria Kristiansen, Associate Professor (Track II)
- Rikke Lund, Professor (Track II)

This Track II project explores the relationship between social relations and healthcare utilization among Danish middle-aged people by linking cohort data with data from Danish national registries. This is supplemented by qualitative data on individual and contextual factors affecting the implementation of a group-based life story intervention among frail older people in nursing homes in Denmark. Finally, a systematic review of effects of group-based interventions to enhance social relationships among older people in nursing home settings has been completed. Preliminary findings indicate that interventions in nursing home settings hold potential for enhancing social relations among residents; however, there is mixed evidence for efficacy in the current scientific literature. Qualitative findings indicate that professionals find the intervention successful and relevant. While the participants expressed satisfaction, they also indicated that they did not establish new relationships as a result of the intervention. Preliminary findings also indicate barriers for successful implementation of the intervention, such as; 1. Differences in physical capacity and cognitive function among participants, 2. Lack of time (for the healthcare professionals) and 3. Competing activities at the nursing homes. We expect the results to improve understanding of patient use of healthcare services, which could inform implementation of future interventions targeting frail older people in nursing homes. Co-author of this study, Anne Sophie Bech Mikkelsen, plans to submit these results as part of her PhD thesis in June 2020, with thesis defense expected in fall 2020.

Health, well-being and social relations in a changing neighborhood (STRIT)

KEY RESEARCHERS
- Rikke Lund, Professor (Track II)
- Abirami Srivarathan, PhD Student (Track II)
- Siv Nygaard, PhD Student (Track II)
- Catharina Thiel Sandholdt, Postdoc (Track II)
- Gritt-Marie Hviid Malling, Research Assistant (Track II)
- Maria Kristiansen, Associate Professor (Track II)

"Health, Well-being and Social Relations in a Changing Neighborhood" (in Danish: "Sundhed, Trivsel og Relationer i Taastrupgaard", STRIT) is a mixed-methods longitudinal study initiated in January 2018. The study investigates changes in well-being, health and social relationships in a large social housing community in the Høje Taastrup municipality, and it builds on a previous intervention study conducted under CEHA II in the same community. The community is undergoing large-scale (900 mill. DKK) changes over the coming years in the built environment/housing, recreational areas, infrastructure and institutions. At the same time, the community has been affected by recent policy changes related to the so-called "ghetto act" that envisions similar restructuring of the built environment and changes in population demographics in selected areas across Denmark. How such changes will affect residents of this and similar communities is unknown.

The 4-year longitudinal study spans the period before, during and after these structural changes to the community are implemented. In the observational parts of the study, annual surveys in 8 languages and qualitative interviews as well as register-based information are used to explore effects of structural changes on health, well-being and relationships from the point of view of middle-aged and older adults living in the community. Register-based data from a similar community located in the same municipality was used as a control/comparison population. Based on the initial needs assessment and with user-involvement, healthy aging interventions were then developed and evaluated in close collaboration with the community, key stakeholders from the municipality and volunteer organizations.

The second wave of surveys were administered between September 2019 and-December 2019. The survey corps included 12 interviewers speaking Danish and one of the other available seven languages. Interviewers went door-to-door and administered the survey to all residents >45 years old. During the data collection, the interviewers experienced a certain "research fatigue" and frustration among the residents regarding the demolition process, which appeared to create reluctance to participate in the survey. The data collection process was evaluated in January 2020 and all metadata from residents and interviewers have been documented and will be used as appropriate.

The first intervention was implemented in 2019. It focused on building relations between residents and increasing well-being and community belonging through shared experiences organized by the STRIT-project. In collaboration with the residents living in the area, it was decided that the first intervention should consist of four bus trips to destinations outside the area of Taastrupgaard, through which the residents hoped to improve existing and develop new relationships with their neighbors, while meeting on neutral ground. The bus trips were a great success and it was observed that residents during the intervention-period became more open and interactive towards each other.

The second intervention will be implemented in 2020, and will draw heavily on the knowledge and relations established in the first intervention, as access to the field – especially in disadvantaged neighborhoods – are central to all qualitative studies. Therefore, a key element of this intervention is to draw on already-formed relations between residents and researchers, and more importantly to draw on existing relations within the resident group. As with the first intervention, the second intervention will focus on community-belonging and what we define as community collectives. This will be done by generating community narratives using graphical facilitation on both individual and collective levels.

LIFESTAT

KEY RESEARCHERS

Faculty of Health and Medical Sciences

- Flemming Dela, MD, DMSci, Professor (PI, Track III)
- Jørn Wulff Helge, PhD, Professor (Track III)
- Allan Krasnik, MD, DMSci, Professor (Not affiliated with the Center)
- Lene Juel Rasmussen, PhD, Professor (Track I)
- Ian Hickson, PhD, Professor (Track I)
- Steen Larsen, DMSci, Associate Professor (Track III)
- John S. Andersen, MD, PhD. Associate Professor (Not affiliated with The Center)
- Margit Kriegbaum, PhD, Postdoc (Not affiliated with the Center)
- Thomas Morville, MD, PhD (Not affiliated with the Center)
- Anja Birk Kuhlmann, MD, PhD (Not affiliated with the Center)
- Tine Dohlmann, PhD (Not affiliated with the Center)
- Anders Heltberg, MD, PhD (Not affiliated with the Center)

Faculty of the Humanities

- Christa Lykke Christensen, PhD, Associate Professor (co-PI, not affiliated with the Center)
- Kasper Liisberg, PhD (Not affiliated with the Center)
- Faculty of Social Sciences
- Bjarke Oxlund, PhD, Associate Professor (Not affiliated with the Center)
- Birgitte Bruun, PhD. Postdoc (Not affiliated with the Center)
- Sofie R. Lau, PhD (Not affiliated with the Center)

LIFESTAT is an interdisciplinary project that leverages approaches and knowledge from medicine, the humanities and the social sciences to analyze the impact of statin use on health, life-style and well-being in a cohort of Danish citizens. The impetus for the study is the fact that 600,000 Danes take statins in order to lower blood cholesterol and reduce risk of cardiovascular disease (CVD). Nearly 40% of these individuals are being treated with statins based only their high blood cholesterol; in these individuals, statins are prescribed for the purpose of 'primary prevention' of CVD. However, the potential benefit of treatment with statins should be considered in light of evidence that statin-use has serious and prevalent side-effects, including skeletal muscle cell death, muscle pain, and low exercise tolerance, which in turn discourages adherence to recommended regimens for regular exercise. Furthermore, glucose intolerance (a risk factor for type 2 diabetes) can be seen as a side-effect of statin use.

Objective: To study the biological consequences of statin use, focusing on muscle metabolism and function.

Approach: Three studies on approximately 150 patients: 1) Cross-sectional study on statin-users with and without myalgia and control subjects (not taking statins). 2) Eight week study of statin-users given or not given Co-enzyme Q10 supplement. 3) Eight week longitudinal study including a physical activity intervention (supervised cycling 3x per week for 8 weeks).

Methods: Clinical and biochemical analyses were conducted to quantify insulin sensitivity and secretion, fitness and muscle strength, blood chemistry, muscle and fat metabolism, mitochondrial respiration and mitochondrial ROS.

Goal: To identify potential mechanism(s) underlying statin-induced myalgia.

Status: Primary funding came from the University of Copenhagen UCPH Excellence Programme and it was funded for 5 years (2013-2017). The majority of data has been published (including 7 PhD dissertations), however some data are still in process and some papers are under submission. Full list of publications can be seen at www.lifestat.ku.dk and further information at www.kolesteroldialog.dk.

Eccentric training for healthy elderly people

KEY RESEARCHERS

Faculty of Health and Medical Sciences

- Flemming Dela, MD, DMSci, Professor (PI, Track III)
- Signe Regnersgaard, Student (Track III)
- Anna K. Knudsen, Student (Track III)
- Filippa O. Lindskov, Student (Track III)
- Marija Mrantinkovic, Student (Track III)
- Eckart Pressel, MD Chief Physician (Not affiliated with the Center)

Eccentric exercise is of particular interest in the search for effective methods for preventing sarcopenia. However, the potential benefit of additional workload during eccentric exercise is not well studied. The objective of this study was to investigate the applicability and muscle response to eccentric training, where healthy elderly study subjects performed descending stair-walking with and without extra weight vs ascending stair-walking without extra weight. Study participants (N=32, mean age 70±3 yrs) were randomly assigned to a group performing concentric work by ascending stair walking (CON), a group performing eccentric work by descending stair walking (ECC) or a group performing eccentric work by descending stair walking while carrying 15% of bodyweight as extra weight in a weight vest (ECC+). The intervention lasted for 3 or 6 weeks over 9 or 18 total sessions, respectively. We found that the ECC+ group reported no increase in perceived exertion and demonstrated improved muscle function and performance after only 9 sessions. Furthermore, the results indicate that eccentric exercise is superior to concentric exercise in terms of 6MWT and leg strength.

Biological age: A reinforced health tool to combat obesity

KEY RESEARCHERS

Faculty of Health and Medical Sciences

- Jørn Wulff Helge, PhD, Professor (PI, Track III)
- Karina Husted, PhD Student (Track III)
- Pernille Hulst, Master Student (Track III)
- Mathilde Fogelstrøm, Master Student (Track III)
- Steen Larsen, Associate Professor (Track III)
- Flemming Dela, Professor (Track III)
- Jens Christian Brings Jacobsen, Associate Professor (Not affiliated with the Center)
- Kaj Åge Henneberg, Associate Professor (Not affiliated with the Center)

Biological age is widely used as a health tool, but validation and documentation of its significance is insufficient. Here we study biological age as used in private workplace health companies and in the fitness and health industry. Furthermore, we sample a broad dataset on biological age to optimize and check quality of measurement, allowing us to subsequently validate the measurements in a "real-life" lifestyle-intervention. Overall, we intend to qualify the application and utilization of biological age to support better lifestyles.

CHALLENGE – Big data

KEY RESEARCHERS

- Majken Jensen, Professor (Track III)
- Laust Mortensen, Professor (Track III)
- Rudi Westendorp, Professor (PI, Track III)
- Amy Clotworthy, Postdoc (Track III)
- Sasmita Kusumastuti, Postdoc (Track III)

The continuous increase in life-expectancy and lengthening of disease trajectories are causing profound upheaval at the individual and societal levels. The majority of people >65 years old suffer multiple morbidities and polypharmacy is the rule. Age is the most important single risk factor for manifold diseases such as diabetes, cancer and dementia, but it is too often ignored as the underlying causal mechanism. Our vision is to better understand the process of human aging, to interfere in the biomolecular process, and to prevent and delay the onset of morbidity. The mission is to bring together excellent researchers with complementary expertise in order to go beyond traditional reductionist approaches to understanding human aging. The research goal is to develop novel methods to generate high-throughput computer-assisted analyses of exceptional datasets.

First, we will analyze the life-histories of people with fast and slow aging trajectories in the general population to identifying the contributing life events, rather than just being able to predict outcomes. Second, we will detect the pathological, morphological and molecular biomarkers of aging in samples of human tissue, generating unprecedented opportunities for (nested) case control studies and Mendelian randomization for causal inference. Third, through matching approaches of statistical- and actual sampling, as well as through experimental perturbation of biological systems, we will decipher the molecular interplay between nuclei and mitochondria in aging cells.

These concerted actions will put in place a durable and flexible systems-wide-strategy that will open up opportunities to obtain a fuller understanding of the aging process and aid the search for specific diagnoses, personalized therapies and healthier lives.

The study is a collaboration with Leibniz Institute for Prevention Research and Epidemiology, which is developing a new machine-learning method called recurrent neural networks for time-to-event predictions with competing risks. Based on that method, four fundamental principles were implemented in our method, as follows: 1. We aim to predict probabilities of using chronic care services at time points in the future for older individuals. Therefore, it is a time-to-event or survival outcome and censoring is applied to take into account when individuals are moving in or out of the municipality etc. 2. Other events can occur before the event of interest, e.g. death or hospitalization. Therefore, we need to apply competing risks in modelling the algorithms. 3. Prediction is based on progression of predictors over time, such as medical history for the last five years. Therefore, our methods need to incorporate these variables. 4. We need a method capable of handling and analyzing the anticipated volume of data. Copenhagen Municipality will provide insight on how they deliver care to older persons and will provide data to further improve the machine-learning algorithms.

COMMUNICATION AND OUTREACH

There is an urgent need to change and adapt the existing health care system to the demands and needs of an aging population. In responding to this urgent need, Center for Healthy Aging is uniquely positioned to disseminate, implement and see immediate impact from its leading edge research on human aging, because the Center's research goal is to prepare society for a future where citizens live longer, but also healthier and more meaningful lives. Therefore, we engage and collaborate with relevant stakeholders and pursue an outreach programme that is responsive to the needs of both municipalities and health care professionals. Over the years, the Center has worked ever more closely with stakeholders to ensure that the results of its research are properly and effectively implemented to have direct benefit on citizen quality-of-life. In 2019, we have strengthened our relationships with key stakeholders and worked to break down barriers that make it difficult to achieve common goals.

Engaging with professionals and citizens

Center for Healthy Aging works strategically to put knowledge about healthy aging on the agenda and ensure that our research forms the basis for recommendations to both decision-makers and citizens. We work across multiple media and seek to be engaging, innovative, and collaborative. Our methods are adjusted to specific settings, target groups, media platforms, and messages as illustrated in the following examples.

Together with Center for Team Sports and Health, University of Copenhagen and several sports associations, the Center hosted a conference on *Physical activity and aging – from research to practice* for authorities, municipalities and sports organizations. More than 120 people attended. Research based recommendations on the positive differences for the health and well-being of the elderly through physical activity were presented alongside presentations from health professional and others working in the field. On the day of the conference, the Danish National newspaper Kristeligt Dagblad published a column addressed to the Ministers for Health and Senior Citizens, which was co-signed by eight University of Copenhagen researchers who participated in the conference.

Along with the Danish Science Festival (Forskningens Døgn) and Copenhagen Culture Night, the Peoples Political Festival has an important place for the Center. The festival is a platform for open debate and informal dialog between politicians, citizens, the business community, and civic organizations (114,000 visitors in 2019). This festival is especially important in relation to the Center's stakeholders, in that it provides an opportunity to strengthen our agenda, disseminate our research results to a diverse audience, and highlight the accomplishments of individual researchers. In addition, Center scientists develop ideas for new research projects, initiate new research collaborations and improve their communication skills.

One event at the festival this year was co-organized with the largest elderly organization in Denmark, DaneAge (more than 880,000 members in 2019). The event was on how to create a successful transition from working life to retirement. The director, Henrik Lehmann Andersen from Nordea-fonden, and Postdoc Aske Juul Lassen participated in a debate on this topic. In another event, Associate Professor Maria Kristiansen participated in a debate hosted by the Faculty of Science on inequality in health. Participants included two MPs Kirsten Normann Andersen from the Socialist People's Party, and Per Larsen from the Conservative People's Party. The Center also hosted an entertaining quiz with invited stakeholders.

Center for Healthy Aging also participated in the Danish Science Festival and Copenhagen Culture Night in 2019. Thousands of people visited the Faculty of Health and Medical Sciences on Culture Night. Activities included strength and balance tests, heartbeat and heart atrial fibrillation measurement, and tours of the laboratories in the Mærsk Tower.

Messaging *active aging* through mass media and social media platforms

The communication officer's role is to facilitate and build bridges between researchers and journalists. The communication officer helps researchers find the right angle and the right media for his or her story, and then helps "sell" the story to journalists, or alternatively, the officer assists journalists in connecting with the relevant scientists/experts. Media coverage of the research activities in the Center for Health Aging increased from 87 articles in 2009 to 177 in 2019. During the past few years, journalists frequently sought contact with Center researchers, because of their

expertise in healthy aging, and this has increased coverage of Center activities and research results in local Danish newspapers and international newspapers.

In 2019, reports on research from Professor Vilhelm Bohr's group were among the two most popular stories on *Futurity*, an internet news site that features research from the top universities in the world, with more than 50,000 views. The reports described research demonstrating that a compound called NAD+ (derived from vitamin B3) prolongs lifespan and improves health span in animal models of the human premature aging disease called Werner Syndrome. These results lay the groundwork for clinical trials s to test the therapeutic value of NAD+ or an NAD+-related compound for treating Werner Syndrome.

In 2013, Center for Healthy Aging launched a Facebook page in Danish, as a forum for advice, to stimulate awareness and debate about healthy aging, and to promote "branding" of the Center. By the end of 2019, the page had more than 19,000 followers and a high engagement rate. We launched our Twitter account @sundaldring (which translates as healthy aging) in 2014. In December 2019, we had 342 followers, including politicians, leaders from The Health Authorities, elderly organizations and health professionals. The account is used to live-tweet from events, to promote awareness and interest in Center research activities, events and the achievements of our scientists.

Influencing the political agenda

The Center participates in political hearings on topics related to the elderly. These hearings have addressed legislation concerning, for example, social services, quality and standards of homecare, preventive homecare, dignity in eldercare, and the use of digital communication tools. This year, several Center researchers contributed to development of a National Action Plan National Action Plan for Good Elderly Living, working together with The National Health Authority of Denmark.

Long good lives on the agenda

For the last few years, Center for Healthy Aging has worked strategically with stakeholders, with the aim of engaging them in discussions on healthy aging and influencing the public agenda through research dissemination and dialog. The primary target groups are elderly organizations, municipal decision-makers, pension companies, government agencies, healthcare professionals, and selected patient organizations. These efforts were very fruitful, and have helped the Center prepare for successful future partnerships with our stakeholders.

One example is a collaboration with three municipalities on the transitions from working life to retirement. The project aims to ensure a smooth transition to retirement and much effort in 2019 has been put into developing common goals and plans for this project. Another example is an initiative lead by Professor Flemming Dela on rehabilitation of the elderly. Professor Dela and Professor Charlotte Suetta from the Department of Clinical Medicine, University of Copenhagen started Copenhagen Center for Clinical Age Research, CopenAge. In November, representatives from 19 municipalities attended a workshop on the rehabilitation of the elderly arranged by CopenAge, and Center for Healthy Aging. The purpose was to identify the areas where vocational professionals at the rehabilitation centers lack knowledge and how researchers can best support their needs. The project emphasizes collaboration among municipalities in order to improve elderly health and welfare. The project was featured in a debate article in Altinget, a national online political news site.

In the coming years Center for Healthy Aging will increase its focus on collaborating with target groups when developing outreach projects in order to benefit citizens.

Table 1. SOCIAL MEDIA ACTIVITIES, 2019

FACEBOOK	
Followers	19,232
Post per month	7
Reach year/month/post	321,569/27,047/4,215
Engagement rate	7%
TWITTER	
Followers	341
Posts	36
Reach year/month	30,399/2,533
Engagement	1,9%

INTERNATIONALIZATION AND NETWORKING

Center for Healthy Aging collaborates actively with institutions and networks in Denmark and around the world. These collaborations increase visibility and awareness of the Center and play a key role in strategic recruitment at all levels. Below, we describe some of these collaborations.

IARU – International research cooperation

Center for Healthy Aging is closely linked with the prestigious International Alliance of Research Universities (IARU, http://www.iaruni.org/), an important alliance that includes the University of Copenhagen. The association between Center for Healthy Aging and IARU is a cornerstone in the efforts to internationalize the Center as well as a valuable networking opportunity for members of the Center, who arrange meetings and workshops and utilize IARU as a mechanism for enhancing collaboration and future research activities. The joint research initiative IARU Aging, Longevity & Health (ALH) is an example of this. The other IARU members are Australian National University, ETH Zurich, National University of Singapore, Peking University, University of California, Berkeley, University of Cambridge, University of Cape Town, University of Oxford, University of Tokyo, and Yale University.

As part of the IARU cooperation, Center for Healthy Aging also hosts an annual summer course on *Interdisciplinary Aspects of Healthy Aging* (see "IARU Summer School – Interdisciplinary Aspects of Healthy Aging", pp. 38).

IARU Aging, Longevity & Health network

Since 2014, the ALH initiative has been led by a Steering Committee. The aim is to increase engagement across IARU campuses and to promote joint activities and funding opportunities for IARU ALH participants within the international aging research community. The Committee intends to meet once per year and was chaired by University of Oxford until fall 2019. Professor Nicolas Cherbuin from Australian National University (ANU) was recently appointed Chair of the Committee for the 2019-2021 period. The Committee members in 2019 were:

- Professor Lene Juel Rasmussen, University of Copenhagen
- Professor Nicolas Cherbuin, Australian National University (current chair)
- Professor Angelique Chan, National University of Singapore
- Professor Hiroko Akiyama, The University of Tokyo
- Dr Louise Lafortune, University of Cambridge
- Professor Sarah Harper, University of Oxford
- Professor David Lindeman, University of California, Berkeley
- Professor Xiaoying Zheng, Peking University
- Dr Sebastiana Kalula, University of Cape Town

On 29 October to 1 November 2019, ANU hosted the 6th ALH Steering Committee Research Meeting in Canberra, at which time ANU assumed chairmanship of the ALH Steering Committee. In addition, a number of initiatives and goals were discussed. These included 1) identifying an impactful journal for publishing a IARU research paper; 2) the need for a document on the importance of interdisciplinary international collaborations to study aging; and 3) the need for a leaflet outlining IARU activities, targeting stakeholders.

In addition to the ALH Steering Committee Research Meeting, four symposia sessions featuring 12 ANU and national speakers were held covering four themes: Chronic Disease, Brain Aging, Cognitive Decline, & Longevity; Work, Retirement & Health; Aging in Asia; and Mental Health & Wellbeing. The symposia were attended by more than 150 delegates, including senior staff from governmental departments.

Detailed information on IARU ALH can be found at http://www.iaruni.org/research-initiatives/aging.

EIT Health

In 2014, the European Institute of Innovation and Technology (EIT) launched a call for Knowledge and Innovation Communities (KICs), as part of the larger European Union (EU) research initiative, Horizon 2020. The aim of KICs is to encourage stakeholders in education, technology, research, business, and entrepreneurship to establish excellence-driven partnerships and provide innovative solutions to tackle the grand challenges (health, climate, bio economy, etc.) facing the EU. The winning consortium – EIT Health – today consists of more than 60 core partners (plus approximately 80 associate partners). These include leading businesses, public partners, research centers, and universities from 14 EU countries (including University of Copenhagen). At the University of Copenhagen, Center for Healthy Aging is a central player.

The goal of EIT Health is to promote entrepreneurship and develop innovations in healthy living and active aging, providing Europe with new opportunities and resources to improve quality of life and healthcare. This will be achieved by delivering products, services, and concepts designed to improve quality of life and contribute to the sustainability of healthcare across the EU. EIT Health revolves around three programmes: 1) *Accelerator* for business development, 2) *Campus* for education, and 3) *Innovation Projects* to support new ideas. Since the launch of EIT Health, Center for Healthy Aging has been involved in several activities in the *Campus Programme*.

PhD programme on aging

In 2019, Center for Healthy Aging has been part of a pan-European doctoral programme, Epidemiology of Ageing and Dementia Prevention, PhD Label (EpiDEMPrev), bringing together an EIT Health consortium consisting of academic and non-academic partners to train a new generation of PhD specialists in gerontology, neuroscience, and epidemiology with innovation and entrepreneurship competencies.

As part of the doctoral programme, the Center offered a PhD course focusing on *The complexity of understanding age-related disease*, led by Professor Rudi Westendorp. The course was a great success with eight PhD students from the consortium's partner universities as well as 11 PhD students from Danish and Scandinavian universities participating in the course, which took place from 4-7 November 2019.

Building on the preparatory year in 2019, an EIT Health PhD Programme will be launched in 2020, aimed at PhD students who are interested in building competences in innovation and entrepreneurship, to accelerate their research and solve future healthcare challenges.

Networks on transnational aging research

In October 2019, Center for Healthy Aging joined the Alliance for Healthy Aging, a partnership of the Mayo Clinic Robert and Arlene Kogod Center on Aging, the University Medical Center Groningen and the Newcastle University Institute for Ageing. Furthermore, the alliance now also includes the previous ABRAHAM network, which includes the above partners plus McGill University (Canada). The Alliance holds annual meetings dedicated to translational research on aging, with the objective to bring together scientists, clinicians and engineers, providing a forum for the exchange of ideas.

Since 2013, Center for Healthy Aging, together with the then ABRAHAM network, participated in these annual meetings. ABRAHAM aimed to create a transatlantic network with partners from the EU, US, and Canada to enhance integration in the field of biobanking and basic aging research in order to contribute to the goal set by the European Commission to add two extra healthy years to life by 2020. This collaborative effort harmonizes, standardizes and exchanges data and materials from biobank and cohort studies, facilitates shared use of infrastructures, facilities and expertise, and enables exchange visits of personnel to participating institutes exploring options for new projects and/or pilot studies.

Center for Healthy Aging has also an active collaboration with the division National Institute on Aging at National Institutes of Health (NIH/NIA) via Professor Vilhelm Bohr who is associated with the Center as a group leader in Track III. Professor Bohr has been instrumental in the establishment of Center for Healthy Aging. The close collaboration with Professor Bohr has been fundamental in securing excellent recruitments to the Center over the years, such as the Professors Ian Hickson and Linda Bergersen and Associate Professor Morten Scheibye-Knudsen and in sharing infrastructure with the NIH/NIA.

MouseAge

To ensure rapid progress, suitable mouse models are needed for the relevant basic preclinical studies on aging and for testing interventions for age-related pathologies. Coordinated interdisciplinary action is needed to standardize methodologies and guidelines for testing and evaluating interventions in mice, to protect animal welfare, and to define endpoints. A centralized model for storing and disseminating information about these models and technologies is also needed. Accordingly, MouseAge – in which Center for Healthy Aging participates – was launched in 2014 as a European COST Action network for preclinical testing of interventions in mouse models of aging and age-related diseases. This Action proposes to set-up a highly interactive and flexible European network of scientists with diverse expertise, clinicians, and industrial partners, who will be tasked to reach consensus around standardization for testing preclinical interventions in mice. MouseAge will also consolidate information on best practices across leading European institutions and laboratories, maximize efficiency, and provide a platform to help train the next generation of scientists. More information at https://www.mouseage.eu/.

Other international networking

Facing the challenge of an aging population with Groningen

The Faculty of Health and Medical Sciences at the University of Copenhagen and the Faculty of Medical Sciences at the University of Groningen signed a Memorandum of Understanding (MoU) in August 2019, creating opportunities for stronger collaboration within aging research, education, and exchange of students between the two institutions.

The new agreement will pave the way for more cooperation, both at university and center level. In fact, the agreement is primarily based on an already existing collaboration on biological aging with researchers from Center for Healthy Aging at the forefront from the Danish side. During the last 10 years, the Center has worked closely with the University of Groningen. The challenge of an aging population is to a great extent the same across borders, which is why international collaboration and knowledge sharing are especially important in the field of aging. This collaboration emphasizes outreach and dissemination. In the future, there are plans to expand the partnership to research in fields other than aging.

Collaboration in research on aging with Birmingham

In 2019, Center for Healthy Aging has laid the foundation of a closer cooperation with the well-recognized aging center at the University of Birmingham, MRC Arthritis Research UK Centre for Musculoskeletal Ageing Research. Together, the two centers will conduct cutting edge research in the field of aging, building on their highly complementary and highly skilled competencies and expertise in aging research. The strong synergies between the two aging research programs are expected to result in productive research collaborations. Joint PhD courses and a student exchange program are also being discussed.

INTERNATIONAL AND NATIONAL COLLABORATION

Research collaborations

Within Denmark, Center for Healthy Aging's researchers in Track III collaborate closely with research groups at the Novo Nordisk Foundation Center for Protein Research and the Novo Nordisk Foundation Center for Basic Metabolic Research, University of Copenhagen.

Furthermore, Karsten Vrangbæk heads the Center for Health Economics and Policy (CHEP) at University of Copenhagen and is part of the steering group for Copenhagen Center for Regulatory Science at University of Copenhagen.

Center for Healthy Aging researchers in Tracks I-III also have multiple collaborations with clinical departments at several Danish hospitals in the Greater Copenhagen area. These collaborations are crucial for the success of several Center for Healthy Aging projects, such as LISA and LIFESTAT. See "Intervention studies and interdisciplinary projects", pp. 24 and 26 for details.

The Center's researchers also have strong collaborations with Aarhus University and University of Southern Denmark. Internationally, research collaborations have been established at the following universities and networks:

- Medical University of Bialystok, Poland
- Oroboros Instruments, Innsbruck, Austria
- Department of Medical Physiology, Faculty of Medicine, University of Granada, Granada, Spain
- Medical Faculty Uppsala University, Sweden
- University of Barcelona
- University of Salzburg
- University of Nottingham
- European College of Sport Science
- Charles University, Prague
- Institute of Health and Medical Research, France
- The Mayo Clinic, USA
- Contestation of Health and Wellbeing in the Nordic Countries, Network with University of Turku, Umeå University and University of Oslo
- Usher Institute of Population Health Sciences and Informatics, University of Edinburgh
- GEREC, University of Tampere, Finland
- RUBICON, EU supported exchange of PhD students
- Chromavision, EU founded research network
- RIBBDD, Research Initiative on Brain Barriers and Drug Delivery
- The Brain Initiative
- The Norwegian Centre on Healthy Ageing (No-Age)

Stakeholder networks

Center for Healthy Aging researchers are represented in and provide expertise to a wide range of stakeholder networks. Examples are:

- Danish Cancer Society, Scientific Board member *(Lene Juel Rasmussen*)
- Lundbeck Foundation, Executive board and Scientific board member *(Michael Kjær)*
- Det Gode Ældreliv Sundhedsstyrelsen, Advisors (*Karsten Vrangbæk, Aske Juul Lassen, Nete Schwennesen)*
- Rådet for tryghedsskabende velfærdsteknologi, Socialstyrelsen, Advisor *(Nete Schwennesen)*
- PACE Proactive Care for the Elderly with Dementia, Innovation Fund Denmark, Advisor *(Nete Schwennesen)*
- Danish Alzheimer Association, Researcher *(Nete Schwennesen)*
- European College of Sport Science, Chair of the Scientific Board *(Flemming Dela),* President Elect and Executive Board member *(Jørn Wulff Helge)*
- European infrastructures – Danish Ministry of High Education and Sciences, Advisory Group member *(Clara Pratts)*
- Arla Food For Health, Steering Committee member *(Jørn Wulff Helge)*
- Dansk Selskab for Sundhedsøkonomi, Board member (*Karsten Vrangbæk)*
- DEFACTUM Social, sundhed & arbejdsmarked, Region Midtjylland, Head of Advisory Board (*Karsten Vrangbæk)*
- SIA Social Inequalities in Ageing, NordForsk, Nordic Council of Ministers, Work package A leader *(Rikke Lund)*
- LOFUS Lolland-Falster undersøgelsen, Region Sjælland, Research Group member *(Charlotte Juul Nilsson)*
- CIRE Center for Integrated Cancer Rehabilitation, Steering board member *(Line Hillersdal)*
- Innovation Southern Denmark, Researcher member *(Line Hillersdal)*
- Digitaliseringsstyrelsen, Advisor *(Line Hillersdal)*

- Research Committee of the Danish Heart Foundation, Board member *(Maria Kristiansen)*
- The Capital Region Research Funding Program, Board member member *(Maria Kristiansen)*
- WHO Europe, aging section, Advisor *(Maria Kristiansen)*

Collaboration with municipalities

Much of Center for Healthy Aging's research is done in dialog with citizens and the health professionals who work with citizens in the municipalities. Therefore, municipalities are important collaborative partners for the Center, given their political influence and administrative responsibility in societal areas relevant to health and aging.

The Center's researchers collaborate on research projects with the following municipalities:

- Copenhagen Municipality, Researcher (Nete Schwennesen, Maria Kristiansen)
- Ærø Municipality, Researcher (Line Hillersdal)
- Aabenraa Municipality, Researcher (Nete Schwennsen)

The following is an example of a collaboration involving Center researchers and Danish municipalities.

Stay CONNECTed; Digital technologies and rehabilitation in Danish dementia care

The aim of this project is to investigate ethnographically the digitalization of dementia care. The point of departure is new digital technologies, such as surveillance, communication and sensory technologies, and uses qualitative methods such as participant observations and interviews, to explore how these technologies shape care, relationships and human life in general. The project is implemented in home care settings and nursing homes in close collaboration with project partners. The project runs from 2018-2020 and partners include the Danish Alzheimer Society, Copenhagen Municipality and Aabenraa Municipality, and is funded by the Velux Foundation.


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EDUCATIONAL ACTIVITIES

Center for Healthy Aging emphasizes education of the next generation of aging researchers. To this end, Center provide the highest quality educational resources to its students and young scientist trainees, and makes concerted effort to recruit top junior and senior scientists, whose research interests align our research goals and philosophy. As described above, undergraduate and graduate level courses on aging studies are offered and there are many opportunities for postdoctoral studies under the mentorship of the Center's faculty.

PhD dissertations

Below, examples of dissertations from the three tracks are described. Complete lists of dissertations are available at pp. 15, 18, and 21.

Neurophysiological correlates of cognitive decline. An EEG and EEG-fMRI study on cognitive aging
Nelly Richard, Track I, 2019

This PhD thesis examined the neuronal response to a low-demand visual task using electroencephalography (EEG) in relation to brain cognitive aging. In addition, we investigated the neurovascular coupling with simultaneous EEG-fMRI (functional magnetic resonance imaging) recordings at rest and during a low-demand visual task in aged males with cognitive decline and an age-matched control group. The study supports the hypothesis that subtle reduction in cognitive skills are associated with alterations in brain network activity and vascular responses that can recorded by standard clinical techniques.

Socioeconomic position across the life course and physical capability in late-middle age
Gitte Lindved Petersen, Track II, Spring 2019

Based on data from Copenhagen Aging and Midlife Biobank this PhD thesis investigates the association between socioeconomic position (SEP) across the life course and midlife physical capability. It concludes that lower SEP in early childhood and across adulthood was associated with poorer physical capability in late-middle age. Moreover, the accumulation of economic hardship across adult life was associated with lower physical capability in late middle age.

The production of reactive oxygen species in response to glutathione supplementation and acute exercise in patients with type 2 diabetes
Stine Dam Søndergård, Track III, 1 April 2019

We found that glutathione supplementation for 3 weeks improved insulin sensitivity in obese patients with and without type 2 diabetes. Furthermore, we also found that an acute exercise bout increases ROS production from the skeletal muscle, which might be the signal for mitochondrial biogenesis.

PhD courses

Center for Healthy Aging researchers also taught or contributed to several PhD courses:

- *Aging from a cross disciplinary perspective* (2.4 ECTS), organized by the PhD Academy for Interdisciplinary Aging Research (PAIAR), UCPH, 2-4 December 2019. Course directors: Claus Desler (Track I), Jakob Agergaard (Track I), and Sasmita Kusumastuti (Track III). Lectures delivered by senior and junior researchers from all research tracks (Tracks I-III).
- *The good scientific presentation – From attractive posters to inspiring talks*, UCPH, 25-27 February and 2-4 October 2019 (bi-annual course). Course director: Claus Desler (Track I).
- *Ageing*, strength training interventions in elderly individuals, UCPH, December 2019. Course director: Michael Kjaer (Track I).
- *After the PhD?*, job seeking in hospitals after PhD, UCPH, January 2019. Course director: Michael Kjaer (Track I).
- *Matrix Biology – Cell-matrix interplay, physiology and function of extracellular matrix*, UCP, November 2019. Course directors: Chloé Yeung, Peter Scherling, Rene Svensson, Constanza Montagna, Monika Bayer (Track I).
- *Skeletal muscle: size, signalling and satellite cells*, UCPH, September 2019. Course directors: Abigail Mackey, Jesper Løvind Andersen, Peter Schjerling (Track I).
- *Regulation of muscle stem cells and regeneration during ageing in humans*, UCPH, December 2019. Course director: Abigail Mackey (Track I).
- *Skeletal muscle and tendon – two very different tissues meet*, Annual Symposium Basic and Clinical Research in Muscu-

lo-skeletal Sciences, Snekkersten, Denmark, November 2019. Course director: Abigail Mackey (Track I).

- *Skeletal muscle cell interactions during human tissue repair and exercise adaptation*. 5th Saltin International Graduate Course in Exercise and Clinical Physiology, Snekkersten, Denmark, 2019. Course director: Abigail Mackey (Track I).
- *Brain Homeostasis and Neurovascular Coupling*, Bordeaux, France, 2019. Course director: Director of the CAJAL Advanced Neuroscience Training Program Martin Lauritzen (Track I).
- *Biology of Aging Course*, Bloomberg School of Public Health, Johns Hopkins University, Baltimore, USA, 2019. Course director: Morten Scheibye-Knudsen (Track I).
- *Mitochondrial Physiology – from Organelle to Organism*, 19-23 August 2019 (Track III).
- *The complexity of understanding age-related disease* (5 ECTS), organized on behalf of the EIT Health Knowledge and Innovation Community (KIC) and as part of the project EpiDEMPrev, UCPH, 4-7 November 2019. Course directors: Professor Rudi Westendorp (Track III), Naja Hulvej Rod, and Zorana Jovanovic Andersen.

Postgraduate level

- Muscle injury, Postgraduate course for MD's on Sports Injuries, Danish Medical Doctors Organization (DADL), Copenhagen, May 2019. Michael Kjaer (Track I).
- Exercise training in Rheumatology, Resident course in Rheumatology, Aalborg, October 2019. Michael Kjaer (Track I).
- Tissue changes with physical activity, Course I, Danish Sports Medicine Society, Bispebjerg, August 2019. Michael Kjaer (Track I).

Master level

- IARU summer school *Interdisciplinary Aspects of Healthy Aging* (5 ECTS), UCPH, 1-19 July 2019. Course directors: Rudi Westendorp (Track III), Claus Desler (Track I), Maarten Rozing (Track I), and Maria Kristiansen (Track II). Lectures delivered by senior and junior researchers from all research tracks (Tracks I-III).
- Physical activity journal club, Cand.scient.san., Fall 2019 (12 hrs). Peter Magnusson (Track I).
- *The muscle-tendon junction: Basic anatomy, physiology, and biomechanics in relation to muscle strain injuries.* Master of Science in Physiotherapy. University of Southern Denmark. Hvidovre Hospital, Denmark, 19 November 2019. Monika Bayer (Track I).
- *Muscle adaptation: changes in muscle fiber area and fibertype distribution.* Applied training aspects: Use of Resistance training in team sports. MSc Course Muscle, University of Southern Denmark, Odense, Function – Resistance Training, 9 April 2019. Jesper Løvind Andersen (Track I).
- Elective course on gerontology. MSc Medicine and MSc Public Health, University of Copenhagen. Charlotte Juul Nilsson (Track II).
- Lecture on life course health and aging. MSc Medicine course on Statistics, Epidemiology and Medical Sociology. Rikke Lund (Track II).
- Supervision of Master theses by Track III: From Sports Science: Andreas Blåholm, Mathilde Fogelstrøm, Morten Strunge Brage-Andersen. From Public Health: Pernille Hulst, Marie Høyer Olsen. From Medicine: Kasper Bygum (Idr.,19E), (Med., 19E); Signe Regnersgaard, Bo Kelly. From Human Biology: Julia Prats. From Biomedicine (University of Southern Denmark): Eva Frederikke Høy Helms.

Center for Healthy Aging perspectives have also been integrated into several graduate level courses, e.g. *Health systems and innovation* at the joint UCPH/CBS Innovation in Health Care master program and the course *Health systems and the Nordic Welfare State* at Department of Political Science, UCPH.

Pregraduate level

- Teaching in the course *Chemical Components of the Cell* for 1st semester medical students (Track I).
- Teaching in the course *Cellular and Tissue Biology* for 2nd semester medical students (Track I).
- Organizing and teaching in the course *Cellular and Tissue Biology* for 3rd semester engineering students (Track I).
- Lectures and SAU classes on module *Human Diseases for non-clinicians*, 2nd semester, Public Health, MedTek, University of Copenhagen, February 2019. Abigail Mackey (Track I).
- Lectures and SAU classes on module *Human Biology*, 1st semester, Public Health, MedTek, University of Copenhagen, September 2019. Abigail Mackey (Track I).
- *Consequences of physical activity and inactivity* and *Connection between inactivity and disease development*. Lectures in the Masters of Science program (Cand.Scient.San.), University of Copenhagen, Denmark. 18 November 2019. Michael Kjaer (Track I).
- *Exercise physiology* (in Danish *Energiomsætning*), 4th semester, Medicine, Faculty of Health and Medical Sciences, University of Copenhagen, December 2019. Michael Kjaer (Track I).
- *Chronic diseases* and *Physical training*, Cand.Scient.San, Faculty of Health and Medical Sciences, University of Copenhagen, November 2019. Michael Kjaer (Track I).
- *Gross Medical Anatomy*, Medicine, Faculty of Health and Medical Sciences, University of Copenhagen, spring and fall semester 2019. Morten Scheibye-Knudsen (Track I).
- Supervision of three Master theses (Medicine) with a focus on Social Adversities and aging, and aging in a vulnerable population of older people. Rikke Lund (Track II).
- Supervision of 6 Master students focusing on diversity-sensitive healthcare for older patients. Maria Kristiansen (Track II).
- *Energy and Exercise Physiology*, Medicine, 4th semester. Course leadership (Track III).
- Life style exercise (in Danish *Livsstilsøvelse, energiomsætningsøvelse*) (Track III).
- Supervision of Public Health students by Track III: Marie Høyer Olsen, Katrine Andersen.
- Supervision of Bachelor students by Track III: From Medicine:

Emil Hyllested, Kristin Mycklebust, Bjørn Kromann Hansen, Ali Mohannad Mohammad, Yusuf Baysal, Jens Warm, Lasse Bo Mortensen, Martin Svanholm Bandrivskyi Møller, Nanna Bo Christensen, Sarah Christensen, Lærke Østergaard, Ahmad Zeidan, Elsa Splidt.

Center for Healthy Aging researchers also supervise master and bachelor level students who are affiliated with various departments at the University of Copenhagen.

Other dissemination activities

Selected activities outside the university, such as lectures and presentations at public and private hospitals, societies, associations, organizations, general public, etc.:

- Lecture at Folkeuniversitetet. *Sundhed – Aldringens mysterier*. 19 March 2019. Speaker: Claus Desler (Track I).
- Lecture at Folkeuniversitetet. *Opskriften på at blive 100 år – Aldring på celleniveau.* 2 September 2019. Speaker: Claus Desler (Track I).
- Copenhagen Culture Night. *Mød dine celler, kroppens byggesten.* 11 October 2019. Speaker: Claus Desler (Track I).
- Keynote presentation at Danish Mitochondrial Patient association. Middelfart, 27-28 September 2019. Speaker: Claus Desler (Track I)
- Keynote presentation at Dansk Gerontologisk Selskab yearly conference. Middelfart, 30 October-1 November 2019. Speaker: Claus Desler (Track I)
- *Longitudinal intervention with physical exercise in elderly individuals,* Nordea Foundation, Medical Faculty, University Copenhagen, Oct 2019. Michael Kjaer (Track I).
- *How alive is connective tissue, and is it good to load it mechanically?* Monthly Lectures, Danish Rheumatism Association, May 2019. Michael Kjaer (Track I).
- Muscle and tendon research at the Institute of Sports Medicine Copenhagen: Tendon injury and repair. Undergraduate students from the USA. 23 October, 2019. Peter Magnusson (Track I).
- Lecture at Folkeuniversitetet. *Sundhed – Aldringens mysterier.* Speaker: Martin Lauritzen (Track I).
- Copenhagen Culture Night. *Experience DNA*. 11 October, 2019. Ian Hickson and Andres J Lopez-Contreras (Track I).
- Lecture on social relations and aging, Folkeuniversitetet, Copenhagen, Spring 2019. Rikke Lund (Track II).
- Maria Kristiansen (Track II) was interviewed by journalist Lone Frank in the science program "24 spørgsmål til professoren", Radio24Syv; hosted two events at Folkemødet 2019, and ran a Heart Lab with younger researchers in her group, colleagues from Department of Biomedicine, and the Danish Heart Foundation.
- Catharina Thiel Sandholdt (Track II) and Maria Kristiansen (Track II) hosted several co-creation seminars on polypharmacy in older patients with national partners.
- Maria Kristiansen (Track II) hosted a seminar on personcentred care for a range of key stakeholders including patients, relatives, ministries, funding bodies, NGOs, regional and municipal partners.
- Nete Schwennesen (Track II) has been a member of the Advisory Board of the Safety technologies for people with cognitive disabilities, Danish Social Board.
- Nete Schwennesen (Track II) has been a member of the Advisory Board, Proactive Care for the Elderly with Dementia (PACE), Innovation Fund Denmark, with Associate Professor Anders Stockmarr, DTU.
- Nete Schwennesen (Track II) and Amy Clotworthy (Track III) hosted the European Association of Social Anthropologists' Age and Generations Network (AGENET) inaugural event, *How to make impact and influence people: Taking the anthropology of ageing beyond the academy*, in September 2019.
- Nete Schwennesen (Track II) hosted the international conference *The digtitally engaged patient* June 2019 (in collaboration with Professor Ayo Wahlberg and Postdoc, Natasja Kingod).
- Karsten Vrangbæk (Track II), Aske Juul Lassen and Nete Schwennesen (Track II) have contributed to the reference group for the government action plan *Det Gode Ældreliv*.
- Karsten Vrangbæk (Track II) has presented research perspectives from Track II at a keynote speak for the annual aging summit organized by Local Government Denmark.
- Lecture on older migrants and refugees, WHO Europe Copenhagen, Spring 2019. Maria Kristiansen (Track II).
- Lecture on personcentred care for older migrants, Capital Region, Spring 2019. Maria Kristiansen (Track II).
- Lecture on compassionate care, Danish Society of Obstetrics and Gynaecology, Fall 2019. Maria Kristiansen (Track II).
- Presentation on inequality in cancer screening, Danish Cancer Society, Spring 2019. Maria Kristiansen (Track II).
- Lecture on cancer rehabilitation for vulnerable groups, SKA (Sammenslutning af Kræftafdelinger), Capital Region and Region Zealand, Spring 2019. Maria Kristiansen (Track II).
- *Idrættens Træningslære*, 3rd edition. Editor and consultant – published 21 January 2019. Jørn Wulff Helge (Track III).
- Folkeuniversitet, Lecture in Center for Healthy Aging lecture series: *Fysisk aktivitet: Det er aldrig for sent*. 9 April 2019. Jørn Wulff Helge (Track III).
- Folkemøde Bornholm; Thursday 13 June 2019 (20:30-21:30) *Klogere end professoren*; Quiz; Friday 14 June 2019 (19:45-20:30) *Videnskabsquiz*, Sunday 16 June (10:30-11:00) *Søndagsskole,* 30 min presentation. Jørn Wulff Helge (Track III).
- Lecture for exercisers in athletics club Sparta, Copenhagen 3 October 2019. Jørn Wulff Helge (Track III).
- Culture Night, 11 October 2019 (18:30 and 20:00). Tour in Mærsk Tower on 2nd floor, *Rundvisning i din fysiologi*. Jørn Wulff Helge (Track III).
- EIT Cross KIC project *Eat healthy to keep healthy* – education material for primary schools to teach 7-12 years old kids on how to age healthy. The material has now been pilot implemented in Spain, Italy and Denmark and the feedback will be used in 2020 to further develop the material and adapt it to be implemented in two East European countries. To see the English version of the education module follow this link: https://innoenergy.learnify.se/l/show.html#B6A2. Clara Prats (Track III).

RESEARCH TRAINING AND DISSEMINATION ACTIVITIES

IARU Summer School – Interdisciplinary Aspects of Healthy Aging

Center for Healthy Aging hosted the 9th annual summer course on *Interdisciplinary Aspects of Healthy Aging* taking place from 1-19 July 2019 at the University of Copenhagen. The summer course provides students with the opportunity to explore diverse research methods across different disciplines and to work with students from all over the world. Summer school courses emphasize interdisciplinary knowledge and approach and provide an opportunity for research experience in the field of aging. At the end of the summer school session, students write a grant application under the supervision of the course faculty. This requires use and/or consideration of interdisciplinary research methods and provides hands-on experience with the process of developing a research program/agenda that addresses critical questions or problems in study and understanding of aging.

This year, the course faculty consisted of Professor Rudi Westendorp (Track III), Associate Professor Maarten Rozing (Track I), Associate Professor Claus Desler (Track I), and Associate Professor Maria Kristiansen (Track II). Together, they executed an interesting course programme, mainly with lecturers from Center for Healthy Aging but also with contributions from Professor Nicholas Cherbuin from Australian National University, Dr Marco Demaria and Associate Professor Jochen Mierau from University of Groningen, and Associate Professor Louise Lafortune from University of Cambridge.

The summer course is part of the IARU Courses initiative (previously known as the IARU Global Summer Program), and among the 26 participating students, 19 students represented the four IARU universities Australian National University, University of Tokyo, Peking University, and University of Copenhagen.

Network for Young Scholars

Network for Young Scholars (NYS) in Center for Healthy Aging is a network for all young researchers affiliated with the center. The vision is to build a platform for Research Assistants, PhD Students and Postdocs to promote educational and research activities in the field of aging, and for social networking for these young scientists. In 2019, NYS arranged five events, including four *PI Lunches*, where young researchers meet with the Center's affiliated Principal Investigators to discuss career development in an informal setting, and one *Research Pitch Battle X Friday Bar*, where contestants pitch their research in front of an audience. All events have relatively high numbers of participants and are attended by young researchers from across the three research tracks. In 2019, the NYS steering group had six members, including:

- PhD Student Anna Constance Vind (Track I)
- PhD Student Michael Ben Ezra (Track I)
- PhD Student Zhiquan Li (Track I)
- PhD Student Casper Søndenbroe (Track III)
- Research Assistant Sarah Zaccagni (Track II)
- Academic Officer Pia Nygaard (Secretariat)

More information can be found at https://healthyaging.ku.dk/education/network-for-young-scholars/.

PhD Academy for Interdisciplinary Aging Research

Center for Healthy Aging's PhD Academy for Interdisciplinary Aging Research (PAIAR) aims to develop and organize high-level interdisciplinary PhD courses in the field of aging research. These courses are internationally-recognized. The intent is to strengthen the focus on aging research now and in the future. The courses primarily target the Center's PhD students, but are open to all students at the University of Copenhagen as well as students from other universities in Denmark or other countries. In 2019, the PAIAR steering group consisted of:

- Associate Professor Claus Desler (Track I)
- Postdoc Jakob Agergaard (Track I)
- Postdoc Sasmita Kusumastuti (Track III)
- Academic Officer Pia Nygaard (Secretariat)

More information can be found at https://healthyaging.ku.dk/education/phd-academy-paiar/.

Workshops

In 2019, Center for Healthy Aging hosted two workshops in Mærsk Tower, which were attended by participants from across the Center. The workshops offered an opportunity for networking to establish or enhance collaboration on interdisciplinary projects.

The first workshop focused on finding areas of mutual interest between Social Science and Health Science faculty in Center for Healthy Aging. The workshop included short presentations by Center researchers and discussions in small groups to explore opportunities for collaboration. The second workshop took place in September 2019 and focused on cycling and many aspects of physical activity and its relevance for human health and aging. The event was organized and led by researchers from Track III as well as invited external speakers. The workshop provided new perspective on optimizing the health benefits of physical activity.

Seminars and academic events

CEHA/BRIC seminars

Center for Healthy Aging hosts or co-hosts academic events to facilitate dissemination of data and promote discussion. Since 2014, Center for Healthy Aging and the Biotech Research & Innovation Centre (BRIC), University of Copenhagen, has organized a research seminar series on important topics in biological sciences. This seminar series features international speakers at the forefront of their respective fields, who present seminars on research and/or technologies that are having a major impact on biological and biomedical sciences. Approximately 50 participants usually attend these seminars, which are usually followed by small group discussions between guest speakers, PhD students and postdocs.

In 2019, BRIC seminar speakers included:

- *Ageing Interventions get Human*. Speaker: Brian Kennedy, Center for Healthy Aging, National University of Singapore, February 2019.
- *How the bacterium Helicobacter pylori damages the host genome, leading to essential events at the origin of gastric carcinogenesis*. Speaker: Eliette Touati, Institut Pasteur, France, March 2019.
- *Hydrogen sulfide in DNA damage, metabolism and aging*. Speaker: James Mittchell, Department of Genetics and Complex Diseases, T. H. Chan School of Public Health, Harvard, March 2019.
- *Causes and consequence of cell cycle heterogeneity*. Speaker: Alexis Barr, London Institute of Medical Sciences, May 2019.
- *Phenotypic Drug Discovery: our take on ALS and Immune Checkpoint modulation using high-throughput screens.* Speaker: Jordi Carreras Puigvert, Karolinska Institutet, SciLifeLab, Stockholm, May 2019.
- *Heterogeneity of senescent cells: from mechanisms to interventions.* Speaker: Marco Demaria, European Research Institute for the Biology of Ageing (ERIBA), University Medical Center Groningen (UMCG), August 2019.
- *The search of chromosome instability markers leads to RNA methyltransferase function at the mitochondria and new cancer therapeutic opportunities.* Speaker: Ignacio Perez de Castro, Instituto de Salud Carlos III, October 2019.
- *Understanding novel features of KRAS biology to discover new therapeutic vulnerabilities*. Speaker: Chiara Ambrogio, Dana Farber Cancer Institute (Harvard Medical School), November 2019.

Selected scientific dissemination activities

- Lene Juel Rasmussen (Track I): Center on Healthy Aging: the Copenhagen experience at The 1st NO-Age Symposium on *How to promote healthy ageing and happy lives*, Oslo, 2019, Mitochondrial dysfunction in Alzheimer's disease/dementia _ Lene J. Rasmussen (University of Copenhagen, Denmark) at *Neuroscience and Mental Health: A clinical and molecular overview in neuropsychiatric and age-related neurodegenerative disorders*, Coimbra, 2019.
- Lene Juel Rasmussen (Track I) (organizer): Replication stress induces age-related disorders via impaired mitochondrial homeostasis at EMBO workshop and 7th Symposium *Genome dynamic in neuroscience and aging*, Tel Aviv, Israel, 2019. Oxidative stress, mitochondrial process and dementia. Lene Rasmussen (UCPH) at Advanced Course on Dementia Prevention, London, 2019.
- Ian Hickson (Track I): FASEB Conference on *Genetic Recombination*, Steamboat Springs, CO, USA (Symposium speaker), Hickson: FASEB Conference on *DNA Helicases and Nucleic Acid Machines*, Steamboat Springs, CO, USA (Symposium speaker).
- Ian Hickson (Track I): 10th International Symposium on *DNA damage responses and human disease*, Shenzhen, China (Keynote Speaker).
- Abigail Mackey (Track I): Human skeletal muscle connective tissue during myofibre repair and at the myotendinous junction. 5th International Autumn School on Movement Science, Berlin, Germany, October 2019. Priming elderly skeletal muscle for heavy resistance training. Annual congress of the European College of Sport Science, Prague, July 2019. Regulation of muscle stem cells and regeneration during aging in humans. 12th International Conference on Cachexia, Sarcopenia & Muscle Wasting. Berlin, Germany, 2019. Regeneration and remodeling of human skeletal muscle from the cellular perspective. Annual meeting of the Scandinavian Physiological Society. Reykjavik, Iceland, August 2019.
- Michael Kjaer (Track I): Development of early tendinopathy. Int Meeting for International Olympic Committee Research Groups, Oslo, Norway, November 2019, Exercise and the interplay between skeletal muscle and connective tissue – From health to disease, Int Bengt Saltin Symposium, Snekkersten, Sept 2019.
- Peter Magnusson (Track I): The ageing tendon. 4th Annual Scientific Symposium. The ageing muscle-bone unit: epideiology, pathophysiology and management. Brussels, 20 November, 2019. Tendon response to loading. European College of Sports Science, Prague, July 6, 2019. Structure and function of tissues affected by strain injuries. Scandinavian Sports Medicine Congress, Copenhagen, 1 February, 2019.
- Martin Lauritzen (Track I): Neurovascular biology of capillary control. Translational Research and Advanced Imaging Laboratory, University of Bordeaux, France, 2019, The blood-brain barrier in acute neurological disorders. NICIS-USA, Washington DC, USA, 2019, Calcium-dependent mechanisms of cerebral blood flow regulation. The European Calcium Society, Portugal, 2019, Precapillary sphincters and vascular control. International Symposium on Subarachnoid Hemorrhage, Amsterdam, 2019, Neurovascular biology of capillary control. Translational Research and Advanced Imaging Laboratory, University of Bordeaux, France, 2019.
- Morten Scheibye-Knudsen (Track I): *Interventions in Aging*, Discovery Network invitation from Bob Weinberg, Whitehead Institute, MIT, USA; *The aging phenome*, National Institute on Aging, NIH, USA; *The aging phenome*, Georgetown University, MD, USA; *The aging phenome*, Mekelle University, Ethiopia; *Interventions in Aging*, Nansen Neuroscience Lecture, Norwegian National Academy of Science, Norway; *Deep Learned*

Drugs for DNA repair, Tsinghua University, Shanghai, China; Organizer: 6th Aging Research and Drug Discovery meeting, Basel, Switzerland.

- Andres J Lopez-Contreras (Track I): 42th Congress of the Spanish Society of Biochemistry and Molecular Biology (SEBBM). Madrid (Spain).
- Marco Piovesan (Track II): Workshop on Behavioral Insight for Healthy Aging 2019 was held on 27-28 November 2019.
- Maria Kristiansen (Track II): Seminar with keynote on person-centred care was held 22 January 2019.
- Maria Kristiansen (Track II): Keynote on importance of language in caring encounters at national conference, 26 September 2019.
- Maria Kristiansen (Track II): Keynote on user engagement in science at seminar, 12 September 2019.
- Maria Kristiansen (Track II): Presentation on older migrants at conference on diversity in aging, 9 May 2019.
- Maria Kristiansen (Track II): Keynote on older refugees and migrants, WHO Europe, 16 July 2019.
- Steen Larsen (Track III): 16th Meeting of the Mediterranean Group for the Study of Diabetes, Casablanca, Morocco (invited speaker), 10-12 April 2019.
- Steen Larsen (Track III): 3rd International Conference on Obesity and Metabolic Disease 2019, Bangkok, Thailand (invited speaker), 25-27 March 2019.
- Jørn Wulff Helge (Track III): Invited talk *Maximal fat oxidation; Implications for health* at seminar at Norwegain School of Sports Science, Oslo, Norway, 15 May 2019.
- Jørn Wulff Helge (Track III): 24th Annual Congress of European College of Sports Science, 3-6 July, Prague. Symposium IS-PM05; *High-carbohydrate or high-fat diets for optimising training adaptation and performance* chair and talk "*Maximising fat oxidation Help or Hindrance to Adaptation & Performance* (invited speaker).
- 17th International Sports Sciences Congress in Antalaya, Turkey on 13-14 November. (Jørn Wulff Helge, Track III, Invited speaker), "Maximal fat oxidation; Implications for health".
- Invited talk at seminar at Le Bourget-du-Lac, University Savoie Mont Blanc, Chambery, France, "Maximal fat oxidation; Implications for health and performance" on 19 December (Jørn Wulff Helge, Track III).
- Flemming Dela (Track III): Invited speaker. Shanghai Institute of Sports Science, Shanghai, China. 11 October 2019, *Effect of physical training on insulin sensitivity in type 2 diabetes + Effects of exercise on skeletal muscle mitochondrial respiration.*
- Flemming Dela (Track III): Invited speaker. 60th Anniversary conference, Shanghai Institute of Sports Science, Shanghai, China. 12 October 2019, *Introduction to the European College of Sport Science*.

Table 2. NUMBER OF INDIVIDUALS FROM VARIOUS CATEGORIES THAT WERE TRAINED (ONGOING) BY CENTER FOR HEALTHY AGING IN 2019

Pregraduate research / BA / MA students	53
Research assistants	14
PhD students	49
Postdocs	31

MAJOR GRANTS AND PRIZES

- Lundbeckfonden's Research Prize for Young Scientists 2019 to Professor Simon Bekker-Jensen (Track I): 1,000,000 DKK
- KFJ-prize (Kirsten and Freddy Johansens Prize) to Professor Michael Kjær (Track I): 1,500,000 DKK

External funding

Table 3. ADDITIONAL FUNDING OBTAINED IN 2019, DKK
(excluding the Nordea-fonden grant)

FUNDED BY	FUNDING
Sven Wewers Fond	40,000
Novo Nordisk Foundation – NNF Challenge Grant (2018-2023)	60,000,000
Dagmar Marshalls Fond	75,000
Fabrikant Einar Willumsens Mindelegat	40,000
Kong Christian den Tiendes Fond	25,000
The Danish Medical Research Council	3,000,000
Novo Nordisk Foundation	1,200,000
Ministry of Culture, Sports Science	400,000
Augustinusfonden	400,000
Novo Nordisk Foundation	2,500,000
Lundbeck Foundation	2,000,000
Direktør Michael Hermann Nielsens Mindelegat	100,000
Insilico Medicine	2,000,000
Synoptik Fonden	150,000
Ministry of Higher Education and Science, International Network Programme	119,999
The Parkinson Disease Association	150,000
EIT Health Campus Programme	339,000
EIT Health Campus Programme	186,000
Danish Agency for Science and Higher Education, International Network Programme	188,244
Fonden Ensomme Gamles Værn	300,000
Beckett Fonden	100,000
Fonden til Lægevidenskabens Fremme	40,000
Brødrene Hartmanns Fond	130,000
Novo Nordisk Foundation	877,447
Fonden til Lægevidenskabens Fremme	50,000
Fonden til Lægevidenskabens Fremme	40,000
Ministry of Culture	311,132
Helsefonden	350,000
Aase and Ejnar Danielsens Foundation	100,000
EIT Cross KIC	740,000
Alzheimer-forskningsfonden	500,000
Total	**76,451,822**

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