EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

Brussels, 25 May 2021

COST 044/21

DECISION

Subject: Memorandum of Understanding for the implementation of the COST Action “Network on evidence-based physical activity in old age” (PhysAgeNet) CA20104

The COST Member Countries will find attached the Memorandum of Understanding for the COST Action Network on evidence-based physical activity in old age approved by the Committee of Senior Officials through written procedure on 25 May 2021.

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Funded by the Horizon 2020 Framework Programme of the European Union

MEMORANDUM OF UNDERSTANDING

For the implementation of a COST Action designated as

COST Action CA20104
NETWORK ON EVIDENCE-BASED PHYSICAL ACTIVITY IN OLD AGE (PhysAgeNet)

The COST Members through the present Memorandum of Understanding (MoU) wish to undertake joint activities of mutual interest and declare their common intention to participate in the COST Action, referred to above and described in the Technical Annex of this MoU.

The Action will be carried out in accordance with the set of COST Implementation Rules approved by the Committee of Senior Officials (CSO), or any document amending or replacing them.

The main aim and objective of the Action is to establish a sustainable network fostering evidence-based research and practice of physical activity in older adults and enhancing integration of innovative ICT solutions based on open data consolidated research information, in order to promote health and reduce the burden of inactivity in ageing populations. This will be achieved through the specific objectives detailed in the Technical Annex.

The present MoU enters into force on the date of the approval of the COST Action by the CSO.

OVERVIEW

Summary
Sedentary lifestyle in old age is associated with increased risk of chronic and disabling diseases, premature mortality, and substantial economic burden for society. Increase in physical activity (PA), on the other hand, may compensate negative effects of ageing and reduce inactivity costs. However, not all exercise regimens are universally effective, and Inter-individual differences in responses to PA exist. Therefore, there is an urgent need for creating "tailored" exercise programmes that will fit the specific needs of the various and diverse ageing populations.

A critical step towards this goal is embracing an evidence-based medicine (EBM) approach where conceptual challenges and pitfalls in basic research and clinical research on ageing and physical activity could be identified and addressed. Unmet needs and gaps in research and practice that currently hinder successful implementation of EBM for training of older adults are:

1. Lack of consolidated research information needed for designing optimal, feasible and effective exercise programs for various target groups;
2. Exclusion of disabled, low income and isolated older adults both research trials and exercise interventions;
3. Lack of real-world conditions studies over long periods and
4. Limited use of technological innovations for assessing, applying and enhancing exercise programs in old populations.

The main aim of the COST Action **PhysAgeNet** is to establish a **sustainable network** that will foster **evidence-based research and practice** of physical activity in older adults and will enhance integration of **innovative ICT solutions** based on open data **consolidated research information**, in order to promote health and reduce the burden of inactivity in ageing populations.

Areas of Expertise Relevant for the Action	**Keywords**
● Health Sciences: Sport and fitness sciences ● Clinical medicine: Geriatrics and gerontology	● standardisation ● open data ● technology-assisted intervention ● evidence-based medicine ● exercise intervention

Specific Objectives
To achieve the main objective described in this MoU, the following specific objectives shall be accomplished:

Research Coordination
● Compile the literature on biological and behavioural markers, and environmental factors.
● Provide a consistent open data framework for all relevant biomarkers from Research Coordination Objective 1.
● Design a prototype for an open data repository for technology-assisted PA interventions in old age.
● Compile a database of literature references involving technology-assisted PA interventions, utilizing evidence levels and reach / generalisation according to EBM standards.

● Assess status and needs, and provide a roadmap for adopting useful tools and standards from EBM resources for technology-assisted PA interventions.
● Develop a description tool for interventions based on EBM standards.
● Develop guidelines for recruitment and sampling of different target ageing groups.
● Develop guidelines and framework for technology-assisted PA interventions in old age.
● Compile an update of final status and needs of the network topics, and report progress beyond the state of the art.

Capacity Building
● Develop the network strategically as a source for well-established standards and for implementing them.
● Make the network sustainable beyond the COST Action.
● Identify research questions regarding the present needs and address them through special interest groups and appropriate funding options.

TECHNICAL ANNEX

1. S&T EXCELLENCE

1.1. Soundness of the Challenge

1.1.1. DESCRIPTION OF THE STATE-OF-THE-ART

The world's population is getting older at a rate that is unprecedented in human history [1]. Between 2000 and 2050, the proportion of the world's population over 60 years will double from about 11% to 22% [2]. Specifically, in all EU member states, the proportion of older people has increased in recent decades, due to a combination of the reduction in childbirth and longer life expectancy [3]. As people get old they become highly sedentary [4,5] and quite often are chronically ill [6,7]. Evidently, **sedentary behaviour is associated with an increased risk of chronic and disabling diseases** [8], **premature mortality** [9], **and substantial economic burden** [10]. Overall in the EU, the total cost of ageing is expected to increase by 1.7% to 26.7% of GDP (gross domestic product) between 2016 and 2070 [11]. An increase in **physical activity (PA),** on the other hand, may compensate for the negative effect of ageing and reduce the inactivity costs [12]. In this COST Action PA refers to all types of activities, including activity in daily life, leisure type PA and sport, purposeful exercise, and training programs.

The benefits of PA are diverse, spanning numerous domains of physical and mental health, overall well-being and social inclusion. More specifically, PA has been shown to be associated with a reduction in coronary heart disease [13], obesity and type II diabetes mellitus [14,15], better cognitive functioning [16], reduced prevalence of cognitive impairment and dementia [17,18] and depression [19], and positive markers of the immune system [20]. The official health bodies (e.g., World Health Organization – WHO) have published guidelines for exercise for people aged 65 and over. These guidelines comprise ⩾ 150 minutes a week of moderate-intensity aerobic exercise, ⩾ three times a week of balance exercise, and ⩾ twice a week of strength training. However, not all exercise regimens are universally effective and should therefore not be treated as a "one-size fits all" prescription [21]. Inter-individual responses of biological and behavioural health markers to exercise training exist, with limited understanding of characteristics that help identify non-responders and responders [7,21]. More than other age groups, old age is typified by increased variability in both physical [e.g. 22] and mental [e.g. 23] fitness. Identifying health markers to exercise training will significantly enhance clinicians' ability to prescribe PA in a more individualized and effective manner [21]. Furthermore, environmental factors are a meaningful moderator of exercise behaviour in older age [24]. Notably, the leading current environmental challenge is the COVID-19 pandemic. People feel reluctant to leave their homes for fear of becoming infected by the virus, and remain sedentary at home [25]. Thus, exercise guidelines should take into consideration both, environmental and personal factors.

Consequently, in order to develop "tailored" exercise programs that will fit the specific needs of the various and diverse ageing populations, there is a need to identify and classify biomarkers and behavioural markers regarding fitness, cognitive and motor performance, sedentary and mobility behaviour, and frailty in the ageing population.

Due to the large heterogeneity in evaluation methods and exercise interventions, there are no guidelines for assessing the benefits of various exercise programs for specific groups of older adults [26]. More specifically, the current research literature is comprised of numerous reports using specific criteria for assessing motor and physical fitness, however, the exercise programs used for intervention are not always clearly described. Besides the lack of **standardised assessment** tools and interventions, current research falls short in providing guidelines for **standardised reporting** protocols and dissemination procedures. For example, a study will report that a certain exercise intervention is useful, but it does not report clearly what the intervention was in terms of the specific kinds of exercise, intensity,

number of repetitions, etc. How, then, can other researchers, or exercise trainers or stakeholders adopt this exercise program?

Scientific communities have embraced evidence-based medicine (EBM) related initiatives to develop guidance for improving the design, conduct and reporting of research. These include checklists and statements on how to develop a research protocol and how to report study design and results [27]. EBM has contributed substantially to improving the quality of research by transparently documenting the problems with existing research and subsequently developing better research standards. It also has improved the practice of medicine by developing methods and techniques for generating systematic reviews and clinical practice guidelines [27]. In exercise sciences, however, there is a dearth of evidence-based strategy in conducting intervention studies, exercise protocols and measurement tools [28]. Researchers exhibit various conceptual challenges and pitfalls related, among others, with research designs, characteristics of the interventional approach and type of the control condition/group, reliable and valid measures, sample size and the statistical approach for data analysis [28]. Various types and forms of exercise, including aerobic, resistance or balance training, dance, yoga, Pilates, flexibility are examples of complex interventions that have been reported to be effective for prevention and treatment of a range of acute and chronic conditions, yet have been poorly described in randomized clinical trial reports in ageing populations [29].

Thus, there is a need for the standardisation of measurements, intervention protocols, evaluation tools among research groups, and study reports.

In addition, research on ageing populations is biased towards healthy and relatively young older adults. There are quite a few older individuals who are often excluded from studies on ageing. This practice hinders the generalization of findings and the development of evidenced-based methods of physical training. They are often excluded by overt age cut-offs or covert exclusions based on co-morbidity and frailty. More specifically, the barriers include communication and cognitive difficulties, limited mobility, transportation difficulties, low income and self-imposed ageism [30-32]. The inclusion of individuals with age-related pathologies and/or disabilities is expected to enlarge the existing database, creating a more solid ground for the application of the EBM approach for training older adults [31, 33-34].

Accordingly, there is a need to incorporate all groups of older adults, including disabled individuals, and older adults with chronic diseases.

Despite the evidence on the benefits of PA in advanced age, public health initiatives quite often fail to demonstrate clinically relevant effects of PA on physical and cognitive health. It has been hypothesized that the highly controlled environments in which PA research is conducted limits its replicability in real-world community settings [35]. While the efficacy of exercise was clearly demonstrated in a laboratory setting, there is a dearth of evidence showing its effectiveness in real-world conditions [36].

As a result, current laboratory-based studies assessing the effect of PA on physical and psychological health are to be replicated in real-world settings and rigorous and clinically relevant naturalistic research is required.

In the last few decades there has been growing interest in applying technological innovations to promote and monitor PA using novel devices, software, and wearable technology such as fitness trackers [37], mobile phone applications [38], tablets [39], virtual reality [40], exergames [41] etc. A recent systematic review on adherence to technology-based exercise programs in older adults provides evidence that technology offers a well-accepted method for providing older adults with exercise opportunities, and that adherence to the exercise programs is high [42]. However, the small sample sizes, short follow-up periods, inclusion of mostly healthy older people, and problems related to the methods used to report exercise adherence limit the generalizability of the findings [42].
If technological innovations can promote and monitor PA programs among older adults, it is necessary to conduct more research to investigate the feasibility, acceptability, and effectiveness of technology-based exercise programs undertaken by older people.

The implications of the above-mentioned gaps are:

1. Lack of **consolidated research information** needed by professionals and practitioners for designing optimal, safe, feasible and effective exercise programs for various target groups
2. **Limited inclusion of disabled, frail, low income or isolated older adults in** both research trials and exercise practice interventions
3. Lack of **real-world conditions** studies over long periods
4. Limited use of **technological innovations** for assessing, applying and enhancing exercise programs in old populations.

1.1.2. DESCRIPTION OF THE CHALLENGE (MAIN AIM)

Despite technological and scientific advances that have led to the extensive increase of knowledge in the domains of public health and healthy ageing, the unmet needs and gaps indicated above pose a great challenge for implementing an **EBM approach** in PA training of older adults and harnessing current scientific knowledge and ICT (Information and Communication Technologies) to improve PA training outcomes. In addition, heterogeneity of assessment methods, neglecting the creation of channels for effective dissemination and education, and improper representation of specific target populations **hinder the gain of relevant knowledge and contribute to the redundancy in research efforts**.
Consequently, the challenge will be to **bring together different types of expertise, practices, and multiple data sources** that will allow the converging of knowledge, technologies, and procedures required to refine physical activity interventions in older adults in the EU as a means to reduce risks for frailty, cognitive impairments and disability.

The main aim of the COST Action PhysAgeNet is to establish a sustainable network that will foster evidence-based research and practice of physical activity in older adults and will enhance integration of innovative ICT solutions based on open data consolidated research information, in order to promote health and reduce the burden of inactivity in ageing populations.

This will be achieved by:

- **Evidence-based research (EBR):** Establishing research standards and tools for recruitment and sampling, data management, and reporting of interventional studies, based on standards from EBM
- **Consolidated research information (CRI):** Broadening the base of data for tailoring interventions by identifying and classifying biomarkers, behavioural markers and environmental factors regarding physical fitness, cognitive/motor performance, sedentary and mobility behaviour, and frailty in the ageing population, and by providing open data repositories.
- **Integration of innovative ICT solutions (ICT):** Providing frameworks for conceptualizing and assessing technological tools and Artificial Intelligence (AI) applications for designing physical activity interventions to meet the needs of different target groups (allowing for individual tailoring, progression and day-to-day adaptation) based on the individual health condition and ecological and social environments.
- **Sustainable network development (NET):** Bidirectional valorisation of the network output by effective dissemination and exploitation to the researchers and professional audience and vice versa, and by attracting additional co-workers and gaining latest topics and aspects for dynamically enhancing the reach, strength and timeliness of the network as well as its sustainability.

The PhysAgeNet COST Action is in line with present priorities of the European Commission, within the scope of the EIT (European Institute for Innovation & Technology) Health framework, including promotion of an active healthy lifestyle among EU citizens through education, implementation of personalized health coaching, development and testing of smart products to establish innovative personalized health, etc.

PhysAgeNet is timely also because it fits well into *Health throughout the Life Course*, an “area of intervention” of the new Horizon Europe programme (cluster health) and the continuing partnership programmes of Horizon 2020 (e.g. personalised medicine). More specifically, “destinations” like *Staying healthy in a rapidly changing society, Living & working in a health-promoting environment,* or *Unlock-*

ing the full potential of new tools, technologies & digital solutions for a healthy society show that the Commission plans to promote research topics and approaches related to PhysAgeNet.

In fact, research and innovation actions in Horizon 2020 and Horizon Europe often ask for up to date applications of healthy activity interventions in integrated care, ageing workforce, and neurodegenerative diseases. The use of ICT and other technology to recommend, to present and to document physical activity for users in the different roles (e.g. older adult, caregiver, practitioner, exercise specialist) is usual in these systems. Consequently, PhysAgeNet will focus on technology-assisted interventions.

1.2. Progress beyond the state-of-the-art

1.2.1. APPROACH TO THE CHALLENGE AND PROGRESS BEYOND THE STATE-OF-THE-ART

The rationale for network collaboration in the PhysAgeNet COST Action comes from the urgent need to implement EBM in PA programs for the training of older adults and to enhance integration of innovative ICT solutions. The overall concept of this COST Action is illustrated in Figure 1.

The concept of EBM had a large impact on medical and health research and practice. However, the gaps mentioned in the state of the art (1.1.1) suggest, that EBM in the physical training of older adults is not sufficiently developed and therefore cannot sufficiently be implemented in health-oriented exercise and physical activity programmes. In addition, the implementation of evidence-based concepts in PA programmes also requires integration of knowledge from multiple sources and disciplines, creating data sets that are too large or complex to be dealt with by traditional data-processing application software. Therefore, access to web applications and implementation of Artificial Intelligence (AI)-based processing tools is also a relevant and timely approach to dealing with this complexity.

However, some steps must be taken as a means towards the goal of implementing EBM and dealing with data complexity in the physical training of older adults. First, certain aspects such as the attitude, rigor and clarity of EBM should be clarified and shared, and potential obstacles for implementation EBM (e.g., heterogeneity of research findings) should be discussed. Second, a consensus about relevant biomarkers and behavioural markers that could be used for both baseline assessment and quantitative benefit–harm assessment in different target populations need to be reached. Third, it is necessary to conceptualize the characteristics of platforms and (AI-based) processing tools that: (1) allow the adequate acquisition, management, integration, and interpretation of large data sets, and (2) coordinate and synchronize the acquisition and synthesis of knowledge from different sources and disciplines. In the future, both researchers and practitioners are expected to make use of AI and other technological innovations to progress beyond the state of the art in their own research domains and to keep up with new requirements and innovations throughout their education and career development.

Notably, the use of AI is rapidly propagating into ageing research as well as into other domains of Heath Care. It enables a holistic view of biological processes and allows for novel methods for building causal models: **extracting the most important features and identifying biological targets and mechanisms**. The use of AI approaches in health care has been shown to **accelerate and improve research and development practices and promote evidence based practices for treatment** in multiple domains (e.g., pharmaceutical research & development, epidemiology). Finally, there is an increasing use of AI technology for sporting performance prediction and injury risk assessment in team sports. Yet, it appears that no corporations or capacity building enterprises currently exist in Europe that make use of this approach for exchanging knowledge, building networks, and finding joint solutions for challenges in the domain of active healthy ageing. Therefore, considering this unique and timely approach as an objective in the PhysAgeNet COST Action is a necessary step towards the goal of implementing EBM in the physical training of older adults.

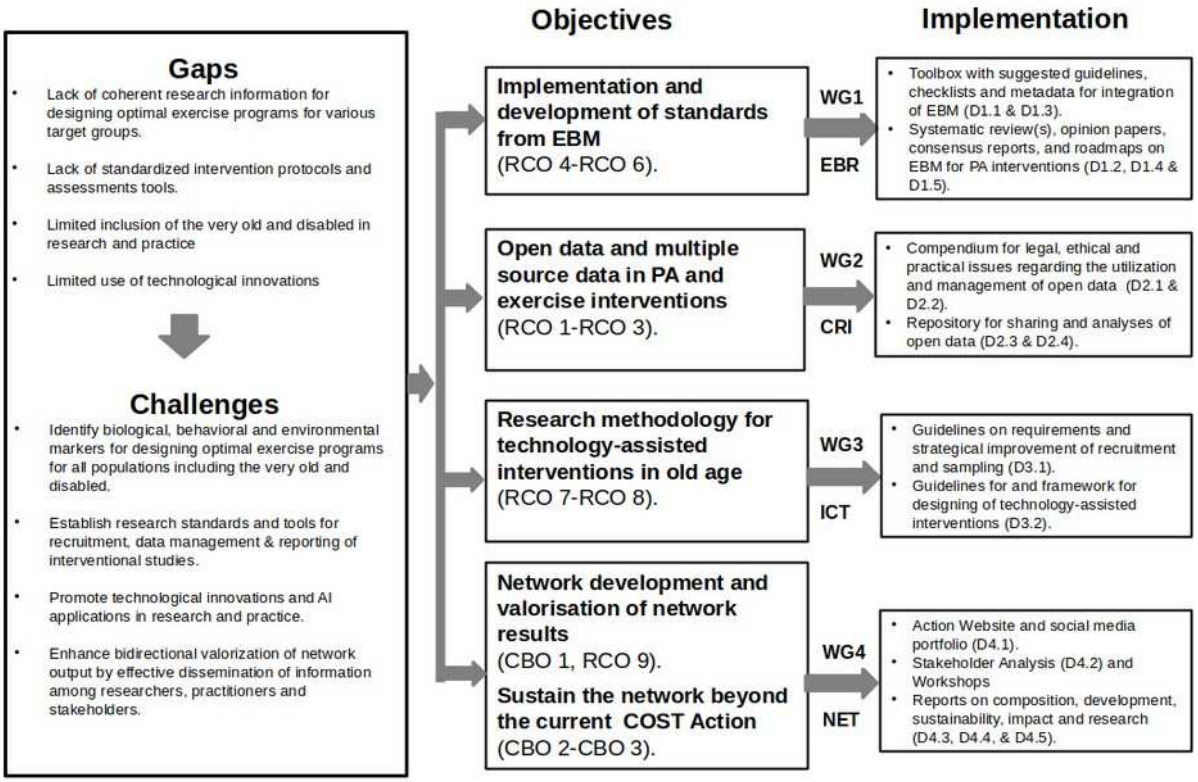

Figure 1: Concept of the PhysAgeNet COST Action - The Network on Evidence-based Physical Activity in Old Age

Taken together, the expected means of progress beyond the state of the art are:

- Formation of an inclusive network of researchers, practitioners and industry representatives to promote knowledge sharing and increase openness for interdisciplinary work as a means of accelerating the implementation of EBM in physical training of older adults.
- Preparing the ground for the integration of AI-based assessment methods to support PA tailored interventions. More specifically: (1) Discuss and agree about the gold standards of research in ageing and PA intervention studies. (2) Suggest experimental frameworks and literature search approaches for identifying principal brain and neuromuscular biomarkers that can be used for making baseline and follow up evaluations of PA interventional effects and pathophysiological processes. (3) Suggest strategies for the optimal utilization of AI in support of PA-tailored interventions.
- Preparing the ground for the implementation of interactive (on-line) training, and for assessment tools that can be adapted to meet the needs of end users based on their health conditions and training needs.
- Formation of frameworks for conceptualizing PA interventions for different target groups, and promoting an active healthy lifestyle stimulated by SMART interactive devices and social media. In addition, designing digital portfolios for effective dissemination of knowledge, attraction of stakeholders, as well as education and training of students and practitioners within Europe and beyond.

1.2.2. OBJECTIVES

The objectives are named and described in accordance with the main aim. The different aspects of the main aim (1.1.2) met by each objective are referenced. For monitoring the achievement, a specific deliverable or a KPI (key performance indicator) is provided.

1.2.2.1. Research Coordination Objectives

RCO 1 Compile the literature on biological and behavioural markers, and environmental factors.
In order to broaden the database for tailoring intervention (CRI), the existing knowledge has to be reviewed. The biological and behavioural markers refer to any variable relevant for PA intervention in ageing, e.g. performance, health, exercise behaviour, or fitness status. The relevance may be different for practical intervention design and/or for research. The mapping of environmental factors and their impact on different aspects of health and fitness may play a moderating role.
Achievement: deliverable D2.2.

RCO 2 Provide a consistent open data framework for all relevant biomarkers from RCO 1.
In order to promote practical use of biomarkers, the open data management application should be easy and transparent (CRI, ICT).
Achievement: deliverable D2.3.

RCO 3 Design a prototype for an open data repository for technology-assisted PA interventions in old age.
A functional example of open data will foster multiple source data use and data management (CRI). Once there is a prototype, other sources can easily be added.
Achievement: KPI: # of studies in the prototype ready for analysis (3) and D2.4.

RCO 4 Compile a database of literature references involving technology-assisted PA interventions, utilizing evidence levels and reach / generalisation according to EBM standards.
This database will characterise the body of knowledge in the field. For example: in order to provide recommendations for strength development, which intervention types for what target groups have been studied, and what are the evidence-based recommendations? This tool will enable reviewing the state of the art, identifying further research steps (e.g. increasing the evidence level by adding higher level studies), as well as designing intervention programmes (ICT) and clearly reporting on them (EBR).
Achievement: KPI: # of target groups with evaluation completed (3) (D1.1).

RCO 5 Assess status and needs, and provide a roadmap for adopting useful tools and standards from EBM resources for technology-assisted PA interventions.
Resource from EBM will play an important role in the network. Based on the database (RCO 4), there are concepts and tools that can be directly adopted (e.g. reporting guidelines for RCTs or systematic reviews). Others, may have to be modified and adapted for technology-assisted PA interventions. The roadmap will support research excellence and thus meet EBR. It will guide further work of the network within the COST Action and afterwards (NET).
Achievement: guidelines/roadmap submitted for publication (D1.5).

RCO 6 Develop a description tool for interventions based on EBM standards.
Volume, intensity, repetitions, exercise frequency and other features of exercise interventions will be meticulously described (CRI). Thus, comparability and replicability will improve, and assessment methods will be easily derived (EBR). The tool will be established in research, education, and interventions planning (NET).
Achievement: KPIs are # of papers submitted using the tool, # of training schools adopting this tool, # of curriculums of postgraduate study programmes teaching the tool (total number = 5) (D1.4).

RCO 7 Develop guidelines for recruitment and sampling of different target ageing groups.
Improving planning and monitoring the recruitment processes will reduce bias and enable generalisation of study results (EBR), thus improving the ground for intervention designs (ICT).
Achievement: guidelines submitted for publication (D3.1).

RCO 8 Develop guidelines and framework for technology-assisted PA interventions in old age.
Building a resource of technology-assisted interventions for practical work with various target groups, for researching these interventions including appropriate assessment standards (ICT) and for consolidating the output, and disseminating it inside and outside of the network (NET).
Achievement: guidelines for technology-assisted PA interventions submitted for publication (D3.2).

RCO 9 Compile an update of final status and needs of the network topics, and report progress beyond the state of the art.
The dynamic network will progressively change and develop. It will be a continuous process. Thus, an update of the progress is essential for re-evaluation of the status, and possibly for establishing new prioritization of the goals (NET). A formal consent process will achieve this.
Achievement: consensus of network partners (D4.5).

1.2.2.2. Capacity-building Objectives

CBO 1 Develop the network strategically as a source for well-established standards and for implementing them.
In addition to creating formal parameters of the COST policy, the partners will survey and benchmark the leverage potential of these parameters on the individual, institutional and policy making levels (e.g. leadership and collaboration in the partners' own projects, study programmes, and promotion of PhD candidates, CRI, EBR, ICT). This will increase the potential for both consensus and the implementation outside the network (NET). The assumption is that collaboration with social bodies and stakeholders will start in the spheres of the partners.
Achievement: KPI: European coverage and balance (>30 countries, 30% young and early career stage, 40% female), necessary disciplines, relevant stakeholders and external expert collaborations according to stakeholder analysis and balanced scorecard (see WG4 and section 2.2, D4.3).

CBO 2 Make the network sustainable beyond the COST Action.
Building a solid network will promote the sustainability of the network beyond the COST Action (NET). It will assist in meeting the other main aim aspects CRI, EBM, ICT on a continuous basis. The network partners will extend the potential for sustainability by interacting with other researchers and practitioners in European and international institutes and organizations. (see WG4 and section 2.2).
Achievement: independent structure, management and finances reached (D4.3).

CBO 3 Identify research questions regarding the present needs and address them through special interest groups and appropriate funding options.
Timeliness and relevance of research questions will be examined, discussed and published. PhysAgeNet will also support special interest groups to transform the yet fragmented research in a harmonized way, to develop research proposals in response to national/international research programme calls (e.g., H2020, ERC synergy grants). This is considered an impact of PhysAgeNet. Corresponding to RCO 9, CBO 3 will support the research proposal's quality by the results of different RCO, stimulating mutual benefits (a "win-win" situation) for both the researchers and the network (NET).
Achievement: KPI: # of opinion papers and/or narrative review papers submitted for publication and # of corresponding research proposals submitted to funding organisations by network partners (in total > 3) (D4.4).

2. NETWORKING EXCELLENCE

2.1. Added value of networking in S&T Excellence

2.1.1. ADDED VALUE IN RELATION TO EXISTING EFFORTS AT EUROPEAN AND/OR INTERNATIONAL LEVEL

Although ideas and approaches from evidence-based medicine have already been presented for several years, application in the field of technology-assisted PA interventions is still scarce (see state of

the art, 1.1.1). One reason for this is, that single researchers or small groups cannot set a standard. The existing interdisciplinary group has remarkable strength, experience and diversity which are needed for collecting expertise, building a consensus, designing good practice examples, and developing critical mass (see 2.2.1).

The chosen topic is very complex, containing many unsolved methodological issues, implementation in real-world settings, newly developed technology, and different scientific disciplines that need to work together. As a consequence, practical and implementation aspects will always interfere with “pure” research results, for often there are conflicting requirements. For example, for developing good balance skills, which is highly recommended for fall prevention, it is recommended to perform the exercise with eyes closed on an unstable floor. Physicians will object to this kind of exercise for safety reasons. Thus, consent and compromise is essential for advancing the objectives. The network approach will meet this need.

2.2. ADDED VALUE OF NETWORKING IN IMPACT

2.2.1. SECURING THE CRITICAL MASS AND EXPERTISE

PhysAgeNet builds on the experiences of and contacts with other European networks and projects, e.g. COST, Horizon2020 and Erasmus+. Synergies have already been proved during the proposal preparation and building the network of proposers. It is expected that this integration of knowledge will continue during the COST Action and also include activities under the upcoming Horizon Europe framework. In addition, network partners are involved in founding start-ups, developing a scientific journal, running study programmes and PhD trainings, working with the target groups in practical professions, and developing technological standards like DIN and ISO. These experiences will be useful for dissemination and exploitation in general, but also for building practical examples of the tools, to be developed, following by developing a critical mass for applying the new standards.

Network statistics show diversity in disciplines (health including exercise science, clinical medicine, psychology, ageing, neuroscience, education and others) and organisations (academic, NGO, government, international RD), fully covering the complexity of the topic and assuring sustaining valorisation.

Leverage will be increased by the activities of the PhysAgeNet members with other networks: Corresponding other COST Actions, Horizon2020 projects, Horizon Europe areas addressing behaviour and health have already been identified. In addition, PhysAgeNet members collaborate with international science organisations and several EU-funded strategic partnerships and innovation actions, and run an international peer-reviewed journal in the field. WG4 (T4.3) will help to mine these opportunities, in particular for the network will grow, and to build a development strategy inside and outside the network.

2.2.2. INVOLVEMENT OF STAKEHOLDERS

The proposers will use existinig contacts to EC research officers and to H2020 projects for approaching representatives and include them as stakeholders, in order to learn from their view about issues and solutions, and to gain feedback. These include researchers, industry and practitioners who work with full diversity of seniors.

As journal editors are part of the network, they will contact their publishing houses, which are interested in improving journal quality, in order to implement new reporting standards developed by the network and for integrating various decisions made in the network first in their own journal, and then disseminating the new standards and decisions to other journals within the scope of PA in advanced age.

External experts in technology, AI, assisted living and data mining will be invited, as well as experts in biomarkers of other disciplines that are related to the needs of the Working Groups.

While a business view is already a part of the network, additional input and exchange will be organised by inviting experts from the gaming industry and health ICT companies, e.g. by utilising contacts in existing innovation projects of the network partners.

Workshops and stakeholder events early in the COST Action (see 4.1.4) will focus on input from stakeholders, later events will focus on dissemination and exploitation.

EGREPA, the European Group for Research into Elderly and Physical Activity, is a scientific association, which offers valorisation of the network results in their conferences and their scientific journal. In return, EGREPA will benefit from the expected interest in these publications. The largest mutual benefit, however, will emerge from a joint transfer of the network into a sustained structure. The board of this organisation has already expressed intent to contribute to develop this structure.

2.2.3. MUTUAL BENEFITS OF THE INVOLVEMENT OF SECONDARY PROPOSERS FROM NEAR NEIGHBOUR OR INTERNATIONAL PARTNER COUNTRIES OR INTERNATIONAL ORGANISATIONS

- Researchers from Japan (Kyoto and Toyohashi) will contribute expertise in education and in physiology, including general knowledge from their country, discuss demographic changes which have preceded those in the European countries, and will extend their cultural perspectives. This will strengthen the contacts with former organisers of the World Congress on Ageing and Physical Activity (Tsukuba), and enhance a longstanding interest in exchanging ideas with European academia.
- The National Ageing Research Institute in Melbourne, Australia, is one of the most well-known institutes in the field. Dr Frances Batchelor, Director of Clinical Gerontology at NARI, and an expert in fall prevention, has joined the network of proposers on behalf of NARI, in order to build research and academic exchange with Europe.
- The University of São Paulo is the largest Brazilian public university and holds a high reputation among world universities. Professor Luis Mochizuki from this institution joined the network and will contribute not only his expertise in the field but also serve as multiplier and promoter of PhysAgeNet results between continents.

3. IMPACT

3.1. IMPACT TO SCIENCE, SOCIETY AND COMPETITIVENESS, AND POTENTIAL FOR INNOVATION/BREAKTHROUGHS

3.1.1. SCIENTIFIC, TECHNOLOGICAL, AND/OR SOCIOECONOMIC IMPACTS (INCLUDING POTENTIAL INNOVATIONS AND/OR BREAKTHROUGHS)

Short-term impact

- Accelerate sharing of knowledge and experiences on current gaps and needs: The development of an interdisciplinary network will allow scientists, public health practitioners, and AI experts to identify gaps in the current scientific/practical knowledge and propose relevant forums to discuss these gaps in upcoming symposia and workshops.
- Raise attention to knowledge gaps: Participants will gain information about knowledge gaps through network interactions and increase this information by incorporating it into their teaching and training activities (e.g., international master and PhD programs focusing on ageing and physical activity).

Long-term impact

- Spreading of knowledge about healthy ageing research concepts and research methods to various stakeholders, ECIs and ITCs, and facilitate sharing of knowledge by initiating large discussion forums that will have a long-term impact on integration of EBM related PA initiatives for disease prevention and improvement of health in senior citizens of the EU. This will aid scientific and technological breakthroughs.
- Enhanced cooperation between basic research and applied research. The increased exchange of knowledge between researchers, clinicians, trainers, developers, and stakeholders will create new technologies to support EBM related interventions and allow efficient translation of knowledge from research to practice.
- Building a data registry, fostering big data approaches, and integrating AI-based analysis tools will allow the conceptualization and development of reliable risk prediction models to identify those at increased risk for developing sedentary behavior and functional impairments. This will have significant societal impact in terms of reducing the burden of ageing and age related disease thereby reducing health care costs.
- Developing platforms for implementation of individual training: It is currently unclear which intervention programs effectively reduce sedentary behavior, risk for falls, and frailly among older individuals. Therefore, by planning a peer network-driven intervention study to assess the effect of a tailored PA training intervention, this COST Action will have a long-term impact in terms of the design of targeted therapies, which allows for a differentiation of applicability at different stages of prevention, diagnosis and therapy.
- Accelerate application of AI capabilities in PA training programs for older adults as a means to improve intervention outcomes within populations with diverse needs towards the development of tailored PA training. This COST Action will create a framework where scientists, practitioners, and innovative SMEs could meet and discuss the current state of AI applications in PA training program and propose AI techniques and methods for optimizing applications of AI capabilities in tailored PA training programs.
- Promoting public health: By promoting concepts relevant to healthy ageing and physical activity across all EU countries, this Action will help to reduce the risk of sedentary behaviour among EU citizens over the long-term while taking into account the combined influence of personal and environmental determinants. This approach is expected to have a significant societal impact on the population's health as well as on the healthcare systems.
- Facilitating the collaboration between members of the network to present new H2020 projects related to physical activity and multidimensional interventions directed to promote healthy ageing.

3.2. MEASURES TO MAXIMISE IMPACT

3.2.1. KNOWLEDGE CREATION, TRANSFER OF KNOWLEDGE AND CAREER DEVELOPMENT

Knowledge creation

One of the objectives of this Action is to coordinate and synchronize the creation of available knowledge and data. Knowledge creation will be assured by collaboration between the leading experts on ageing and sports sciences. Since research in these areas is rather fragmented, the most important step for promoting the concept of healthy ageing and translating it into the development of the EBM approach and the conceptualization of AI tools for interventional practice is arriving at a consensus on physiological biomarkers and measurement techniques for the assessment of age-related processes and beneficial effects (as well as risk factors) of PA interventions. This will not only help to improve the understanding of the underlying ageing mechanisms, but will also be a stepping stone for new innovations and breakthroughs, specifically, but not exclusively the **integration and use of AI in tailored PA programs for older adults as a means to optimize intervention outcomes**. In medicine, robust evidence from research studies is of vital importance for translating concepts and innovations from both basic research and clinical research into guidelines and clinical practice.

Transfer of knowledge & career development
In this COST Action there will be several ways to transfer knowledge. Firstly, WGs meetings will be scheduled and organized on a regular basis (face-to-face twice a year and monthly using online teleconferencing tools). Other means for knowledge transfer within, but not restricted to, the network are Short Term Scientific Missions (STSMs; two per year up to 3 months long) and annual Training Schools for PhD students and post-doc early career researchers. This will not only intensify the exchange among early career investigators (ECIs), but also with senior researchers and company representatives. Workshops, seminars, the final conference and the public awareness events will be used for promoting the concept of healthy ageing not only to the participants of the COST Action but also to external stakeholders, health institutions, and to the general public. The Action will also be of great advantage to the career development of healthcare personnel and PA trainers by exposing them to current research in interdisciplinary fields throughout their basic and practical education.

3.2.2 PLAN FOR DISSEMINATION AND/OR EXPLOITATION AND DIALOGUE WITH THE GENERAL PUBLIC OR POLICY

A webpage of this COST Action will be created for disseminating knowledge and updating the Action members on upcoming relevant events (e.g., conferences, workshops, PhD summer-schools, etc.), Action meetings/events and deliverables. Dissemination to the previously mentioned stakeholders will take place as follows (for details see WG descriptions in section 4.1.1. and the Gantt chart in section 4.1.4):

- For senior researchers and ECIs, the Action results will be disseminated through presentations and the organization of symposia in conferences and workshops that will be open particularly to ECIs, practitioners and policy-making communities and other stakeholders. ECIs will be encouraged to prepare seminars and Literature Club Meetings in their own institutions. At least four (open-access) articles in peer-reviewed scientific journals will be prepared/submitted based on the outcomes (per each WG). The results of the COST Action will also be disseminated in one special issue of an international peer-reviewed journal focused healthy ageing. ECIs in all WGs will prepare scientific publications to be presented at conferences and non-academic forums. Each WG will make briefs/reports based on the outcomes of work meetings and annual meetings and dedicated pages on the Action in the website.
- For companies and practitioners, the Action results will be disseminated through: participation in WGs meetings, participation in Training Schools, organising specific panels on healthy ageing during conferences. Participants will also dedicate pages on the Action in the website and social media (e.g., Twitter, Facebook, Instagram, blog) of their institutions.
- For the general public, the Action results will be disseminated mostly through flyers and posters and in public events (e.g., lectures) addressing non-professionals as well as by distributing quarterly newsletter of the COST Action Group in social media (e.g., Twitter, Facebook, Instagram, blog). Hard-copy newsletters and posters describing this Action will be displayed by all participants in their institutions.

4. IMPLEMENTATION

4.1. COHERENCE AND EFFECTIVENESS OF THE WORK PLAN

4.1.1. DESCRIPTION OF WORKING GROUPS, TASKS AND ACTIVITIES

WG 1: Implementation and development of standards from evidence-based medicine (EBM)
This WG relates to technology-assisted PA and exercise interventions. In order to achieve RCO 4, RCO 5 and RCO 6, WG 1 will review the material and tools from EBM (considered as an umbrella term). It is expected that some tools will be adopted and promoted without change, while others will have to be carefully modified in order to adapt to PA interventions. The concept of evaluating evidence levels will be applied to a reference database, possibly without modification. It should be noted, that

exercise interventions are sometimes more complex than drugs therapy, in terms of the subject's behaviour. Thus, a framework of evidence-based standards should be created in a detailed manner to fit the complexity of exercise standards and behaviour.

Tasks:
T1.1 Reviewing the EBM concepts and material for examining the usefulness of these concepts for PhysAgeNet's topics. Compiling a toolbox with EBM guidelines, checklists, and frameworks which may be applied directly or need to be modified for use in the area of PA in old age.
T1.2 Collecting projects and publications on technology-assisted PA interventions, categorising participant groups and intervention types (e.g., resistance training, exercise groups, everyday activity)
T1.3 Rating of evidence level (referring to the EBM conception) and the generalisability of results (for the various target groups) and compiling a literature review for demonstrating the usefulness of the database.
T1.4 Developing a descriptive tool for interventions (e.g. intensity, volume, frequency of exercise /activity, practical aspects) and training material, according to EBM standards
T1.5 Pointing out issues for improving research (parallel to T2.3) material, collecting them and forming guidelines and a roadmap using a formal consensus process.

Deliverables
D1.1 Database with references and metadata related to PA interventions and based on EBM. (Collection update after two years), Complete coverage of EU funded research. Updated versions of the reference database includes evaluation results (one category or target groups per year with evidence level and generalisation options) (RCO 4)
D1.2 Systematic review using the database D1.1 related to PA interventions and EBM, submitted for publication (RCO 4).
D1.3 Description tool for PA and exercise interventions, based on EBM standards (RCO 6).
D1.4 Curriculum for teaching students and young scientists on the description tool (RCO 6)
D1.5 Consensus paper and roadmap on EBM for PA interventions submitted for publication (RCO 5)

WG 2 Data for utilising biomarkers and behavioural markers as well as environmental factors.
This WG relates to open data and multiple source data for utilising biomarkers and behavioural markers as well as environmental factors in technology-assisted PA and exercise interventions. In order to reach RCO 1, RCO 2 and RCO 3, this WG will create an overview on markers of the ageing processes, environmental factors, and fitness components (with a broad meaning) including measurement issues, for establishing a cohesive conception of measurements and meaningful data. This includes open data and citizen science. These concepts are innovative in the field and can leverage the usefulness of the multiple source approach. Not only prospective (after publication of research papers) collection of data should be covered and promoted, but also retrospective data, in order to understand the progress of research on ageing and PA and the mechanisms behind these concepts.

Tasks:
T2.1 Collecting the legal and ethical aspects of open data and citizen science in COST countries
T2.2 Collecting the technical, practical, and financial aspects related to open data in COST countries
T2.3 Listing the scientific requirements and potentials for open data including biomarkers and other data from multiple sources,
T2.4 Establishing the requirements, barriers, and opportunities for open data collections from a citizen science perspective.
T2.5 Building a demonstrator of open data bank of PA intervention, with retrospective data publication and /or citizen science (seniors, hospital or other practitioners).
T2.6 Identifying scientific improvements in order to utilise the potential of open data and citizen science.

Deliverables
D2.1 Compendium of legal, ethical and resource aspects for open data repositories.
D2.2 Scientific literature status, requirements and roadmap for the development of standards and utilisation of biomarkers, behavioural markers and environmental factors with open data (RCO 1).

D2.3 Open data framework including PA intervention and multiple data sources and biomarkers (RCO 2).
D2.4 Demonstrator (prototype) of the repository including real data from technology-assisted PA interventions (RCO 3).

WG 3: Research methodology for technology-assisted PA and exercise interventions in old age
In order to achieve RCO 7 and RCO 8, methodological issues are to be collected and analysed. A consensus on reasons, risks and mechanisms for pitfalls and problems in technology-assisted interventions is necessary. Once this is achieved, work on improvements can start including improvement in recruitment criteria and procedures, improving comparability of assessments (and thus comparability of study results, in order to raise evidence levels, see WG 1), and improving goal-setting and intervention design. For all three of these tasks, the priority is to find a topical focus or reduction of complexity (e.g. narrow goals or target groups) which allows for a simple and exemplary solution ready for implementation in algorithms and thus technology.

Tasks:
T3.1 Overview and classification of pitfalls and problems in technology-assisted PA interventions for older adults from a proper research methodological point of view, forming a work plan for the WG
T3.2 Strategy for improving comparability and standardisation of assessment of motor-cognitive and functional capabilities.
T3.3 Strategy for improving recruitment and sampling of old age target groups for achieving meaningful and generalizable results.
T3.4 Compiling concepts for goal-setting and corresponding principles for intervention design.

Deliverables:
D3.1 Guidelines on requirements and strategical improvement of recruitment and sampling for different target groups, using a formal consensus procedure (RCO 7).
D3.2 Guidelines and framework for designing technology-assisted PA interventions including appropriate assessment standards (RCO 8).

WG4: Network development, sustainability and dissemination of network results
Inside the network, activities, membership, participation and collaboration will be developed.
Outside the network, application and implementation of the network results (see deliverables) in various activities of the network members (research projects, funding proposals, publications, teaching and education) should be an example and proof for others (see section 2.2). Objectives are
(1) to develop the network in terms of full European coverage, age and gender balance, necessary disciplines, relevant stakeholder and external expert collaborations;
(2) to make the network sustainable beyond the COST Action in terms of structure, management and finances;
(3) to establish the results of the other Working Groups in appropriate and sustaining formats.

Tasks:
T4.1 Establish internal communication (contact and mailing lists, reporting and planning schedules) of all network activities, continuous screening of all minutes / reports for ad-hoc and strategic dissemination and exploitation.
T4.2 Create and provide promotion material and dissemination channels, to be used by all network members on the occasion of their own conference visits, projects, teaching, including a yearly public newsletter
T4.3 Explore requirements and opportunities for perpetuating the network partly or as a whole (e.g. collaboration and connection with universities, other networks or societies, business), including sustainability strategy and action planning, stakeholder analysis and balanced scorecard
T4.4 Implement and further develop the measures to maximise impact (2.2, 3.2), including funding proposals (3.2).
T4.5 Conduct a consensus process on the progress beyond initial topical status and needs update.

Deliverables
D4.1 Design and set up of standard tools for internal and external communication, including logo, website and social media accounts
D4.2 Stakeholder Analysis Matrix, containing a list of stakeholders, their interests and influence on the topic. (CBO 2).
D4.3 Report on PhysAgeNet composition, development and sustainability, including status and strategy (CBO 1, CBO 2)
D4.4 Report on PhysAgeNet research and impact, including implementation of measures to maximise impact (CBO 3)
D4.5 Consensus report on final state of the art and further needs (RCO 9).

4.1.2. DESCRIPTION OF DELIVERABLES AND TIMEFRAME

The following elaboration contains the deliverables for measuring the achievement of the research coordination (RCO) and capacity building (CBO) objectives.

RCO 1: D2.1 Compendium of legal, ethical and resource aspects for open data repositories. Timeframe M1-M12. D2.2 Scientific literature status, requirements and roadmap for the development of standards and utilisation of biomarkers with open data. Defines the basis for RCO 2+3. Timeframe M1-M18.
RCO 2: D2.3 Open data framework including PA intervention and multiple data sources and biomarkers. First practical result of WG2 for future usage. Timeframe M12-M24.
RCO 3: D2.4 Demonstrator (prototype) repository including real data from technology-assisted PA interventions. Application of D2.3, necessary for decision on availability of data (from other projects or to be recorded) and on usefulness for demonstration. Timeframe M12-M36.
RCO 4: D1.1 Updated versions of the reference database, which include evaluation results (one category or target groups per year with evidence level and generalisation area). While the reference database is rather easy to collect by keyword searches, D1.1 includes an evaluation of each paper. This is very ambitious, therefore restrictions to one category (narrow target group or intervention type) is necessary. The aim is to retrieve a functional example for one category after the other, demonstrating the usefulness of the concept, and allowing for compiling a systematic review (D1.2), as application of D1.1. Timeframe M6-M24 (D1.1), M18-M30 (D1.2).
RCO 5: D1.5 Consensus paper and roadmap on EBM for PA interventions submitted for publication. Final description and conclusion. Timeframe M30-M48.
RCO 6: D1.4 Curriculum for teaching students and young scientists on the description tool, usable for training schools and/or inclusion in postgraduate study programmes. Application of the interventions description tool D1.3, which has to be developed in advance (timeframe M12-M30). Timeframe M36-M48.
RCO 7: D3.1 Guidelines on requirements and strategical improvement of recruitment and sampling for different target groups, using a formal consensus procedure. Timeframe M18-M36.
RCO 8: D3.2 Guidelines and framework for designing technology-assisted physical activity interventions, including appropriate assessment standards. Development of content, prioritisation, description and conclusion of a formal consensus procedure. Timeframe M24-M42.
RCO 9: D4.5 Consensus report on final state of the art and further needs
Final description of progress during the COST Action, new state of the art and conclusion.
Timeframe M36-M48.
CBO 1, CBO2: D4.1 Design and set up of standard tools for internal and external communication, including logo, website and social media accounts (time frame M1-M6). D4.2 Stakeholder Analysis Matrix. It contains a list of stakeholders, their interests and influence on the topic, corresponding to workshops for exchange with stakeholders (4). Timeframe M1-M48 (yearly). D4.3 Report on PhysAgeNet composition, development and sustainability, including status and strategy regarding COST policy parameters and sustainability ambitions, using the balanced scorecard. Timeframe M1-M48 (yearly).
CBO 3: D4.4 Report on PhysAgeNet research and impact, including implementation of measures to maximise impact (3.2), research questions identified by all WGs, corresponding research proposals submitted by network partners (3.2). Timeframe M12-M48 (yearly)

4.1.3. RISK ANALYSIS AND CONTINGENCY PLANS

Risk	Risk for WGs	Chance	Impact	Contingency plans
Suboptimal network size at the start of the Action	All	Medium	High	Network expansion by inviting new participants through online social media (by WG4) and personal contacts (by all Action Members).
Low attendance at the Action networking activities	All	Medium	High	Delegation of responsibilities by WG4 to Action Members of all WGs to enhance commitment among all Action Members. Overlap Action networking activities between Action members of WG2 and WG3
Low attendance of practitioners and SMEs in the Action	WG1 WG2 WG3	Medium	High	Focus efforts of network expending for SMEs and practitioners. Delegation of responsibilities to research Action members who can be involved in development of ICT, AI, or serve as trainers.
Incapability to involve a wider audience in Wgs activities	All	Medium	High	Overlap the Action networking activities between Action members of all WGs
Lack of research resources limiting the creation of sufficient database for AI	WG1 WG2 WG3	Low	High	Synthesize information from meta-analyses. Increase research collaboration between Action members to produce additional research resources through multicenter studies.
Legal issues considering the data registry and sharing	All	Low	High	Appoint a coordinator from WG2 who will be responsible for getting ethical approval for data sharing from the EU commission. Include data collected in research projects approved by a local ethics committee for data sharing.
Lack of sufficient data from clinical trials and intervention studies	WG1 WG3	Medium	Medium	Synthesize information from meta-analyses. Increase research collaboration between Action members for the coordination of multicenter intervention studies and clinical trial studies
Lack of research resources limiting the achievement of the objectives.	WG1 WG2 WG3	Low	Medium	Individual Action members from the same institute will receive extra financial support through their institutions. Action members from the same country will coordinate applications for national grants.
Low attendance of young researchers and PhD students in the Action	WG1 WG2 WG3	Low	Medium	Senior Action members of all WGs will invite PhDs and post-docs from their lab to join network activities.
Countries leaving the Action	All	Low	Medium	Approach new Action members /representatives from the same counties, Network enlargement to other countries.

4.1.4. GANTT DIAGRAM

Activity/Event	Year 1				Year 2				Year 3				Year 4			
	M1 M3	M4 M6	M7 M9	M10 M12	M13 M15	M16 M18	M19 M21	M22 M24	M25 M27	M28 M30	M31 M33	M34 M36	M37 M39	M40 M42	M43 M45	M46 M48
KO Meeting	X															
Yearly MC Meeting				X				X				X				X
Website launch and update		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WG Meeting WG1	X		X		X		X		X		X		X		X	
WG Meeting WG2	X		X		X		X		X		X		X		X	
WG Meeting WG3	X		X		X		X		X		X		X		X	
WG Meeting WG4		X		X		X		X		X		X				X
Workshops and stake-holder events (using D4.2)		X		X		X				X					X	
Training Schools (using D1.4)							X				X				X	
STSM			X		X		X		X		X		X		X	
Final Conference																X
Deliverables (in case of yearly up-dates, only the last is entered)		D4.1		D2.1		D2.2		D1.1 D2.3		D1.2 D1.3		D2.4 D3.1		D3.2	D1.4 D4.2	D1.5 D4.3 D4.4 D4.5
Milestones (MS)		MS1						MS2				MS3		MS4		

MS1 = Input from stakeholders' workshop received (D4.2), Promotion via website and social media started (D4.1); **MS2** = Reference database (D1.1) and data framework (D2.3) ready for use; **MS3** = real data from technology-assisted PA in the repository; **MS4** = Designing tailored interventions and assessment possible via the framework D3.2.

5. REFERENCES

1. Kontis, Vasilis, et al. "Future life expectancy in 35 industrialised countries: projections with a Bayesian model ensemble." *The Lancet* 389.10076 (2017): 1323-1335.
2. WHO Aging and Health, February, 2018 https://www.who.int/news-room/fact-sheets/detail/ageing-and-health#. entered Sep 1 2019
3. Rechel, Bernd, et al. "Ageing in the European union." *The Lancet* 381.9874 (2013): 1312-1322.
4. Harvey, Juliet A., Sebastien FM Chastin, and Dawn A. Skelton. "How sedentary are older people? A systematic review of the amount of sedentary behavior." *Journal of aging and physical activity* 23.3 (2015): 471-487.
5. Leask, Calum F., et al. "Exploring the context of sedentary behaviour in older adults (what, where, why, when and with whom)." *European Review of Aging and Physical Activity* 12.1 (2015): 4.
6. Crimmins, Eileen M. "Lifespan and healthspan: past, present, and promise." *The Gerontologist* 55.6 (2015): 901-911.

7. Partridge, Linda, Joris Deelen, and P. Eline Slagboom. "Facing up to the global challenges of ageing." *Nature* 561.7721 (2018): 45.
8. Patterson, Richard, et al. "Sedentary behaviour and risk of all-cause, cardiovascular and cancer mortality, and incident type 2 diabetes: a systematic review and dose response meta-analysis." (2018): 811-829.
9. Arem, Hannah, et al. "Leisure time physical activity and mortality: a detailed pooled analysis of the dose-response relationship." *JAMA internal medicine* 175.6 (2015): 959-967.
10. Ding, Ding, et al. "The economic burden of physical inactivity: a global analysis of major non-communicable diseases." *The Lancet* 388.10051 (2016): 1311-1324.
11. 2018 Ageing Report: Policy challenges for ageing societies.
12. Dallmeyer, Sören, Pamela Wicker, and Christoph Breuer. "How an aging society affects the economic costs of inactivity in Germany: empirical evidence and projections." *European review of aging and physical activity* 14.1 (2017): 18.
13. Lear, Scott A., et al. "The effect of physical activity on mortality and cardiovascular disease in 130 000 people from 17 high-income, middle-income, and low-income countries: the PURE study." *The Lancet* 390.10113 (2017): 2643-2654.
14. Reiner, Miriam, et al. "Long-term health benefits of physical activity–a systematic review of longitudinal studies." *BMC public health* 13.1 (2013): 813.
15. Stessman, Jochanan, and Jeremy M. Jacobs. "Diabetes mellitus, physical activity, and longevity between the ages of 70 and 90." *Journal of the American Geriatrics Society* 62.7 (2014): 1329-1334.
16. Netz, Yael. "Is There a Preferred Mode of Exercise for Cognition Enhancement in Older Age?—A Narrative Review." *Frontiers in medicine* 6 (2019).
17. Paillard, Thierry. "Preventive effects of regular physical exercise against cognitive decline and the risk of dementia with age advancement." *Sports medicine-open* 1.1 (2015): 20.
18. Livingston, Gill, et al. "Dementia prevention, intervention, and care." *The Lancet* 390.10113 (2017): 2673-2734.
19. Loprinzi, Paul D. "Objectively measured light and moderate-to-vigorous physical activity is associated with lower depression levels among older US adults." *Aging & mental health* 17.7 (2013): 801-805.
20. Dinh, H. Cao, et al. "Effects of physical exercise on markers of cellular immunosenescence: a systematic review." *Calcified tissue international* 100.2 (2017): 193-215.
21. Calisaya, Michele L., et al. "Ageing and gait variability—a population-based study of older people." *Age and ageing* 39.2 (2010): 191-197.
22. Hultsch, David F., Stuart WS MacDonald, and Roger A. Dixon. "Variability in reaction time performance of younger and older adults." *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences* 57.2 (2002): P101-P115.
23. Hoppmann, Christiane A., Jennifer C. Lay, and Setareh Shayanfar. "12 Intraindividual Variability in the Context of Adults' Health Behavior." *Handbook of Intraindividual Variability Across the Life Span* (2014): 216.
24. Rachele, Jerome N., et al. "Neighbourhood built environment and physical function among mid-to-older aged adults: a systematic review." *Health & place* 58 (2019): 102137.
25. Hinrichs, Timo, et al. "Perception of parks and trails as mobility facilitators and transportation walking in older adults: a study using digital geographical maps." *Aging clinical and experimental research* 31.5 (2019): 673-683.
26. Levin, Oron, Yael Netz, and Gal Ziv. "The beneficial effects of different types of exercise interventions on motor and cognitive functions in older age: a systematic review." *European Review of Aging and Physical Activity* 14.1 (2017): 20.
27. Djulbegovic, Benjamin, and Gordon H. Guyatt. "Progress in evidence-based medicine: a quarter century on." *The Lancet* 390.10092 (2017): 415-423.
28. Hecksteden, Anne, et al. "How to construct, conduct and analyze an exercise training study?." *Frontiers in physiology* 9 (2018).
29. Slade, Susan C., et al. "Consensus on Exercise Reporting Template (CERT): explanation and elaboration statement." *Br J Sports Med* 50.23 (2016): 1428-1437.
30. Godlovitch, Glenys. "Age discrimination in trials and treatment: old dogs and new tricks." *Monash bioethics review* 22.3 (2003): S66-S77.

31. Witham, Miles D., and Marion ET McMurdo. "How to get older people included in clinical studies." *Drugs & Aging* 24.3 (2007): 187-196.
32. Brach, Michael, et al. "Recruiting hard-to-reach subjects for exercise interventions: a multicentre and multi-stage approach targeting general practitioners and their community-dwelling and mobility-limited patients." *International journal of environmental research and public health* 10.12 (2013): 6611-6629.
33. Hutchins, Laura F., et al. "Underrepresentation of patients 65 years of age or older in cancer-treatment trials." *New England Journal of Medicine* 341.27 (1999): 2061-2067.
34. Crome, Peter, Antonio Cherubini, and Joaquim Oristrell. "The PREDICT (increasing the participation of the elderly in clinical trials) study: the charter and beyond." *Expert review of clinical pharmacology* 7.4 (2014): 457-468.
35. Beedie, Chris, Steven Mann, and Alfonso Jimenez. "Community fitness center-based physical activity interventions: a brief review." *Current sports medicine reports* 13.4 (2014): 267-274.
36. Beedie, Chris, et al. "Death by effectiveness: exercise as medicine caught in the efficacy trap!." (2016): 323-324.
37. Shin, Grace, et al. "Wearable activity trackers, accuracy, adoption, acceptance and health impact: a systematic literature review." *Journal of biomedical informatics* (2019): 103153.
38. Düking, Peter, et al. "Integrated framework of load monitoring by a combination of smartphone applications, wearables and point-of-care testing provides feedback that allows individual responsive adjustments to activities of daily living." *Sensors* 18.5 (2018): 1632.
39. Delbaere, K., et al. "Evaluating the effectiveness of a home-based exercise programme delivered through a tablet computer for preventing falls in older community-dwelling people over 2 years: study protocol for the Standing Tall randomised controlled trial." *BMJ open* 5.10 (2015): e009173.
40. D'Cunha, Nathan M., et al. "A Mini-Review of Virtual Reality-Based Interventions to Promote Well-Being for People Living with Dementia and Mild Cognitive Impairment." *Gerontology* (2019): 1-11.
41. Costa, Marcos Túlio Silva, et al. "Virtual reality-based exercise with exergames as medicine in different contexts: a short review." *Clinical practice and epidemiology in mental health: CP & EMH* 15 (2019): 15.
42. Valenzuela, Trinidad, et al. "Adherence to technology-based exercise programs in older adults: a systematic review." *Journal of Geriatric Physical Therapy* 41.1 (2018): 49-61.