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AGEDESIGN

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AGEDESIGN Interreg ITA-AUS cooperation to promote healthy and active ageing through the use of properly designed wearable devices

Abstract

The paper presents the four research lines addressed by the Interreg ITA-AUS Project involving CPV, IUAV, ULSS Dolomiti, SFRG and PLUS.

The first part focuses on the brief definition and the goals to address for each research line, the second introduces the process that drives to the formal definition, the identification of the expected results and of the technologies to be applied, and the third presents the relation of the products with the context through the definition of the connected services and the relation with the local healthcare environments.

Keywords

AGEDESIGN, Interreg, Design, Healthcare, Prevention, Healthy Ageing, Active Ageing

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Introduction

The project consists of a joint research activity (Veneto-Salzburg) oriented to the definition, development and testing of new "design concepts" of products and services for ageing people: the main objective of the project is to provide suitable tools that in the near future can help the improvement and preservation of health and wellness for elderly people, and to prevent the emergency of physical and psychological problems.

The project foresees the definition of the objectives of 4 research lines, the analysis of the differences and compatibility of the research results when exploited in Italy and in Austria, the implementation of the research with the production of 4 "design brief" merged into 3 "design concepts", a demonstrative check on a panel of end-users, the final characterization and the evaluation of forms and methods for the continuation of the research. The wearable devices designed through the project will provide a support to the users for reaching a healthier lifestyle in a home-based environment, therefore they won't be registered as medical devices.

This project aims to be the initial step for a joint programme of research activities and cooperation between the partners, also due to the similarities of the two regions and the chances of development given by the local demands.

With the present paper we present the work that has been done in the first semester of activity: the first section introduces the four research areas identified as relevant by the AGEDESIGN team and explores them in terms of impact on the health of an ageing population, the approach with which the partners have started the research and the process that has driven to the brief definition, and the agreement by all the partners on the concepts; the second part introduces the technical aspects of the project development, focusing on the research activities, the human resources and the needed assets; the third section ends with the observations on the project and with some considerations about the possible further developments.

1. Brief and goals of the AGEDESIGN Project

The future of wearable devices integrates existing technologies at affordable prices, encouraging the adoption of health monitoring technologies in everyday life. These facilitate the home assistance during the performance of physical activities inside and outside home perimeter in a friendly way, becoming tools that looks like ornamental objects. They collect and manage specific physical and behavioural data and at the same time monitor the environmental conditions.

With the term "design brief" we intend here the specification of the typology and the characteristics of the products on which the researchers will work to address the four research lines introduced in the AGEDESIGN Project Agreement. The characterization implies the study of technical components, ergonomic aspects, performance, aesthetics and the interaction expected.

Despite the identification of four research lines into the Interreg Ita-Aus Agedesign agreed document, the preliminary research phase has driven to the identification of two research lines as similar and addressable with the same sensors and movements: to avoid the design of products with analogous functions and features, "muscular control and balance" and "sensory abilities" have been merged in a single research line (Table 1). Once defined the typology of sensors the partners agreed upon the design brief to combine three aims – heartbeat control, muscular control and functional abilities control– into a unique smart tracksuit. Eventually, the design brief and the concepts developed into the project are three:

- ✓ **vascular circulation;**
- ✓ **muscular control, balance and sensory abilities;**
- ✓ **dehydration.**

Table 1 - Definition of the design concept (WP3.2)

Research lines	1 - Vascular circulation	2 - Muscular control and balance	3 - Functional abilities	4 - Dehydration
Design Brief	AIM: monitoring arrhythmia during physical activities	AIM: monitoring the lack of balance and the loss of muscular tone, to stimulate correct posture during physical activities	AIM: monitoring the lack of balance during physical activities	AIM: monitoring the dehydration during the day
	upper limbs	lower limbs	lower limbs	to be defined
	• LVL sensor • IMU • Connectors • USB charge station	LVL sensor IMU Connectors USB charge station	• LVL sensor • IMU • Connectors • USB charge station	still under research

Concept	smart t-shirt	smart trousers	wearable device

The first approach to the research lines has been oriented to a general identification of the physical parameter to monitor in order to get the relevant data that give an overview on the user's situation. The users have been identified as persons over 65, with an healthy lifestyle and without existing pathologies: they might have familiarity with diseases such as diabetes, high or low pressure, hypertension, arthritis, sarcopenia but they have not been diagnosed with any of these; therefore the use of medical terms in the development of the project shall not imply the treatment

of the user as a patient but the goal of the research is to develop a product, or a series of products, that address the lifestyle of different personas in a programme of prevention of any disease that can occur in connection to the ageing process. The wearable devices designed through the project will provide a support to the users for reaching a healthier lifestyle in an home-based environment, therefore they won't be registered as medical devices.

The second step after the identification of the parameters has been the research on the existing technologies that monitor such parameters. The decision to work towards the prevention of the disease instead on the treatment of the same has oriented the researchers to exclude the technologies that require invasive monitoring techniques. A brainstorming phase was necessary to understand and define aims and electronic components for each project's lines. A list of possible sensors to use for the development of the project has been provided by SRFG and PLUS in the document "First sensors assessments" shared with the partners in June 2017.

The details of the three research concepts will be exploited in the following paragraphs.

1.1 Formal definition and expected results

1.1.1 Project proposal

Since the first kick-off meeting, which took place in Salzburg on the 23th and 24th of February, Iuav researchers have been reasoning on the design possibilities: the first three research lines have been introduced to the students of the laboratory held by professor Chiapponi into the master programme in Product and Graphic Design of Iuav University, and then have been elaborated by the team of Iuav researchers together with the remaining research line.

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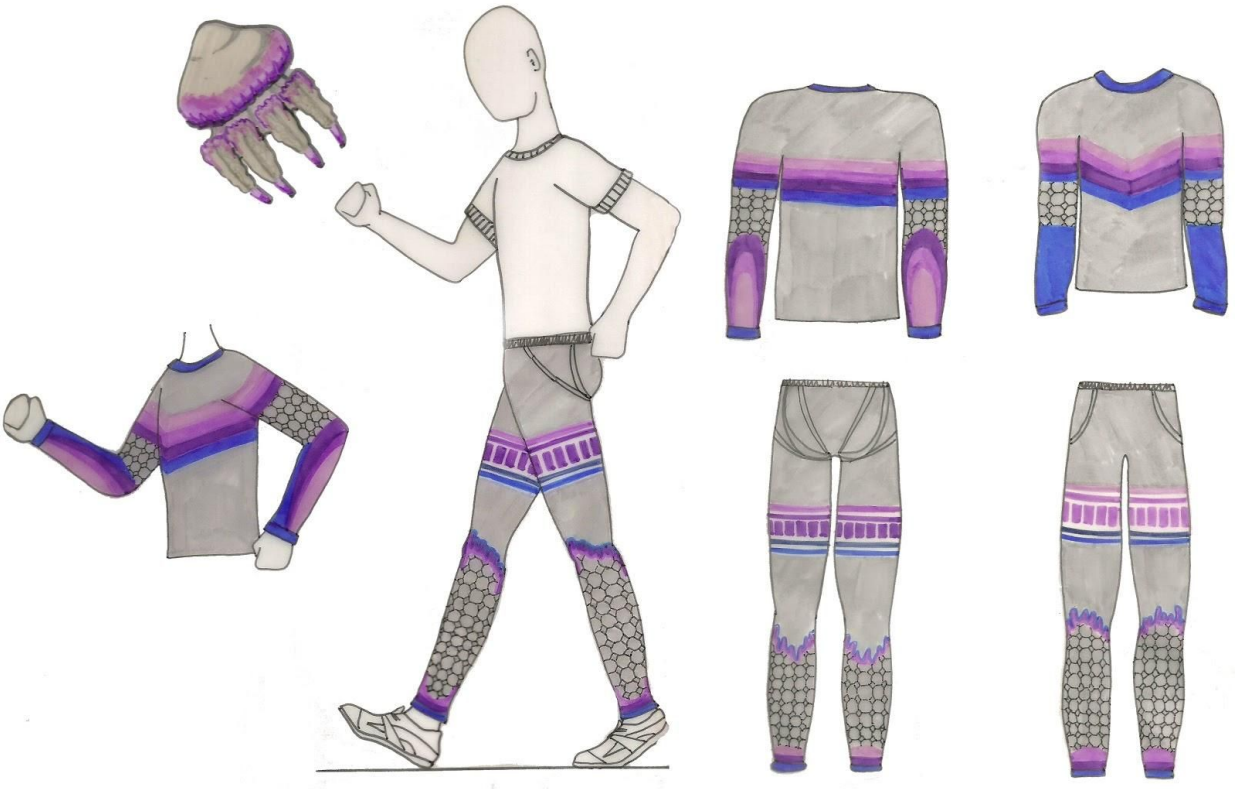
The second step after the identification of the parameters has been the research on the existing technologies that monitor such parameters. The decision to work towards the prevention of the disease instead on the treatment of the same has oriented the researchers to exclude the technologies that require invasive monitoring techniques.

The four research lines have been addressed separately and, by the month of May, Iuav has presented to the partners eight different concepts. All the concepts were intended as a combination of product and software system (app) supported by personal devices as smartphones and tablets, in

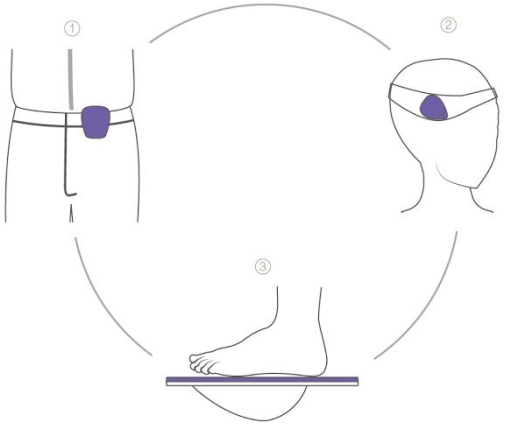
which the data collected by the devices were downloaded elaborated, shown to the user and stored into the user's' digital health profile.

- ✓ Concept 1, 2[1] - Sport t-shirt with integrated sensors that monitor vascular circulation combined with trousers to monitor muscular control and balance, and app with exercises (fig.1);
- ✓ Concept 3[2] - Wearable devices that monitor the regularity of physical activity, physical support (board) for lower limbs movement in domestic environments, and playful app providing paths in the urban area;
- ✓ Concept 4[3] - Digital scale with balance board for monitoring and stimulating muscular control and balance, provided with extractable handlebar to exercise the upper part of the body and app with suggestions for physical activities;
- ✓ Concept 5[4] - Sensor to be used within the fridge that identified the stored food's state of degradation, supporting the reduction of smell, sight and taste (sensory abilities) in elderly people and reducing the risk of intoxication;
- ✓ Concepts 6,7,8[5] - Wearable device that monitors the dryness of the skin, and app that reminds to drink and gives nutritional advices - Dehydration.

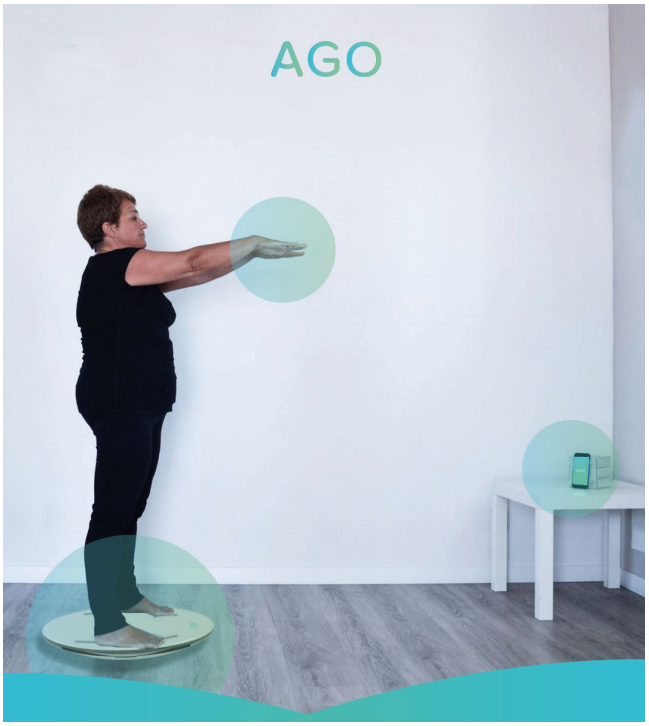
Concept 1, 2 - Aesthetic study for the sport t-shirt and trousers designed by IUAV team inspired by a jellyfish:



Concept 3 - Dinamico, designed by Lorella Pigatti, Martina Varuzza:

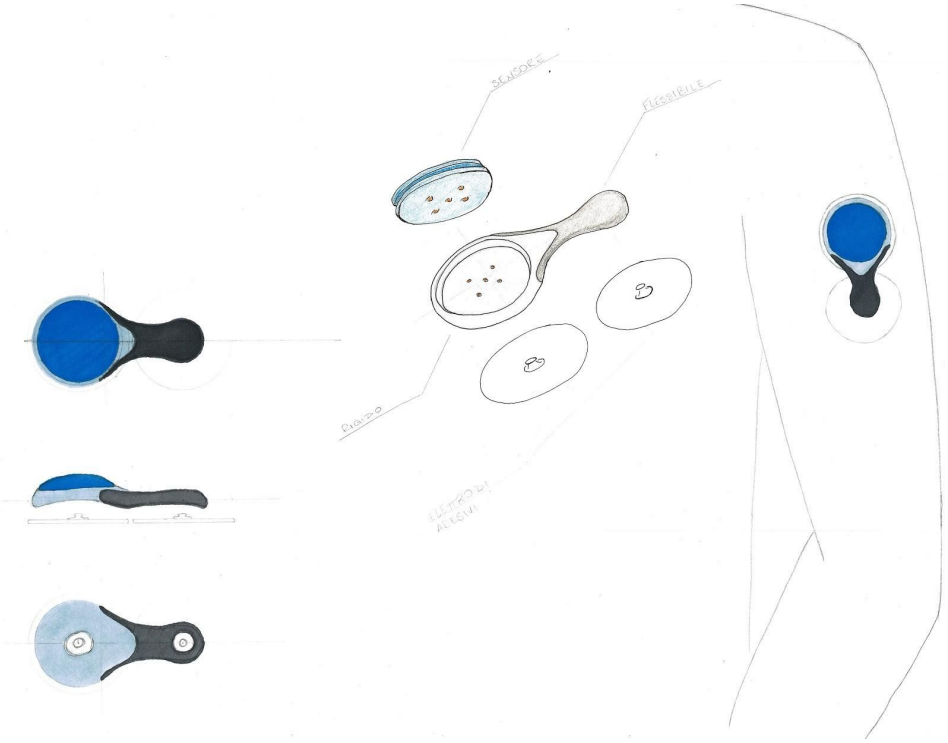


Concept 4 - Ago, designed by Carlo Guazzo, Laura Lenzi, Giulia Siviero:

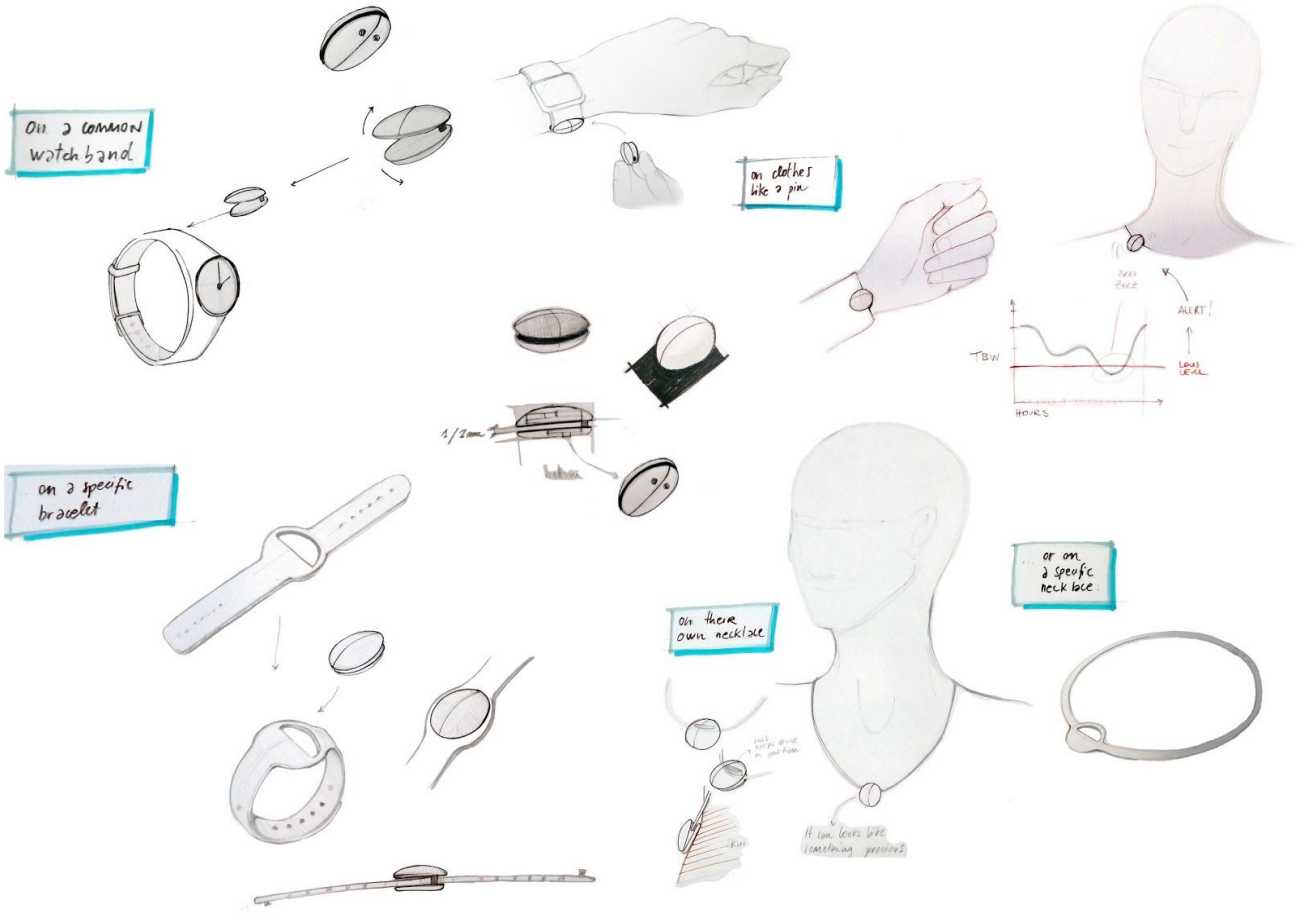


Concept 5 - Fresco, designed by Margherita Marzaduri:

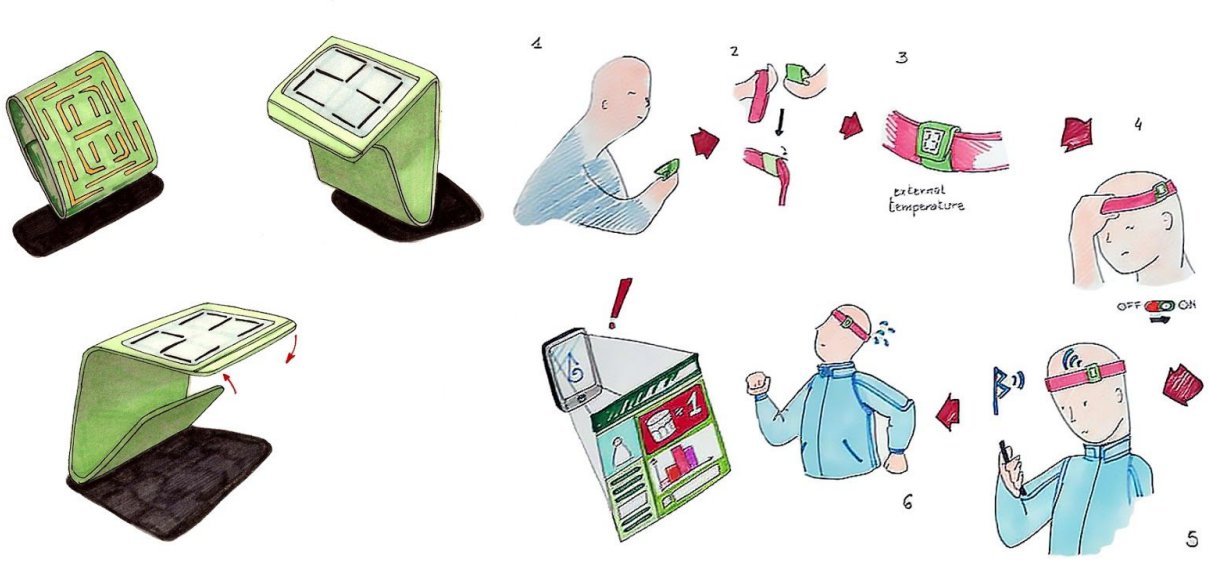
Concept 6 - Dehydration wearable device, designed by IUAV team:



Concept 7 - Dehydration wearable device, designed by IUAV team:



Concept 8 - Dehydration wearable device, designed by IUAV team:



1.1.2 Agreed Projects

The definition of the design brief has been completed by all the partners with the meeting in Feltre (Italy) on the 15th and 16th of May. In that occasion IUAV presented the eight project's concepts through sketches, handmade drawings, a first hypothesis on the necessary technologies and paper models. The technological knowledge of Salzburg Research Forschungsgesellshaft (SRFG) and Paris-Lodron Universitaet (PLUS) has driven to the dismissment of some proposed concepts.

A brainstorming phase was necessary to understand and define aims and electronic components for each project's lines (Table 2). Once defined the typology of sensors (an infrared sensor to detect heart activity and a series of Inertial Measurement Unit sensors to control physical performance) partners agreed upon the design brief to combine three aims – heartbeat control, muscular control and functional abilities control– into a unique smart tracksuit.

Table 2 - Expected outcome

#	Topic	Concept	
1	vascular circulation	t-shirt	A
2	muscular control and balance	trousers	B
3	sensory abilities		
4	dehydration	wearable device	C

A. T-shirt for Vascular Circulation

The t-shirt will be worn during physical activity to detect arrhythmia.

Elderly will be monitored on each their movement and they will be followed by a smartphone app, CARIMO, proposed by the partner SFRG which will guide the workout session and give alerts if the body position is incorrect, tracking the progresses of the user and involving them in a gamification dynamic that provides feedbacks on the progress.

B. Trousers for Muscular Control, Balance and Sensory Abilities

The trousers will be worn during physical activity to detect the loss of balance and of muscular strength, when the interested apparatus are in action.

Elderly will be monitored on each their movement and they will be followed by a smartphone app, CARIMO, proposed by the partner SFRG which will guide the workout session and give alerts if the body position is incorrect, tracking the progresses of the user and involving them in a gamification dynamic that provides feedbacks on the progress.

C. Wearable Device for Dehydration

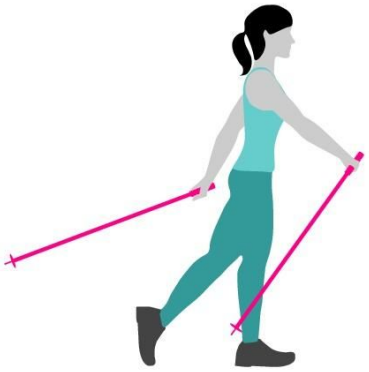
Elderly lose the sense of thirst and forget to drink water, for this reason they easily get dehydrated. Therefore, dehydration is a physiological parameter to be measured every day and not only in a workout session. The device will be designed to be worn all day long, from the morning until the evening.

2.Research activities, human resources and needed assets

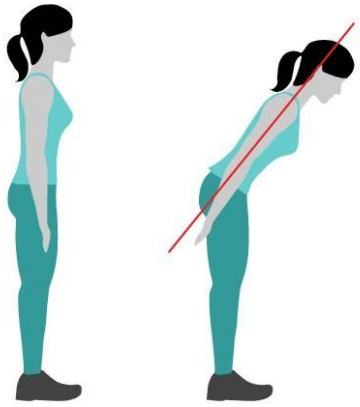
2.1 Guidelines for product development

The physical activities to be monitored have been defined in the document provided by SRFG and PLUS in June 2017 and verified by ULSS1- Dolomiti in July 2017 with the facilities in which the testing will be done (Table 3).

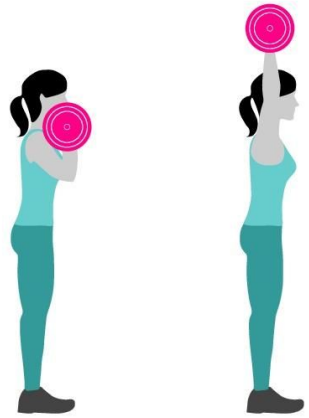
Table 3 - Excerpt from exercise selection

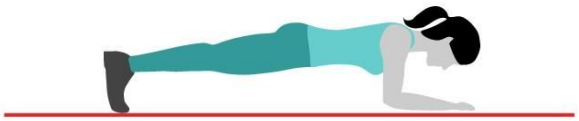
Exercise	Sensors	Measurement Variables
Nordic Walking  or Brisk Walking, jogging, running	✓ Ambient ✓ IMU ✓ LVL	✓ heart rate ✓ breathing hard and fast (pulmonary expansion) ✓ knee angle ✓ knee angle velocity ✓ knee angle acceleration ✓ varus/valgus ✓ use of the sticks (impact forces) ✓ gait cycle (e.g. asymmetries)

Exercise	Sensors	Measurement Variables
Squat (Kniebeuge) 	✓ Kinect ✓ Ambient ✓ IMU ✓ LVL	✓ heart rate ✓ breathing hard and fast (pulmonary expansion) ✓ knee angle ✓ knee angle velocity ✓ knee angle acceleration ✓ varus/valgus ✓ lumbar spine

Exercise	Sensors	Measurement Variables
Hinge (Kreuzheben) 	✓ Kinect ✓ Ambient ✓ IMU ✓ LVL	✓ heart rate ✓ breathing hard and fast (pulmonary expansion) ✓ knee angle ✓ knee angle velocity ✓ knee angle acceleration ✓ varus/valgus ✓ lumbar spine

Exercise	Sensors	Measurement Variables
Lunge (Ausfallschritt) 	✓ Kinect ✓ Ambient ✓ IMU ✓ LVL	✓ heart rate ✓ breathing hard and fast (pulmonary expansion) ✓ knee angle ✓ knee angle velocity ✓ knee angle acceleration ✓ varus/valgus ✓ lumbar spine

Exercise	Sensors	Measurement Variables
Military press (Schulterdrücken) 	✓ Kinect ✓ Ambient ✓ IMU ✓ LVL	✓ heart rate ✓ breathing hard and fast (pulmonary expansion) ✓ height of shoulders ✓ extended elbows

Exercise	Sensors	Measurement Variables
Plank (Unterarmstütz) 	✓ Kinect ✓ Ambient ✓ IMU ✓ LVL	✓ heart rate ✓ breathing hard and fast (pulmonary expansion) ✓ shoulder blades ✓ long neck ✓ lumbar spine

Exercise	Sensors	Measurement Variables
Standing on one leg 	✓ Kinect ✓ Ambient ✓ IMU ✓ LVL	✓ heart rate ✓ breathing hard and fast (pulmonary expansion) ✓ hip

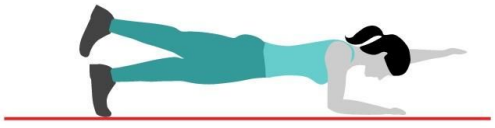
Exercise	Sensors	Measurement Variables
Plank (Unterarmstütz) remove feet/hands from floor 	✓ Kinect ✓ Ambient ✓ IMU ✓ LVL	✓ heart rate ✓ breathing hard and fast (pulmonary expansion) ✓ shoulder blades ✓ long neck ✓ lumbar spine

Table 4 - Description of the KITs to provide to the partners for the testing (WP4)

Research KITs		
	Salzburg	**Veneto**
Laboratory testing		
	1 x t-shirt (1 t-shirt + 1 strip of 5 sensors IMU + 1 strip of 5 connectors IMU + 1 hub USB for recharge + 1 infrared sensor LVL)	**1 x t-shirt** (1 t-shirt + 1 strip of 5 sensors IMU + 1 strip of 5 connectors IMU + 1 hub USB for recharge + 1 infrared sensor LVL)
	1 x trouser (1 trousers + 1 strip of 6 sensors IMU + strip of 6 connectors IMU + 1 hub USB for recharge)	**1 x trousers** (1 trousers + 1 strip of 6 sensors IMU + strip of 6 connectors IMU + 1 hub USB for recharge)
	1 x dehydration device (1 single wearable component + batteries)	**1 x dehydration device** (1 single wearable component + batteries)
Final testing with users		
	1 x t-shirt (1 t-shirt + 1 strip of sensors + strip of connectors + 1 hub USB for recharge)	**1 x t-shirt** (1 t-shirt + 1 strip of sensors + strip of connectors + 1 hub USB for recharge)
	1 x trousers (1 trousers + strip of sensors + strip of connectors + 1 hub USB for recharge)	**1 x trouser** (1 trousers + strip of sensors + strip of connectors + 1 hub USB for recharge)
	1 x dehydration device (1 single wearable component + batteries)	**1 x dehydration device** (1 single wearable component + batteries)

2.2 Guidelines for the testing phase (WP6)

SALZBURG:

Facility responsible for the testing: SRFG(?)

Type of testing: UX and Accessibility Testing (?)

Number of subjects to be tested: 6 o 12(?)

[How long will the user test the model? How will be conducted the observation? In which context will the model be used? How long will the sessions last? What parameters are going to be tested and how?]

Total timing WP6: 8 months / september 2018 - april 2019

Time for testing: 5 months / september 2018 - january 2019

Time for evaluation of the results: 3 months / february 2019 - april 2019

VENETO:

Facility responsible for the testing: ULSS 1 Dolomiti + Palestre della Salute

Type of testing: UX and Accessibility Testing (?)

Number of subjects to be tested: 12(?)

[How long will the user test the model? How will be conducted the observation? In which context will the model be used? How long will the sessions last? What parameters are going to be tested and how?]

Total timing WP6: 8 months / september 2018 - april 2019

Time for testing: 5 months / september 2018 - january 2019

Time for evaluation of the results: 3 months / february 2019 - april 2019

3. Observation

Integration of the projects into the APPs of Salzburg region and FSER of Veneto Region.

While the first involves systems already in use, the second is still under development_the relevance of the Austrian experience is to be an example and a guideline for the transfer into the Italian region.

The system of devices and APPs has been thought as a starting pack to be integrated into the e-healthcare programs for the regions involved in the project. While Salzburg Region uses CARIMO as supporting system, the program for Veneto Region is the development of a proper platform in accordance to the Fascicolo Sanitario Elettronico Regionale (FSEr). Further information about the healthcare system in both the regions can be found in the document written by ULSS 1 (?), PLUS and SRFG in July 2017. The research and the development of the physical products is going to be done by 4 Iuav's researchers, 1 SRFG's and 1 PLUS's, and it will last 10 months. Iuav is going to provide a digital research platform, QUALIFEDESIGN, to share the materials between the partners.

4. Update on the project's status

The last international meeting has been held at the beginning of October 2017 in Venice, in which IUAV researchers started with a brief presentation of the state of the art and the topics to be discussed in order to share a common understanding of the lines of research.

After discussing on movements definition, hypothesis on the kit composition, hypothesis on data sensor and position, Austrian partners proposed to add a further concept to the smart suit: a pair of sensorized sticks to monitor the Nordic Walking.

The meeting between Italian partners in Treviso on the 29th of November has been decisive for the verification of clinical parameters that should be addressed for the monitoring and the identification of further exercises' hypothesis. During this meeting, doubts has been raised about the functionality of the sticks and their pertinence to the Agedesign project.

The results of the Italian partners' meeting have been synthesized in the following tables.

	Prevention for ageing people	**Proposed physical activities**	**Possible sensors**	**Physiological and physical parameters to detect**	**Test 1**	**Test 2**
1	**Cardiovascular system's pathologies**	- Nordic Walking* - Squat - Hinge - Lunge - Military press* - Plank	Wearable pletysmograph	- heartbeat (arrhythmia)	Check of correct execution January 2018 (SFRG e PLUS)	- Monitoring - Management of physiological data - User Experience October 2018 ~ (IUAV, ULSS, Arsenal)
2	**Muscular control and balance's pathologies**		Wearable sensors system (16 IMU)	- loss of balance		
3	**Pathologies related to loss of functional abilities**					

* use of tools: Nordic Walking sticks and barbell for Military Press

Some international monitoring scales has been identified as possible instrument for the evaluation of functional abilities: Barthel, S.V.A.M.A., Mingazzini (1 and 2). In fact, evaluations usually applied in neurological visits and occupational therapy can give a feedback on the ability to move of the user. ULSS Dolomiti will provide specific exercises for monitoring functional abilities after a comparison with the territorial Healthcare's Gym System.

Given that the topic of Dehydration is not a matter of interest by the Austrian partners, the concept development will be conducted by Iuav's researchers under the directives that will be sent

by the ULSS Dolomiti on the 20th of December.

ULSS will verify the technologies and systems used into the Hospital laboratories to evaluate dehydration by the analysis of blood and sweat, and verify other possible parameters presented in the papers shared by Iuav.

If the parameters found will be considered valuable for a quantitative analysis of dehydration, they might be added as relevant data to be inserted in the FSER (Fascicolo Sanitario Elettronico Regionale).

<table>
<tr><th></th><th>Prevention for ageing people</th><th>Proposed physical activities</th><th>Possible sensors</th><th>Physiological and physical parameters to detect</th><th>Test 1</th><th>Test 2</th></tr>
<tr><td rowspan="4">4</td><td rowspan="4">Dysfunctions related to body dehydration</td><td rowspan="4"></td><td>Bioelectrical impedance analysis</td><td>Total Body Water</td><td rowspan="4">Check of correct detection of physiological data

(IUAV, ULSS, Arsenal)</td><td rowspan="4">- Monitoring
- Management of physiological data
- User Experience

October 2018 ~ (IUAV, ULSS, Arsenal)</td></tr>
<tr><td colspan="2">OR</td></tr>
<tr><td>Body temperature detector</td><td rowspan="2">Body temperature variations compared to environmental temperature variation</td></tr>
<tr><td>Environmental temperature detector</td></tr>
</table>

5. Conclusion and further developments

The technical meeting foreseen in Salzburg on 20th and 21st of November has been postponed to January 2018 to collect more material on which building the further work and discussion.