ISSN 1590-8844
International Journal of Mechanics and Control, Vol. 24, No. 02, 2023

CARDIOMETABOLIC BENEFITS FROM A COASTAL SAILING IN A RADICAL CYSTECTOMY PATIENT REMOTELY CONTROLLED BY AN INTERNET OF THING MECHATRONIC TOOL: A CASE STUDY

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ABSTRACT

This study concerns a case of a 74 years old man who underwent a radical cystectomy since a cancer of the urinary bladder. After about one year from surgery he performed a coastal cruise lasting about 3 weeks while, every morning, were remotely assessed his cardio-metabolic variables by an internet of thing equipment. At cruise end, the subject showed 22% increase, at rest, in the ventricle stroke volume accompanied by +14% in myocardial contractility with -3% in peripheral vascular resistances and -4% in mean arterial blood pressure. Moreover, in the last days of cruise he showed an increase of about 2.5 times of the sailing metabolic cost to sustain the high demanding of metabolic power despite occurring higher peak of energy costs while rating of perceived exertion was the same as at inning cruise. Confirmation of cardio-metabolic improvements of our sailor is also provided by data from cardio-pulmonary tests at the cycle ergometer which show cruise-dependent increases in the peaks of: oxygen consumption (6%), aerobic efficiency (20%), pulmonary ventilation (18%) and arterial blood's oxygen fraction (13%). Cardiac mechanics also benefited from the cruise since rest heart's mechanical work and efficiency had increased by 17% and 45% respectively. So coastal cruise could improve health related quality of life in cystectomised patients.

Keywords: radical cystectomy, sailing cruise, cardio-metabolic adjustments, blue spaces benefits, internet of things tool

1 INTRODUCTION

Cancer of the urinary bladder ranks among the top 10 most commonly diagnosed forms of cancer in the world with more than half a million cases annually and approximately 2% of cancer deaths are due to this form of solid tumor [1].

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Urinary bladder radical cystectomy (RC) remains the best elective surgery to treat this malignancy when patients' diagnoses muscle-invasive bladder cancer [2].
RC is a very complex surgical procedure in men contemplates removing the urinary bladder together with the prostate and the seminal vesicles and involves extended lymph node dissection [3]. These patients are often subjected to an incontinent urinary reconstruction which implicates the creation of a unilateral urostomy with an external bag for urine collection, leading to a permanent depreciation of body image and disability [4].

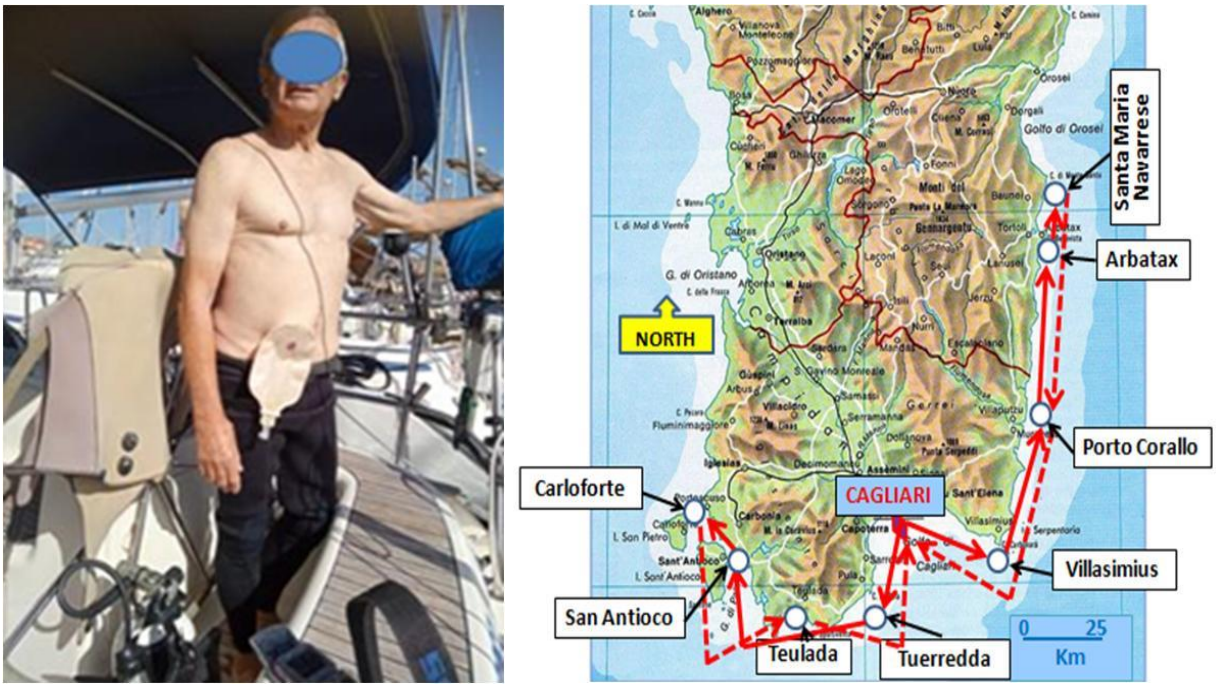


Figure 1 An image of recruited RC patient is shown on the left where it can be seen the external bag to collect urine and discharge it through the valve located at its bottom. Our patient is wearing the scuba suit with bottles of breathing gas mixture to dive in order to inspect the hull of the boat. On the right is represented the map of the cruising along the southern coasts of Sardinia, in the centre of the western Mediterranean Sea. The solid red arrows indicate the two outward routes from Cagliari and, respectively, towards the south-west up to the village of Carloforte and then towards the south-east up to the village of Santa Maria Navarrese, while the dashed arrows indicate the corresponding return routes to Cagliari. The blue circles indicate the places where the boat was moored to stop periodically.

The RC is a life-changing surgical intervention which affects several aspects of the patient's physical, mental and social conditions, this starting from the self-care and stoma management to cope everyday up to limiting sexuality and psychological well-being [5].

All these occurrences could seriously affect the quality of life of these patients, especially in aged ones since after the RC took at least 12 months to a little adapt to their new health status. Consequently, historical rates between 30% and 60% in large pelvic oncology centres are common in post-surgery and patients could experience a large reduction in physical activity which, especially in elderly ones, might also lead to an increased risk of cardiovascular disease [5].

It has been found that participation in sailing by subjects with disabilities [6] or mental disorders [7] is widely regarded as inducing positive outcomes on their health-related quality of life (HRQoL). Moreover, it has been also shown that sailing activities induced improvements in HRQoL in both children [8] and adult cancer patients [9]. Starting from what above described, and thanks to a proprietary Internet of Things mechatronic tool for remote cardiometabolic biosignals control from wearable sensors, this study presents a case concerning an RC patient (RCp) who, after sailing coastly for about 3 weeks, showed an increase in his aerobic capacity and cardiovascular efficiency. Thus, we sought to determine the benefits and survival outcomes between health status after coastal sailing. Taking into consideration, the location along the same route and month significantly affects the benefits.

2 METHODS

2.1 THE PATIENT

The subject presented in this case report (see Figure 1 at left) was a 74 years male (n = 1, body weight = 66 kg, height = 168 cm) who underwent an RC with urinary diversion according to Bricker (see Figure 1) for pT1 G3-pTis multifocal urothelial carcinoma of the urinary bladder [10]. Patient lost after the RC about 15 kg of body mass and he proceeded, self-referentially, to apply a physical and nutritional rehabilitation protocol thanks to which, after about a year from the surgery, he regained an acceptable HRQoL. RCp was well-instructed on stoma care and urinary-bag managing. Oncological follow-up was performed with 3, 6 and 12 month intervals and showed no recurrence of malignancy; renal function was normal.

2.2 THE BOAT

The boat, named *Seventy...een* (Figure 2), was a Bavaria 44 sailing boat model (Germany) about 14 meters long. It is considered an ideal boat for a family cruise because its distinctive features are comfort and manoeuvrability also thanks to the control links in the cockpit.



Figure 2 Archive image of a Bavaria 44 sailboat sailing under full sail.

It goes fast and goes far, thanks to the numerous lockers and the capacity of the water and fuel tanks. Below deck it has three bedrooms and a living room with kitchen. In addition, this boat is also equipped with a 55 HP diesel engine (Volvo Penta) and has all the on-board equipment for long sailing.

2.3 THE SAILING CRUISE

The boat crew was of 3 skilled older sailors which captain was our RCp. The cruise lasted 20 days, departed and ended from the port of Cagliari, in Italy, travelling for a total of about 370 nautical miles (see map in Figure 1 on the right). The first route, which lasted 9 days, travelled from Cagliari towards southwest up to the village of Carloforte in the San Pietro isle, then returning to Cagliari following the same route as before. Afterward, the boat stayed about 6 days moored on the pier of the Ichnusa rowing association, west of the port of Cagliari, for the boat's maintenance works and various supplies self made by the crew. However, practically daily some boat excursions out of the port and coastly have been carried out to verify the goodness of repairs.
In this time interval a physician specialist in sports medicine went on board the boat to check the health of the crew (Figure 3). The boat then took again to the sea sailing coastally from Cagliari along a south-east route up to the village of Santa Maria Navarrese and returned to Cagliari, from the same route as before, after 5 days of coastal cruise. While cruising the crew often went on excursions for tourists and tasting of typical foods at the seaside villages along the coast and, every three or four days, they also devoted themselves to about an hour for moderate walking and running on land. Moreover, our patient did not disdain to do some scuba diving as well (see Figure 1 left).



Figure 3 While the boat was moored in Cagliari in the time interval between the two cruise routes, a physician from the experimental staff was visiting on board the crew members to establish their good healthy conditions.

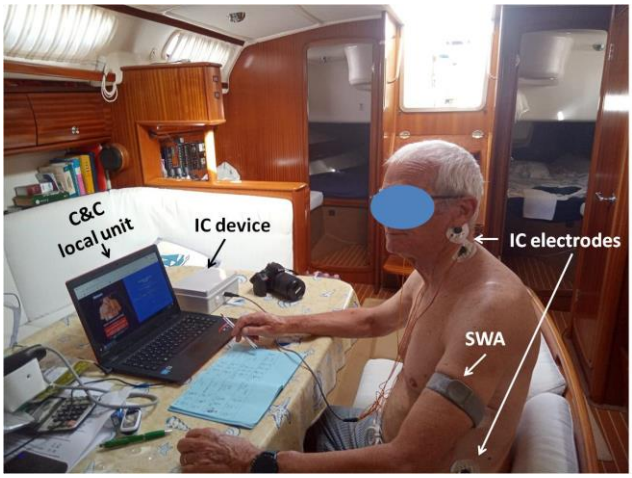


Figure 4 The moored boat's living room is represented by the recruited patient sitting comfortably on the sofa while proceeding with the remote acquisition of his cardio-dynamic profile. Along the left side of his body 4 disposable electrocardiographic electrodes (IC electrodes) are visible, of which the 2 outer ones injected an intensity-low alternating current while the two immediate inner ones read the drop in electrical potential difference due to the impedance of the chest. Symmetrically, on the right side of his body and not visible here, there were 4 other electrodes and, all together, formed the multipolar cable which was connected to the impedance cardiography device (IC device) via a five-pole connector. The laptop on the table is the local control & command (C&C) device, operated by the patient himself. In the left arm, at the level of the patient's triceps muscle, is fastened the metabolic sensor device SWA.

2.4 EXPERIMENTAL PROTOCOL

As previously experienced [11], the protocol applied to this RCp included two experimental procedures: [A] in which the general conditions of the patient who connected himself to several different wearable sensors during coastal navigation, were acquired remotely, from the central control in Cagliari, with a technology based on the Internet of Things (IoT) [12]; [B] in which the RCp was subjected to various morphological, psychological and functional tests both just before embarking on the cruise and after having disembarked from the boat, going for this to specific medical units in the University Hospital of Cagliari.

2.4.1 Experimental procedure [A]

This experimental procedure was in turn differentiated into three sub-procedures which were: [A1] while cruising the patient daily dressed around the left triceps muscle, a metabolic sensor device as long as possible; [A2] daily in the early morning and sometimes evening when the boat was moored, while sitting comfortably inside the boat's living room, the patient proceeded to self-made some instrumental tests concerning the acquisition of the general systemic variables; [A3] again daily in the morning, but after [A2] was stopped, the patient always staying in the living room, proceeded to connect itself with an IoT tool, i.e. the E-Physio, for beat-to-beat assessment of his cardio dynamic profile which was sent, in real time, to the acquisition remote centre, at the AC Technologies lab.

2.4.1.1 Sub-procedure [A1]

While cruising, the patient dressed, around the left triceps muscle, a metabolic sensor device, i.e. the SWA (Sense Wear Armband, Body Media Inc, Pittsburgh, USA), which integrates data from a three-axis accelerometer and from sensors for the body's heat flux, galvanic skin response, skin temperature and near-body ambient temperature (see Figure 4) in such a way of estimate energy expenditure while free-living [13, 14]. The SWA can quantify the energy expenditure at rest [15, 16], for very low-intensity activities or during static exercises [17] as sometime was the case of our cruising sailor. Moreover, it has been found that this device also supplies reliable values of energy expenditure up to ten METs of intensity of physical activity [11, 18]. Recently [19], a published meta-analysis concerning the applications and limitations of the SWA stated that this device consents to accurately estimate energy expenditure corresponding to the distance travelled while walking as well as at rest and, in general, during light to moderate physical activities, as resulted from the comparison of the SWA to both the methods of the indirect calorimetry and the doubly labelled water method [20]. Thanks to this wearable device it could be assessed the daily total energy expenditure (E_{Tot}, in Kcal), the portion of E_{Tot} spent to pay all activities in displacing the subject's body centre of mass (BCoM) on and off the boat (E_{Act}, in Kcal) the time spent at the E_{Act} delivery (T_{Eact}, in hours), the total distance covered while walking on and off the boat (D_{Tot}, in Km).

Starting from the above-described variables assessed from the RCp's SWA, some other variables were also obtained [11] as:

- daily mean metabolic power output per kg of body mass as:

$$W_{Met} = [(E_{act}) \div (BM) \times 4.18] \div T_{Eact}\{\text{W kg}^{-1}\} \quad (1)$$

  in, where BM is the body mass measured in kg;
- daily mean velocity of transport of the sailor BCoM in the environment on and off the boat as:

$$V_{Tran} = D_{Tot} \div T_{Eact} \quad \{\text{m s}^{-1}\} \quad (2)$$

- daily mean metabolic cost of transport of the BCoM in the environment on and off the boat as

$$C_{Tran} = W_{Met} \div V_{Tran} \{\text{J kg}^{-1}\,\text{m}^{-1}\} \quad (3)$$

2.4.1.2 Sub-procedure [A2]

Daily in the early morning when the boat was moored, while sitting comfortably inside the boat, the RCp proceeded to self-acquiring the following variables by repeating three times each specific measurement, and writing the assessed values on a register:

- both systolic (SABP) and diastolic (DABP) arterial blood pressure values, measured in Torr, together with contemporaneous heart rate per minute (HR), assessed by a commercial, automatic brachial sphygmomanometer (Model M2, Omron Healthcare Ltd, Japan);
- percentage of oxygen saturation of haemoglobin in arterial blood (HBO_2) using a portable device applied to an hand's finger (Pulse Oximeter, Model FS20C, Hunan Accurate Technology, China);
- tympanic temperature (Ty_t) measured in C° by a portable digital thermometer (Microlife dual mode, Model IFR 100, Switzerland);
- peak expiratory flow values (PEF) assessed in l min^{-1} from a manual flow meter (Standard Mini Wright, ClementClarche Int., UK);
- dimensionless urine density (U_d) acquired through specific reactive strips (Combi Screen, Analyticon Biotechnologies AG, Germany).

Moreover, in the same data register, the patient wrote the value of the rating of perceived exertion (RPE), concerning the previous day, based on the Borg's scale which includes a rating of 6 perceiving "no exertion at all" up to 20 perceiving a "maximal exertion" of effort [21, 22].

2.4.1.3 Sub-procedure [A3]

After the [A2] measurements, always staying in the boat lounge, the patient proceeded to connect himself with the Internet of Things (IoT) tool, i.e. the E-Physio tool, for beat-to-beat assessment of his cardio-dynamic profile (see Figure 4) which was sent, in real-time, to the acquisition remote centre, at the AC Technologies lab. However, if of any interest, the same procedure was also repeated in the evening after the boat was moored.

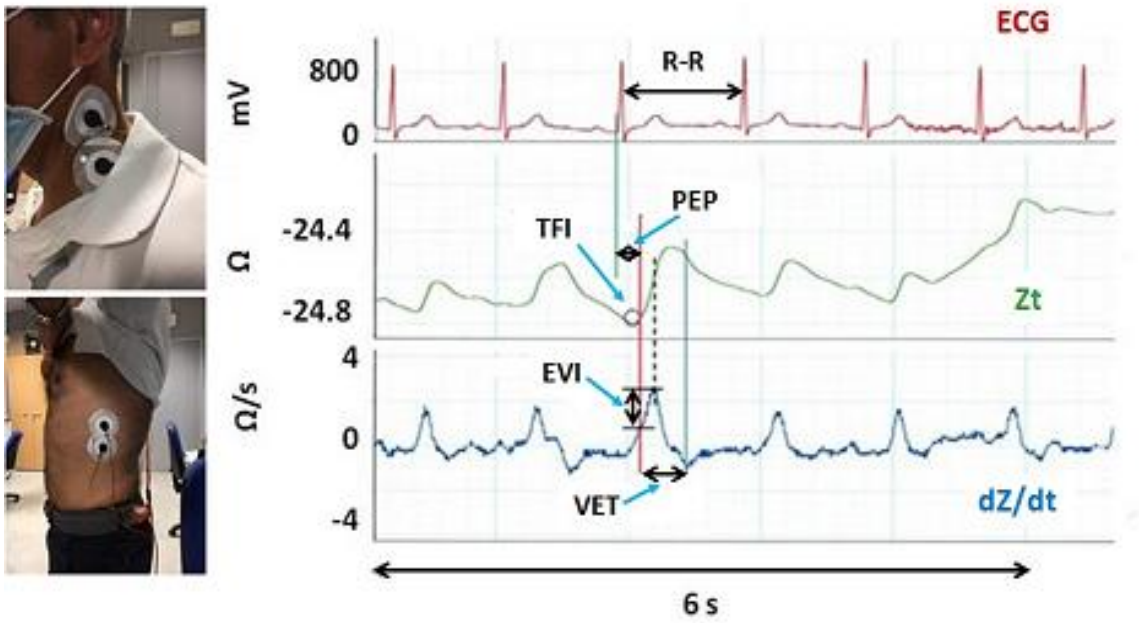


Figure 5 ECG disposable electrodes positioned in the left side of the neck and thorax in a testing subject (other 4 not visible are on the right thoracic side) which internal inner one lies in the plane of the roots of the neck muscles and lower one lies in the plane of the xiphoid process of the sternum, and from which thoracic electrical impedance is assessed when a low intensity–high-frequency electrical current is injected into the thorax from the external couple of electrodes(left). Beat-by-beat instrumental traces respectively of the electrocardiogram (ECG), the thoracic bioimpedance (Zt) and its first mathematical derivative (dZ/dt), obtained from the laboratory automation software. R-R: time interval between 2 consecutive R waves in the ECG trace (s); PEP: left ventricle pre-ejection period (ms) obtained as the time interval between the foot of Q wave in the ECG trace and the beginning of dZ/dt increase (see time interval from green and red vertical lines); VET: left ventricle ejection time (ms) obtained from the beginning increase and the following minimum point in the dZ/dt trace (see time interval from red and following green vertical line); EVI: maximum ventricle ejection velocity index (Ω/s) obtained between beginning dZ/dt increase and its peak; TFI: thoracic fluids index (Ω) identified by the circle at the minimum of the Zt trace preceding the EVI (right).

The current availability of low-cost technologies capable of acquiring information on environmental and biological physical and chemical quantities now makes it possible to implement pervasive and real-time monitoring of variables of interest, i.e. the IoT technologies [23]. A key feature of our IoT device is its ability to connect to the Internet. This connectivity allows it to send and receive data in real-time, enabling interaction and communication with other remote devices and systems. An important feature of IoT devices is the ability to be managed and controlled remotely via web platforms. So, our E-Physio tool is an IoT equipped with sensors and actuators that allow it to gather data from the physical world and interact with it by means of sensors that can detect various quantities such as all those concerning the cardiovascular profile in a tested subject.

E-Physio tool has been designed to support complex operational scenarios, characterized by poorly reliable or completely absent internet connectivity. For this reason, the device was designed as a micro-datacenter capable of governing digital biosignal acquisition systems and providing command and control interfaces through standard Web tools even in the total absence of connectivity to the Internet. To operate adequately into complex scenarios such as boats at sea, without electrical stabilization systems and reliable connections to the Internet, E-Physio has been structured into two main electronic macro components, the biosignal acquisition module and the command module and control. For the first module, delegated to acquire the bioimpedance changes of RCp's thorax it has been utilized home-made impedance cardiography (IC) device, shown in Figure 4, implementing a low cost and commercially available mono-frequency (65 kHz) evaluation board, i.e. the ADAS-1000 board (Analog Devices, USA), which contains an alternating current supply at a constant value of 1mA [24]. The command and control module, however, was implemented by a Single Board Computer (SBC), in this specific case a Raspberry model PI 3, equipped with storage consisting of an SD-Card and the Linux operating system. The SBC that implements the command and control module is connected via a high-speed data bus (Serial Peripheral Interface - SPI bus) to the biosignal acquisition module, with which it communicates directly to impart configuration and operational directives and to perform the reading of the sampled data in real time. Furthermore, the SBC is equipped with network communication systems (wireless and wired) which allow the device to interface with other IoT systems via standard communication channels (e.g. Ethernet or WiFi networks).

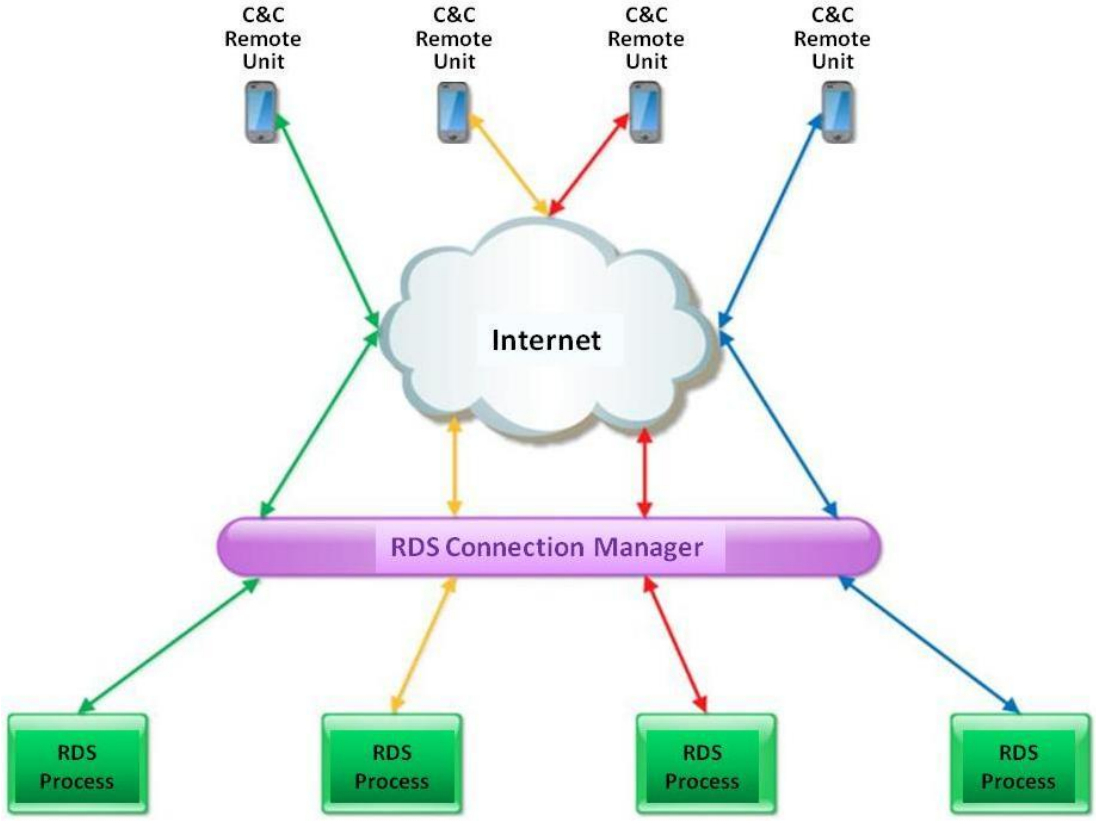


Figure 6 The overall structure of the E Physio biosignal acquisition, transmission and processing platform. The remote devices, through a command and control system, transmit the information to the main AC Technologies data centre, within which the data collection and analysis software (RDS) instances receive the acquired data packets and process them processing to extract the features of interest.

The operating system used, which does not belong to real-time class operating systems, as been profoundly modified to guarantee the execution of high priority processes continuously and without external interruptions, through the exclusive assignment of one of the computational cores of the SBC at the runtime of the biosignal acquisition process. The modification carried out affected some portions of the operating system kernel and made it possible to implement the direct and continuous acquisition of digital biosignals without the occurrence of interruptions and/or slowdowns or interference due to other software processes active in the system. Thanks to this configuration, the remaining computational capabilities of the SBC were used to implement a complete Web stack (Web server, application server, database), operating on top of the operating system. The exchange of high volumes of data, such as those produced during high resolution biosignal acquisition sessions, between real time processes and ephemeral processes such as instances of application modules constituting Web applications, is structurally difficult and required the design and implementation of a complex Inter Process Communication (IPC) logic capable of extensively exploiting all the hardware resources made available by the SBC. The application portion of the Web application was implemented using the Fast Common Gateway Interface (FastCGI) infrastructure to allow high performances for all the software operating on the device. The biosignal acquisition sessions, managed by users through the Web interface displayed by the device, give rise to data files that are immediately compressed and protected by digital encryption, before being stably stored within a specific queue transmission, within the storage of the command and control module of the device. The data packets, once stored in the transmission queue, are sent to the remote processing infrastructure of the AC Technologies lab if connectivity to the Internet is available.

The E-Physio tool (Figure 6) makes access to operators possible via direct Ethernet connection or via WiFi (Access Point or Client mode, if connected to a pre-existing network). To acquire the bioimpedance changes of the patient's thorax it has been utilized a homemade impedance cardiography (IC) device shown in Figure 7. It implements a low-cost and commercially available mono-frequency evaluation board, i.e. the ADAS-1000 board, which contains an alternate current supply at a constant value of 1mA [24].

The relatively high frequency of the current injected into the thorax is such as to short-circuit all the electrical capacities of the cell membranes, thus nullifying the capacitive component of the electrical impedance so that the latter only consists of its resistive component which gives information concerning structural and functional characteristics of the body portion crossed by the electric current [25].

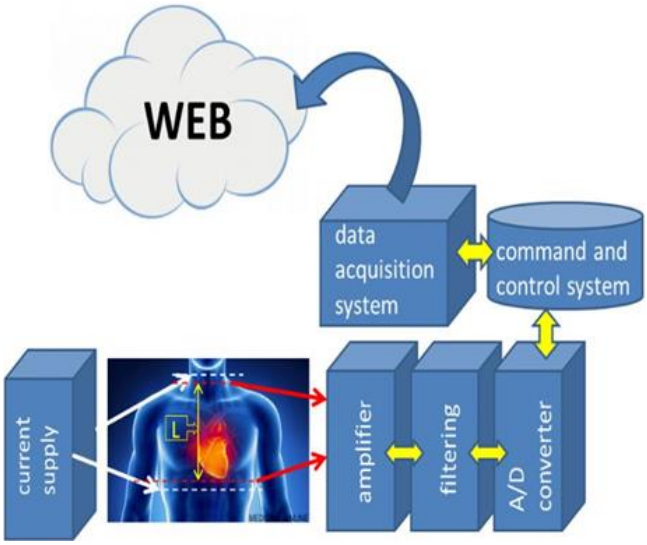


Figure 7 Block diagram of the impedance cardiography device implemented in the E-Physio Tool. L: height of the thorax frustum participating in constituting the impedance.

Shortly, the IC device consists of three separate blocks: a sampling front-end, a command-and-control system and a data transmission system. The sampling front-end block contains the ADAS-1000 board injecting the electrical current into the patient's thorax which voltage difference is assessed by a module containing the electrical signals amplifier. A three-stage filtering section also ensures the elimination of frequencies outside of the range of interest from the acquired signals as well as a 10-bit analogical-digital converter appropriately calibrated (A/D converter block). The command-and-control block supports the radio frequency communication protocol which enables a totally wireless operation mode of the device. The data transmission block, i.e. a WEB block, consents to the device to be remotely controlled by a personal computer running a proprietary software. For each recording session, both in the morning and in the evening (this latter when occurred), the beat-by-beat changes in the patient's thoracic bioimpedance were acquired over a period of 3 minutes.

Figure 5 on the left show in detail the position of the disposable electrodes on the neck and thorax of a testing subject while, on the right, are beat-by-beat represented analogical traces respectively of an electrocardiogram (ECG), a thoracic bioimpedance (Zt) and of its first mathematical derivative (dZ/dt) obtained from the LabChart 8 Reader tool (ADInstruments Ltd, UK). From the variables highlighted in these instrumental traces it can be obtained the left ventricle stroke volume (LSV) by applying the following Sramek-Bernstein equation [26]:

$$LSV = (VEPT)\,(TFI)\,(EVI)\,(VET) \quad (4)$$

in which the (*VEPT*) is the volume of the electrically participating tissues in constituting the thorax bioimpedance. It corresponds to the volume of a truncated cone which upper base lies in the plane of the roots of the neck muscles and the lower one lies in the plane of the xiphoid process of the sternum. This volume (in cm^3) can be indirectly calculated from a nomogram in which were insert gender, weight and height of the subject [26], and it has been found that this volume corresponds to the hydraulic volume of the heart [27].

The (*TFI*) is the electrical index of the thoracic fluids expressed as the 1/Zt ratio (in Ω^{-1}) and corresponds to the maximum negative value of the Zt track when the left ventricle reaches its end-diastolic volume (LVEDV), so it has been found a direct matching between TFI and LVEDV [28].

The (*EVI*) is the peak value of Zt first derivative (in $\Omega\ s^{-1}$) and, because an almost perfect overlap was found between the EVI track and the Doppler one in the ascending aorta [29], EVI can be considered as the electrical index of the ejection velocity of the left ventricle.

The (*VET*) is the left ventricular ejection time (in s) because, like the track of Zt/dt in Figure 5, it is the period between the opening of the aortic valve, indicated by the beginning of the abrupt increase of the curve and the closure of the same valve indicated by the minimum point of the curve following its peak.

Now rewriting (1) in dimensional terms we have:

$$LSV = (cm^3)\,(\Omega^{-1})\,(\Omega \times s^{-1})\,(s) = cm^3 \quad (5)$$

The (5) shows that three electrical variables directly gettable from thorax electrical bioimpedance, i.e. TFI, EVI and VET, added to the one of anthropometric nature, i.e. the VEPT, consent all together to result in a volumetric dimension, i.e. cm^3, like as the LSV dimension.

To give a mechanical rationale to what aforementioned, we can consider a simplified model of the circulatory system consisting of a closed hydraulic circuit (the blood vessels) with an alternative pump (the heart) connected in a mechanical series and characterized by two phases of operation: the aspiration (the heart's venous return and diastolic filling) and the delivery (the systolic stroke volume) of the fluid (the blood) inside the circuit. As is known, in this hydraulic circuit, the delivery fluid volume at each working cycle (the heartbeat) depends on the following four variables: i) the hydraulic volume of the pump, ii) the volume of fluid that returns to the pump at the end of the aspiration, iii) the maximum ejection speed of fluid during delivery, iv) the duration of the fluid delivery. In fact, the Sramek-Bernstein equation (4) includes the electrical equivalents of all four of these hydraulic variables. Several studies on humans [30, 31, 32, 33] and animals [28] confirm the validity of the Sramek-Bernstein equation to assess, non-invasively, beat-by-beat values of the LSV in a lot of psycho-physical and pathological conditions [34, 35, 36, 37, 38, 39].

Moreover, bioelectrical traces in Figure 5 also consent to calculate the beat-to-beat HR from the ECG trace as follows:

$$HR = 60 \div (RR)\,\{beats \times min^{-1}\} \quad (6)$$

where *RR* is the time interval, in s, between two consecutive R waves. Since the cardiac output per minute (CO) is conventionally due as the number of LSV ejected in a minute into the aorta, this cardinal cardio-dynamic variable can be beat-to-beat calculated as:

$$CO = LSV \times HR\,\{cm^3 \times min^{-1}\} \quad (7)$$

Furthermore, from the ECG and dZ/dt graphs of Figure 5, the ventricular pre-ejection period (PEP) is calculated which, put in relation to the VET, it allows of obtain a clinically validated index of myocardial contractility (MCI), as a

dimensionless value [40, 41], based on the following equation:

$$MCI = PEP \div VET \quad (8)$$

The MCI, calculated as in (8), changes inversely with respect to the report PEP/VET. In fact, a reduction in PEP with an increase in VET, or a reduction in their report, implies a dynamism increase in the intra-ventricular pressure development and vice versa.

Through both data directly obtained from thoracic bioimpedance assessment and arterial blood pressures were also calculated other derived cardiovascular variables of non-negligible value which were the mean arterial blood pressure measured in Torr as

$$MABP = DABP + [1 \div 3\,(SABP - DABP)] \quad (9)$$

the total peripheral vascular resistance index [42] measured in Torr l^{-1} min^{-1} as

$$TPVRI = MABP \div CO \quad (10)$$

the double product [43] measured in Torr beats min^{-1} as

$$DP = SABP \times HR \quad (11)$$

the mechanical work index of the heart [44] measured in Torr ml as

$$HWI = MABP \times LSV \quad (12)$$

the mechanical efficiency index [44] of the heart measured in ml min $beats^{-1}$ as

$$HMEI = DP \div HWI \quad (13)$$

2.4.2 Experimental procedure [B]

Just before and after the coastal sailing cruise, the RCp reached the University Hospital of Cagliari where he underwent, in turn, two clinical sub-procedures which were: psychological and anthropometric tests at the Obesity Centre (Sub-procedure B1); cardio-pulmonary exercise tests (CPET) at the cardio-pulmonary stress test laboratory of the Cardiovascular Intensive Care Unit (Sub-procedure B2).

2.4.2.1 Sub-procedure [B1]

As reached the Obesity Centre, the patient was submitted questions concerning his medical history after which he compiled the Patient Health Questionaire-9 (PHQ-9) with the aim of score his possible depressive condition [45]. Then he underwent to the body composition analysis by a body impedance analysis (BIA) device (Tanita, model BC-420MA, The Netherlands) from which the following anthropometric variables were assessed [46]:

- body mass (BM) expressed in kg;
- body fat mass (BMF) expressed both in % and kg;
- body muscle mass (BMM) expressed in kg;
- body mass index (BMI) expressed in kg m^{-2};
- basal metabolic rate (BMR) expressed in Kcal/day.

2.4.2.2 Sub-procedure [B2]

After underwent the [B1] testing and controls, the RCp reached the cardio-pulmonary stress tests laboratory where, as shown Figure 8, he performed an incremental CPET at the cycle-ergometer (20 W min^{-1} of incremental ramp) up to exhaustion. During the CPET the patient was connected to a metabolic unit (Ergostik, Germany) by means of a face mask, thus several values of cardiopulmonary variables were assessed breath-by-breath and beat-to-beat. The incremental test ceased when the participant was no longer able to maintain the pedaling rhythm of 60 ÷ 70 revolutions per minute. In the RCp the 12-led ECG was continuously monitored, and the systolic and diastolic arterial blood pressures were also assessed at each step increase of load by means of a handled brachial sphygmomanometer and a stethoscope [10]. From each of the two CPET performed by the RCp, before and after cruise, the following variables were respectively assessed at the rest before the test and during the test duration up to the workload corresponding to the anaerobic threshold (AT) [21] and at the peak work rate:

- workrate (WR) in W;
- oxygen consumption per minute (VO_2) as referred to the whole body mass in l min^{-1};
- carbon dioxide production per minute (VCO_2) in l min^{-1};
- dimensionless respiratory exchange ratio (RER) as the VCO_2/VO_2 ratio;
- Aerobic efficiency as the VO_2/WR in ml min^{-1} W^{-1};
- expiratory pulmonary ventilation (V_p) in l min^{-1};
- respiratory tidal volume (V_t) in l;
- respiratory rate per minute (B_f) in breaths min^{-1};
- heart rate per minute (HR) in beats min^{-1};
- oxygen pulse (O_2P) as the VO_2/HR ratio in ml $beats^{-1}$;
- end tidal oxygen (PO_{2ET}) and carbon dioxide (PCO_{2ET}) fractions at rest both in Torr.

Moreover, to better understand the systemic integrative adaptation to the coastal sailing, were calculated also the following other variables:

- excess of carbon dioxide production as

$$CO_{2Exc} = RER_{Rest} \times VO_{2Peack} \quad (14)$$

measured in l min^{-1} [47, 48], which, stoichiometrically, correlates with the blood lactate concentration at the WR peak, thus indicating the maximum level of engagement of the anaerobic lactate acid mechanisms for the muscle fuel [47].

- rapid shallow breathing index as

$$RSBI = B_f \times V_t^{-1} \quad (15)$$

measured as breaths $min^{-1}l^{-1}$ [11, 49], which indicates the relative contribution to the respiratory impedance due to the air flow rate (the viscous component) and to the pulmonary stiffness (the elastic component);

- aerobic efficiency index as

$$E_{oxy} = (WR \div 4.18) \times [(VO_2 \times 5)]^{-1} \quad (16)$$

which is a dimensionless value obtained as the ratio between the mechanical energy output at the cycle-ergometer (in kcal) and the corresponding aerobic energy expenditure, obtained by multiplying VO_2 by the equivalent caloric value which was considered as 5 kcal per each litre of oxygen consumption [11].

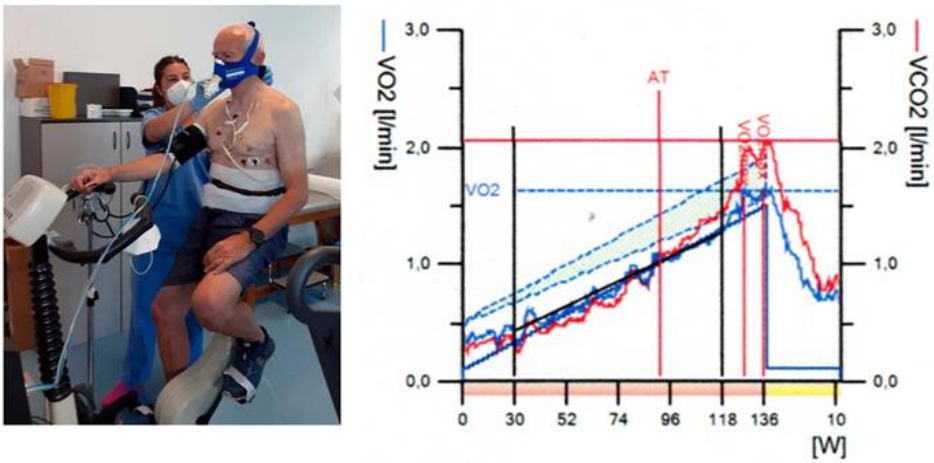


Figure 8 Patient while sitting on the cycle ergometer just before the start of CPET test (left). An ergonomist operator proceeded to connect him to the metabolic unit via a face mask that collected the respiratory gases. Furthermore, it should be noted that the disposable electrodes for the beat-by-beat detection of the 12 ECG traces are applied on his chest. At each increase in workload, the same operator proceeded to measure arterial blood pressures using the sphygmomanometer applied to his right arm. Graphs returned from the metabolic device (right) printer concerning the breath-by-breath changes of oxygen consumption (blue) and carbon dioxide production (red) together with the growing straight line which represents the progressive increase of the work rate up to exhaustion, all obtained during the patient's CPET test performed before the cruise beginning. Observing these graphs, it can be seen that, initially, the oxygen consumption overcame the carbon dioxide production up to a critical value of the work rate (W), identified by the straight vertical red line in which the two values are equal, the anaerobic threshold (AT), after which the increase of the carbon dioxide production was always more consistent than that of the oxygen consumption up to the end of the test. The dashed blue line at the top of the Figure (VO2) indicates the maximum value that can be reached by oxygen consumption, i.e. the maximum work capacity obtainable with the contribution of oxidative mechanisms.

2.4 APPLIED STATISTICS

Where possible, comparative, and predictive statistical methods were applied to data assessed in the different conditions in which the RCp was engaged during the applied experimental protocol, choosing as significant level that of a $P<0.05$. The used statistic package was: MedCalc, Statistics for biomedical research, Belgium.

When appropriate, an index of variability (VI%) was calculated as the percentage of the standard deviation versus the mean value of a given group of data.

3 RESULTS

Noted by the logbook, table I shows the details of the coastal itinerary travelled by crew during the sailboat cruise. They sailed daily an average of about 7 h but day-to-day time spent in this activity showed a very high index of variability (VI = 53%). However, this certainly confirms the fact that our sailors did not have any competitive inclination during the navigation but rather aimed above all at tourist and naturalistic leisure. It is interesting to note that for at least 9 nights they slept in the moored boat, sometimes in port and sometime at anchor.

Table I - Logbook

Day	Departure	Arrival	Sailing hours	Borg Index
June[1] 26	Port of Cagliari	Tuerredda harbor	06:10	12
June[2,1] 27	Tuerredda Harbour	S. Antioco	07:05	16
June[3,1] 30	S. Antioco	Carloforte	03:15	12
July[1,3] 03	Carloforte	Teulada harbor	05:50	10
July[1,4,3] 04	Teulada harbor	Port of Cagliari	06:10	10
July[5,6,1] 12	Port of Cagliari	Porto Corallo	10:10	10
July[1] 13	Porto Corallo	Arbatax	05:45	10
Jul 14[1]	Arbatax	S. Maria Navarrese	03:00	8
July[1] 15	St Maria Navarrese	Porto Corallo	08:15	10
July[7] 16	Porto Corallo	Port of Cagliari	16:20	17
Mean ± SD			7:20 ± 3:50	11.5 ± 2.9

[1]Overnight staying on boat; [2]difficulty entering the channel to the port; [3]leisure activities at place; [4]boathouse activities; [5]medical check-up on board; [6]shipwreck rescue; [7]very rough sea.

Table II –PHQ-9 Questionnaire

Questions	Never		Some Days	
	06/ 29	07/ 16	06/ 29	07/ 16
scarce interest in doing things		X	X	
feeling down, sad		X	X	
sleep problems		X	X	
feeling tired		X	X	
appetite disturbances		X	X	
having a low opinion of himself		X	X	
difficulty concentrating on something		X	X	
slow or excessive movements	X	X		
thoughts of self-harm	X	X		

The table also shows that the daily mean value Borg index of the rating of perceived exertion (RPE) was about 11 to 12 which could be considered as fairly light to somewhat hard. However, at the second and the last sailing days in which our patient reported having encountered great difficulties in boat's manoeuvering and in navigation both his RPEs indexes rose up to hard and a very hard value. Table II shows our RCp's responses to the 9-item patient health questionnaire (PHQ-9) filled both just before and after the coastal cruise. In this questionnaire the scores range from 0 to 27 and cut-points are considered of 5, 10, 15 and 20 items respectively representing mild, moderate, moderately severe and severe levels of depressive symptoms [45].

Table III - BIA variables

	BM kg	FBM kg	MBM kg	BMR KJ	BMI Kg/m^2
Before cruise	67.3	12.7	51.8	6489	23.6
After cruise	68.0	13.1	52.1	6527	23.8
Δ	+0.7	+0.4	+0.3	+38	+02
%	1.01	3.15	0.58	0.59	2.12

BIA: body impedance analysis; BM: body mass; FBM: fat body mass; MBM: muscle body mass; BMR: basal metabolic rate; BMI: body mass index.

Data in this Table indicate that, before cruising, the patient showed a score of 7, and this indicates a mild towards moderate condition of depression. However, when he put ashore from the sail boat at the port of Cagliari as cruise ended, these depressive symptoms were completely disappeared since the reached score was 0.
Changes in anthropometrical variables occurred in our RCp after the coastal sailing are shown in the Table III where BM increased of 700 g and, what is of interest, the patient's muscle mass was increased by as much as 300 g. This latter occurrence also justifies the little but not negligible increase in the BMR shown by him after he put ashore from the sailboat at the cruise end. Moreover, the Table shows about +3% of FBM which, however, this one corresponds to only a 2% increase in the BMI, i.e. a non-worrisome increase in this variable for what concerns a possible risk of overweight.
Table IV shows values of functional variables having a general healthy value, daily self-measured by our cruising patient every morning below deck of moored boat after waking up and breakfast. Mean values of these variables from the 20 days cruising, report that all of them kept within values that can be considered as physiological. It is also of interest that the VI% for each of these averages is very low. Moreover, oncologic follow-up was uneventful.
Table V Shows the daily metabolic energy supply of our RCp for all his body needs, acquired from the SWA device dressed on his arm, i.e. the E_{Tot}. The E_{Tot} portion spent for his physical activity in displacing the BCoM, i.e. the E_{Act}, was also shown. Moreover, a relationship between each of these two modalities of energy expenditure and respective time duration (T_{Etot} and T_{Eact} respectively) is also shown in the table V in terms of ratios E_{Tot}/T_{Etot} and E_{Act}/T_{Eact} which could be assumed as mean metabolic power daily dispensed in each of the two-activity condition considered, i.e. W_{Etot} and W_{Eact} respectively. This table shows that daily E_{Tot} behaved with not remarkable oscillations since the VI% was only of about 13%.

Table IV - Daily systemic variables assessed while boat moored

Day	M_{ABP} Torr	HR b/min	$O_{2\text{-}HB}$ %	PE_f l/min	Ty_t °C	U_d
Jun 26	93	70	97	550	35.9	1025
Jun 27	95	84	95	550	36.3	1025
Jun 28	85	68	98	500	34.6	1030
Jun 29	89	69	98	550	34.8	1015
Jun 30	89	64	97	500	34.9	1020
Jul 01	96	63	98	450	34.4	1030
Jul 02	91	64	97	530	34.8	1020
Jul 03	91	65	97	500	35.6	1020
Jul 04	89	76	98	500	36.0	1020
Jul 05	92	63	97	450	34.5	1020
Jul 06	84	66	97	500	34.7	1020
Jul 07	87	68	97	500	35.1	1025
Jul 08	87	75	96	500	35.1	1015
Jul 09	85	72	97	500	34.7	1020
Jul 10	87	74	97	500	34.3	1015
Jul 12	88	65	98	500	34.2	1015
Jul 13	90	64	97	500	34.5	1020
Jul 14	89	64	98	450	34.5	1010
Jul 15	89	66	98	500	34.4	1015
Jul 16	89	75	97	500	34.2	1025
Mean	89.2	68.7	97.2	501	34.9	1020
±SD	3.1	5.6	0.8	28.9	0.6	5.2
VI%	3.5	8.2	0.8	5.8	1.7	0.5

M_{ABP}: mean arterial blood pressure; HR: heart rate; $O_{2\text{-}HB}$: oxygen saturation of haemoglobin; PE_f: peak of expiratory flow; Ty_t: tympanic temperature; U_d: urine density; VI%: variability index percentage.

Table V - Daily mean values of main SWA assessed variables

Day	E_{Tot} (Kcal)	T_{Etot} (h)	W_{Etot} (Kcal/h)	E_{Act} (Kcal)	T_{Eact} (h)	W_{Eact} (Kcal/h)
27-6	2431	24	101	260	1	260
29-6	2690	24	112	845	3	282
30-6	2823	21	134	1080	4	270
1-7	2434	15	163	657	2	328
2-7	2368	24	99	508	2	254
3-7	2048	18	114	126	0.5	252
4-7	2192	24	91	248	1	248
5-7	1838	14	131	195	1	195
6-7	2301	24	96	367	1.5	245
7-7	2080	24	87	129	0.5	258
8-7	1734	15	116	97	0.5	195
9-7	2123	24	88	174	0.5	348
10-7	2182	24	91	239	1	239
12-7	2337	17	138	202	1	202
13-7	2420	24	101	373	1.5	562
14-7	2187	18	122	452	2	226
15-7	2375	24	99	338	1.5	507
16-7	1816	16	114	394	1.5	591
M	2243.3	21	110.9	371.3	1.5	303.4
± SD	284.8	4	20.5	262.8	1	122.4
VI%	12.7	19.1	18.5	70.8	66.7	40.3

E_{Tot}: daily total energy expenditure; T_{Etot}: time daily spent dressing the armband; W_{Etot}: daily energy spent at each hour; E_{Act}: portion of total energy spent to pay all activities on and off the boat; T_{Eact}: time daily spent in physical activities; W_{Eact}: daily energy spent at each hour of physical activities; VI%: variability index percentage. Data from dais June 28 and July 11 were not assessed since the SWA device was charging its electric power supply battery.

Table VI - Bioenergetic variables from the SWA device

day	E_{Act} Kcal	T_{Act} hours	D_{Tot} Km	W_{Met} W kg^{-1}	V_{Tran} m s^{-1}	C_{Tran} J kg^{-1} m^{-1}
Jun 27	260	0:58	4.4	4.6	1.26	3.7
Jul 16	394	1:22	2.7	5.0	0.55	9.1

E_{Act}: active energy expenditure; T_{Act}: active time lasting; D_{Tot}: distance travelled by body centre of mass; W_{Met}: metabolic power output; V_{Tran}: transport velocity of body center of mass; C_{Tran}: metabolic cost of transport of body center of mass.

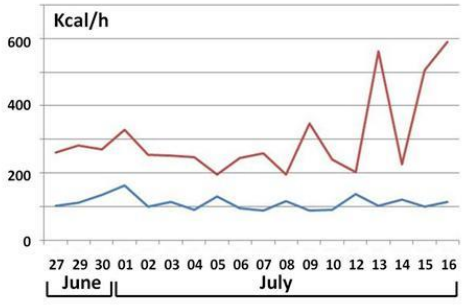


Figure 9 Day-to-day graphic representation of both W_{Etot} (blue line) and W_{Eact} (red line) measured as Kcal/h.

Table VII - Cardio-dynamic variables remotely assessed while cruising by the IoT tool E-Physio

Variables	June 27	July 16	Δ%	P
TFI Ω	29.8 ± 0.00	32.9 ± 0.07	+ 10.4	< 0.0001*
EVI Ω s^{-1}	1.25 ± 0.11	1.55 ± 0.16	+24.0	0.0086*
PEP ms	185.4 ± 17.9	170.0 ± 7.91	- 8.3	0.1179
VET ms	330.4 ± 14.3	358.0 ± 7.6	+ 8.3	0.0050*
HR b min^{-1}	78.7 ± 1.2	68.3 ± 0.9	-13.2	< 0.0001*
LSV ml	38.8 ± 4.8	47.3 ± 5.4	+ 21.9	0.0301*
CO l min^{-1}	3.06 ± 0.3	3.22 ± 0.4	+5.2	0.5141
PEP/VET	0.56 ± 0.07	0.48 ± 0.03	-14.3	0.0350*

TFI: thoracic fluids index; EVI: ejection velocity index; PEP: pre-ejection period; VET: ventricular ejection time; HR: heart rate per minute; LSV: left ventricle stroke volume; CO: cardiac output per minute; PEP/VET: dimensionless index of myocardial contractility. Each of the shown variables are represented as the mean ± SD of values assessed from 5 consecutive heartbeats and the method of the Student's t for paired groups was applied to verify statistical significance between the July 16 versus June 27 assessed data. *P<0.005 was considered as statistically significant.

Table VIII - Cardiovascular variables from matching bioimpedance variables with arterial blood pressures self-assessed from cruising patient

Variables	June 27	July 16	Δ	%
MABP Torr	95	91	- 4	- 3.9
TPVRI Torr l^{-1} min^{-1}	31	28	- 3	- 8.4
DP Torr beats min^{-1}	10147	8199	- 1948	- 19.2
HWI Torr ml	3690	4321	+ 631	17.1
HMEI ml min $beats^{-1}$	0.36	0.56	+ 0.16	44.8

MABP: mean arterial blood pressure; TPVRI: total peripheral vascular resistance index; DP: double product; HWI: heart mechanical work index; HMEI: heart mechanical efficiency index.

Moreover, our tested subject showed a daily mean E_{Act} which was about 51% of that measured in a previous study concerning a cohort of at rest 40 freely living healthy subjects, both males and females, aged meanly of about 70 years, [50]. However, in this latter study the VI% for the E_{Act} was about 19% or lower than half of in the present study. This probably occurred since differences in the modalities of physical activity levels among these two experimentations.

Table IX - CPET test peak values of cardio-metabolic variables assessed before beginning sailing cruise

WR W	VO_2 l min^{-1}	VO_{2AT} l min^{-1}	VCO_2 l min^{-1}	VO_2/WR ml min^{-1} W^{-1}	R_{ER}	V_p l min^{-1}	B_f br^{-1}	V_t l	HR b^{-1}	O_2P ml b^{-1}	S_{ABP} Torr	D_{ABP} Torr	PO_{2ET} Torr	PCO_{2ET} Torr
134	1.57	1.02 (65%)	1.9	9.7	1.23	63	28	2.0	150	11	180	85	105	37
(102)	*(1.63)*	*(53%)*	*(2.0)*	*(9.7)*	*(1.21)*	*(75)*	*(55)*	*(3.1)*	*(138)*	*(10)*	*(207)*	*(99)*	*(>90)*	*(39)*

WR: work rate; VO_2: oxygen consumption; VO_{2AT}: oxygen consumption at the anaerobic threshold; VCO_2: carbon dioxide production; VO_2/WR: aerobic mechanical efficiency; R_{ER}: respiratory exchange ratio; V_p: pulmonary ventilation; B_f: breaths frequency; V_t: tidal volume; HR: heart rate; O_2P: oxygen pulse; S_{ABP}: systolic arterial blood pressure; D_{ABP}: diastolic arterial blood pressure; PO_{2ET}: end tidal oxygen fraction; PCO_{2ET}: end tidal carbon dioxide fraction. In the last row of the table are presented theoretical values estimated from the device software concerning healthy subjects having age and somatic characteristics as that here studied.

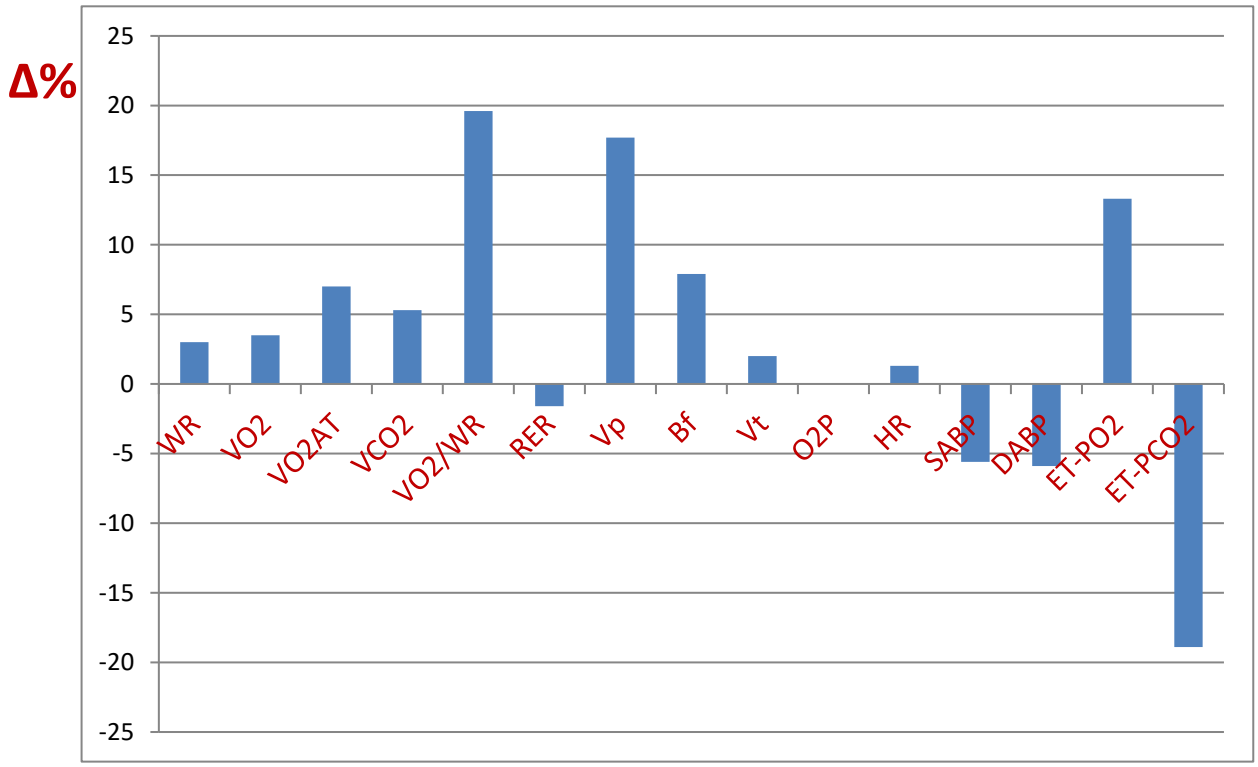


Figure 10 Percentage changes in cardio-metabolic variables peak values assessed from the CPET performed by the tested patient after the coastal cruise, with respect those assessed before beginning cruise. WR: work rate; VO2: oxygen consumption; VO2AT: oxygen consumption at the anaerobic threshold; VCO2: carbon dioxide production; VO2/WR: aerobic mechanical efficiency; RER: respiratory exchange ratio; Vp: pulmonary ventilation: Bf: breaths frequency; Vt: tidal volume; HR: heart rate; O2P: oxygen pulse; SABP: systolic arterial blood pressure; DABP: diastolic arterial blood pressure; PO2ET: end tidal oxygen fraction; PCO2ET: end tidal carbon dioxide fraction.

What which is of not negligible interest concerns the day-to-day W_{Etot} respect to W_{Eact}. In fact, Figure 9 clearly shows a strong surge of W_{Eact} when the coastal cruise was approaching is end since from July 13 to 16 this variable reached peaks more than 5 times with respect to the corresponding W_{Etot} (see the July 16).

Table VI shows that the W_{Met} released during the last day of cruise was about 9% higher than in the 2nd one as well as the C_{Tran} which, in the last day, overcame of about 2.5 times that spent at the beginning of cruise.

What which draws attention is that the V_{Tran} corresponding to the 2nd day was more than double of that in the last day. This happened because the D_{Tot} covered during the boat activities in the last day of cruise was about 60% lower than in 2nd one and the T_{Act} engaged during the unblocking manoeuvres in the Sant Antioco canal entering was about half an hour less than during sailing with a very rough sea in the last cruise day.

Table VII shows the cardio-dynamic variables values remotely assessed by the thoracic bioimpedence of the patient from the E-Physio tool and acquired, as above explained, from analog tracks as shown in Figure 5 on the right. As for bioenergetic variables, cardio-dynamic values from 2nd and last day of cruise were compared and, due to repeated measurements lasting 3 minutes, a statistical comparison by a Student' t test for two paired group of data could be applied. What which is relevant concerns the significantly higher values of EVI, VET, LSV measured in

the last cruising day respect to the 2nd one while for PEP/VET and HR this condition was reversed. All of these changes happened with unchanging significantly the CO.
Table VIII show some derived cardiovascular variables from matching those from thoracic bioimpedance and those from self-measured arterial blood pressures. As in Tables VI and VII, also in this latter table are shown variable values from the beginning and the end of the cruise.
However, no statistical comparison could be made among these two days since no serial values of blood pressures could be assessed. Anyway, it is of interest to observe that
at the end of cruise rest values of MABP, TPVRI and DP were lesser than at the cruise beginning while both HWI (about +17%) and HMEI (about +45%) were greatly increased.
Figure 8 shows our RCp while being prepared for a CPET test. The figure also shows the instrumental graphs, acquired breath-by-breath, of oxygen consumption and carbon dioxide production throughout the test.
Table IX shows peak values of cardio-respiratory and metabolic variables reached at the exhaustive WR performed by the RCp before the coastal cruise. These data show that the AT was reached at a WR corresponding to 65% of VO_2.
Moreover, taking into account that the software installed in the device for assessment of cardio-metabolic and respiratory variables during the CPETs also provided the expected peak values for each subject being examined, in our RCp who approached the sailing cruise, CPET assessed peak values of respiratory variables were quite below those theoretically expected. In fact, values of V_p, B_f, and V_t, were, respectively, -16%, -49% and -35% lower than expected. However, the two end tidal gases, i.e. O_2 and CO_2, respectively showed -4% and -5% of the expected values.
Concerning cardiovascular variables, HR peak was higher (+9%) while both arterial blood pressures peaked at lower values (SABS: -13%, DABS: -14) than those expected.
Finally, the O_2P peak was as about that expected as well as and WR peak.

Table X - Variables derived by those assessed during CPET

Conditions	$CO_{2\text{-exc}}$ l min^{-1}	RSBI br min^{-1} l^{-1}	E_{oxy}
Before cruise	2.01	16.5	0.24
After cruise	1.93	26.8	0.25
Δ%	-4.0	62.4	4.2

$CO_{2\text{-exc}}$: after exercise excess of expired carbon dioxide; RSBI: rapid shallow breathing index; E_{oxy}: aerobic efficiency index.

With respect to the peak values of cardio respiratory and metabolic variables, induced by the pre-cruise CPET and represented in Table IX, columns histogram represented in Figure 10 shows that the coastal cruise gave rise to an increase of the VO_2 peak of 3.5%. Furthermore, Figure 10 also shows that the coastal cruise gave rise to increases in patient's peak values of VO_{2AT} (+7%) and VO_2/WR (+20%) while R_{ER} decreased (-2%).
Concerning the breathing variables, Figure 10 shows +18% in peak V_p, +8% in peak B_f and +2% in peak V_t. On the contrary, while the after cruise peak HR practically remained the same (+1%), both S_{ABP} (-5%) and D_{ABP} (-6%) were reduced. Further, a marked increase in PO_{2ET} (+13%) and decrease PCO_{2ET} (-19%) resulted in the subject's rest condition preceding the after cruise CPET with respect that assessed before cruise.
Table X shows some variables derived by those assessed during CPET. It appears that the post-cruise $CO_{2\text{-exc}}$ fell of 4% compared to that presented in the pre-cruise CPET. Moreover, the 4% increase of peak $E_{oxy,}$ shown by tested RCp in the post-sailing CPET indicated that the oxidative contribution to reach peak muscle contraction was increased due to the coastal cruising. Table X also shows a more than 60% increase in the peak RSBI assessed in the incremental test performed by the RCp after he came ashore from the boat.

4 DISCUSSION

The potential health promotion of natural environments has been widely investigated [51], and great attention is dedicated to the health and well-being benefits of green space proximity or exposure [52, 53]. Nevertheless, less attention has been given to the specific benefits of blue spaces.
Below, based on the results acquired from this experiment, the benefits that can be brought to the HRQoT by actively living in blue areas for a prolonged period of time are discussed and highlighted.

4.1 BLUE SPACE BENEFITS

Blue spaces are environments defined by the presence of water and include inland and coastal aquatic environments [54, 55]. Nonetheless, positive associations between coastal proximity and indicators of general health, mental health and physical activity have been found [56, 57]. In this respect, the study of Bell et al. [58] highlights the health benefits of living in or near blue areas. However, the central theme concerning the possibility that the marine coastal environment could supplement physical activity in producing disaggregate morpho-functional adaptations in the human body systems and organs responsible for optimizing life and health conditions, remains controversial. In a population of more than 20,000 subjects, Pasanen et al. [59] studied possible relationships between coastal proximity and the degree of health and well-being declared by the studied subjects practicing surface and underwater sports, outdoor physical activity conducted in mixed land/water natural environments such as walking, running, cycling, etc. or physical activity conducted in indoor environments such as gyms, swimming pools, sports centres, etc. They highlighted complex interactions between these three types of locations for physical activity that are difficult to differentiate as regards the specific effectiveness in generating well-being for the practitioners. So, it has been concluded that people living in coastal areas tend to be happier and healthier than those living inland! However, the study does not show quantitative relationships between blue spaces and body organ and system functions.

Specifically, the aforementioned study by Bell et al. [58] which lasted 7 months, consisted of generating customized activity maps produced using wearable devices such as accelerometers and GPS systems, to guide geo-narrative interviews in a sample of 33 participants. These researchers have highlighted quantifiable therapeutic interactions favouring a condition of well-being generated by living in coastal spaces, including immersive experiences, rewarding experiences, symbolic experiences and social experiences.
But even in this case the study does not show any correlation between physical activity and the activity of the recruited organs and systems.
More recently, in a systemic review from Britton et al. [60] where checked 33 experimental works on this topic with the aim of bridging the gap in understanding the impacts of blue spaces in the context of targeted interventions for individuals with fragilities. This study included only blue space interventions that were specifically designed and structured with a therapeutic purpose for individuals with a defined need and did not include nature-based promotion projects or outdoor recreation. Overall, the papers reviewed suggest that blue healing may be beneficial to health, particularly mental health and psychosocial well-being. Indeed, most of the works considered found a positive association between blue care and indicators of health and well-being, but the results were inconsistent and difficult to distinguish from each other with very few references to physical health.
In contrast, a recent multicenter study from Vert et al. [61] had the objective of evaluating the psychological and cardiovascular responses of exposure to blue spaces in a sample of 59 subjects by randomly assigning them to one of the following 3 different environments: blue space, urban space and control site. Recruited subjects walked 20 minutes per day along a blue or urban space or rested at a control site for 4 days per week and for 3 weeks and, before, during, and after environmental exposure, were self-reported well-being and parameters of mood, blood pressure, and heart rate variability. Like the others hereinbefore, also these authors found a significant improvement in well-being and mood responses immediately after walking in the blue space compared to when they walked in the urban space or while resting at the control site. However, no positive effects due to motor activities in blue spaces were observed for any of the cardiovascular indicators evaluated in this study.
These latter results were clearly in contrast with those observed in the present study as regards the effects of physical activity in the blue spaces concerning cardiovascular adaptations, and not only, deriving from performing physical activity of light/moderate intensity such as sailing for pure pleasure along the coasts.
In fact, even if this was a case study in only one subject, the present experimentation has clearly highlighted that this type of amateur activity, conducted in full immersion of the blue space, has generated in the studied RCp a series of cardio-respiratory and metabolic adaptations as well as in his mood, which evidently highlighted the close relationship between living and moving in a marine/coastal environment and the establishment of objective improvements in the aerobic performance capacity.

4.2 RC PATIENT'S CARDIOMETABOLIC IMPROVE BY COASTAL SAILING

Making a synthesis of the main experimental results reported in this study, what is of particular relevance was the cardio-dynamic profile that the E-Physio acquired from the studied RCp the last day of the cruise compared to the second one, taking into account that the two RPE values were practically equivalent. In fact, in the last day there was a statistically significant increase in the left ventricle peak EVI of blood together with in its VET which latter reached to significantly reduce the PEP/VET ratio (or increase in myocardial contractility). All of these changes reached to a significant 22% increase in the LSV. Now summing this centrally cardiac-supported aerobic vantage to the other than advantageous arising from the fall (-3%) in the indirect index of peripheral vessels resistance, i.e. the TPVRI (in Table VIII) as well as to the mean arterial blood pressure reduction of 4%, since the cardiac output did not change significantly, it appear that coast cruise, despite leaving the CO at rest almost unchanged after 3 weeks of navigation, could induce a change in the cardiovascular pattern in terms of both a greater cardiac inotropism and a reduction of the ventricular after-load. Data from both the two CPET, respectively performed by the RCp before and after the sail cruise, confirm that after cruise there was a greater oxygen delivery to the muscles of his working limbs. In fact, when reported to body mass unit, peak VO_2 assessed before cruising reached a value of 23.4 ml kg^{-1} min^{-1} which, as stated from the American College of Sports Medicine (ACSM) [62], stayed between those 4^{th} and 5^{th} positions of the seven increasing classes concerning "sedentary healthy" subjects and which goes from 14 to 35 ml min^{-1}. When the CPET was performed by the RCp after cruise the peak VO_2 was of 24.7 ml kg^{-1} min^{-1} (+5.6%), thus climbing beyond the fourth position in the scale concerning "sedentary healthy" subjects highlighted in the ACSM's Guidelines. That a patient's greater oxygen delivery occurred after coastal cruise is also confirmed by the corresponding CPET induced higher peak value in the PO_{2ET} which latter reflects a higher partial pressure of this gas at the arterial blood level [47]. Moreover, also the post cruise reduction in peak R_{ER} found at the exhaustion from the CPET reinforced the above observation.
Another index of the after cruise induced increase in the RCp's oxygen delivery descents from the peak value of the VO_2/WR. As is known, this variable provides information on the capacity of the musculoskeletal system to generate power from the aerobic energy pathways. Before cruise the RCp's peak of VO_2/WR was of 9.7 ml min^{-1} W^{-1} which was about 8% lower than 10.6 ml min^{-1} W^{-1} reached in a group of about 60 free living subjects ageing 61±7 years, tested in a previous study by a cycle ergometer CPET [63]. However, after coastal cruise, in our RCp this variable increased of 20% thus rising up to 11.6 ml min^{-1} W^{-1} or quasi +10% than in the aforementioned other experiment [63].
On the other hand, Figure 9 shows that the W_{Eact} delivered on the last day of cruising during a strenuous sailing activity was 2.3 times higher compared to that delivered on the second day, again during a critical sailing condition, despite

the RPE perceived by the subject was practically of the same entity. Moreover, the sailor in the July 16 was able to sustain a C_{Tran} which was about two and a half times that spent in the previous June 27.

At the same time also the RCp's heart bioenergetics gave rise to advantages at the cruise end since practically unchanging in the HR together with reducing SABP at rest reached to a fall in the DP of almost 20% than before cruise, which reflected a reduced oxidative energy cost in the myocardial contraction [43]. This ultimately led to a greater heart mechanical efficiency index of this organ, i.e. the HMEI of Table VIII, when assessed at the last day of cruise (more than two and a half times that measured on the 2nd day of cruise).

Changes induced by the costal cruise in the CPET peak breathing patter of our patient certainly owed a significant contribution in increasing the recruitment of the aerobic pathways for exercising muscle supply since the modifications undergone by the respiratory pattern in a chronotropic way. This respiratory shift strongly pointed out by the 62% increase in the peak rapid shallow breathing index, i.e. the RSBI in Table X, compared with the pre-cruise condition and might refer for a blue spaces training induced adaptation of the brain stem centre for breathing modulation [64]. In considering the relative $CO_{2\text{-}exc}$ reduced value found in the recovery from the CPTE performed by the patient after cruise (-4% with respect that assessed before one), this was due to a lower respiratory super-compensation, i.e. a relative post cruise hypocapnia. As is known [65] this respiratory super-compensation takes place when the WR overcomes the value corresponding to the AT. This has the target of avoiding a fall in the blood pH caused, in turn, by the excess of lactic acid which pours from working muscle cells into the bloodstream (see in Figure 8 on the right the two consecutive peaks in the instrumental trace of the expired CO_2 and the consequent slower rate of reduction of this gas, compared to that of the oxygen, during the recovery from the CPET). Since it has been suggested that a relative hypocapnia could induce an increased excitability in the lungs stretch receptors [66], the effect of these overexcited receptors is an enhancement of their reflex volley of action potentials towards the brain stem which results in a cutting short the inspiration [67]. This occurrence could produce in our sailor performing the CPET after cruise, a reduction in the volume and duration of the breaths as was the here observed reduction of peak V_t together with the increase of peak B_f. Therefore, it is reasonable to suppose that such an adaptation of the breathing pattern, as observed in or patient after a long lasting coastal sailing, could have the purpose of reduce the stretch of the inspiration muscles with a lower mechanical work to be made from they, i.e. a not negligible aerobic energy saving.

As observed in Table X, all these advantageous cardio-respiratory and metabolic changes detected in the CPET performed by the subject tested here after he had sail in the blue space, gave rise to an increase in his E_{oxy} which reached the value of 0.25. Since this latter is the theoretic maximum value for the E_{oxy} in the muscle machinery [68]. This obtained result is a goal of great biomechanical efficiency that can be ascribed to the physical activity carried out in a blue area.

4.3 CRUISE INDUCED GENERAL WELLBEING IN THE RC PATIENT

The PHQ-9 questionnaire answers from the tested subject, shown in Table II, indicated that, before coastal cruising, he was in a more than mild condition of depression which, however, completely disappeared after he performed the sailing cruise into the blue environment. This result is fully in agreement with other experimental results obtained from previous papers [45, 69], and confirms that living and travelling within a blue space for several weeks gives rise to a mood enhancement.

This latter condition could at least in part descend from what exposed in Table IV concerning the daily behaviour of the chosen indicator for a good compliance of the sailing subject with the sea environment. In fact, it has been observed that sailing several days in open sea waters could induce inflammations/infections of the upper respiratory tract [70] with reduction of lung vital capacity due to obstructive damage at the bronchial level, and from this can derive a reduction in the percentage of oxygen saturation of haemoglobin together with the onset of a feverish, and a decompensation could also occur in heart rate and arterial pressure. All these homeostatic failures together with a creeping dehydration and other failures being often at the limit of the sailor's sensory threshold might not be perceived in time, putting the sailor at serious risk [71, 72]. Hence, need to frequently measure the indicators of these potential risks in a person who sails on a boat in the sea for several days. Thanks that our RCp monitored himself in this sense every day of the cruise, it was possible to ascertain that this type of coastal navigation lasting several days had not caused any danger as cardio-respiratory damage or blood hydro-osmotic imbalances in this post-oncology patient.

4.4 SAILING-CONDITIONING PHYSUCAL ACTIVITY LEVEL OF THE RC PATIENT

In a free living subject the E_{Tot}, in addition the E_{Act} in displacing the BCoM, includes components namely resting energy expenditure or the base metabolic rate (BMR as represented here in Table III) and the thermic effect of food energy expenditure (E_{Tef}) [Hills], i.e. the diet-induced thermogenesis which spend about 4-7% of the total [73]. All these kind of energy expenditure were daily assessed, cumulatively, as the E_{Tot} by our cruising RCp from the brachial SWA and reported in the Table V with a mean value of 2243 ± 285 Kcal/day. However, our patient did not wear the SWA for the full 24 h every day (daily average: 20.8 ± 3.9 h/day), so the mean E_{Tot} in Table V was normalized as $E_{Tot/24}$ by the following equation:

$$E_{Tot/24} = (E_{Tot} \div 24) \times 20.8 = 2563\ Kcal \quad (17)$$

Interestingly, Tanaka et al. [74], used the criterion doubly labelled water (DLW) technique (the absolute gold standard concerning these measurements) in a group of 22 men ageing from 65 to 85 years in free living condition. They showed a meanly estimated E_{Tot} of 2219 ± 325 Kcal/day. This latter mean daily energy expenditure was 344 Kcal lower than in the present study report, a difference that, anyway, is almost

within the variability, in terms of standard deviation, of the mean value in the above study of Tanaka et al. [74].
However, in considering that both absolute energy requirement and base metabolic rate vary with subject's body size, gender and age, so the active energy requirement may be stated in general terms E_{Tot} versus BMR relationship has also come to be known as the physical activity level (PAL) [75] and expressed as

$$PAL = E_{Tot} \times BMR^{-1} \quad (18)$$

The (18) results in a dimensionless variable since both E_{Tot} and BMR are expressed in Kcal or KJ. So putting now, in (18), $E_{Tot/24}$ in place of E_{Tot} and translating the BMR value of Table III (calculated as the mean value among those two assessed pre and post cruise respectively) from KJ to Kcal by subdividing it from the caloric equivalent of the Joule which is 4.18, we could have the following adjusted equation concerning the PAL of our RCp:

$$PAL_{RC} = 2563 \times (6508 \div 4.18)^{-1} = 1.65 \quad (19)$$

The validity of PAL has been tested and confirmed in a large sample [73] and it has been stated that typical PAL values in free living adults range from 1.40 to ~ 2.40, and it consents to compare among different subjects the relative excess output of energy related to physical activities within 24 hours. The World Health Organisation (WHO) recommended a PAL of 1.55 as probable minimum energy requirement, obtained by 1.55 x BMR, for light activity [76]. Again, it has been suggested a PAL interval comprised between 1.6 and 1.7 values which concerns to seated work with discretion and requirement to move around but little or no strenuous leisure activity [73]. Since the (19) shows a PAL of 1.65 in our coastly sailing RCp, this implies that his physical engagement should have been very light and, likely, not such as to justify the conspicuous cardio-respiratory and metabolic improvements observed during and at the end of the cruise.

4.5 BLUE AREAS CONDITIONING AUTONOMUS NERVOUS SYSTEM ACTIVITY

In a recent meta-analysis from Jo et al. [77], several papers reviewed from they found a variety of physiological indicators showing the benefit of viewing nature. In particular, Lauman et al. [78] have found in a group of 14 undergraduate students who were invited to watch a 20-minute film in which flowed images and sounds depicting the waterside of an island close to the west coast of Norway, i.e. a typical nature blue environment, a significant increase ($P < 0.01$) of the cardiac inter-beat interval (about +50 ms), or an HR reduction occurred when compared with a control group who saw a film shot in the streets of Oslo (capital of Norway) with images and sounds typical of an urban environment. Authors suggested a blue areas vision induced reduction in the sympathetic domain of physiological arousal from which a relative bradycardia could be reached. In the same direction go the results of Anderson et al. [79] who underwent 18 healthy subjects to the vision of virtual reality scenarios concerning respectively indoor environments and nature remote beaches of the Australian coast. They observed a significant reduction ($P = 0.002$) in the electrodermal activity (EDA: about -2 μSiemens) after virtual reality viewing of Australian beaches compared to indoor ones. Since EDA is a measure of skin conductance [80], its increase corresponding to an increase in sympathetic tone without any parasympathetic component [81] and vice versa, so dream beaches images induced in these tested subjects a reduction in sympathetic tone.
The heart rate variability (HRV) in terms of low frequency power (LF) versus high frequency power (HF) ratio (LF:HF) is utilized to show possible changes in the sympathetic versus parasympathetic balance of the cardiovascular controlling autonomous nervous system (ANS). In this light, in a group of healthy subjects in turn really exposed to natural blue and urban environments, Triguero-Mas et al. [82] found a beneficial association between the blue environment and LF:HF fall (- 0.51 with respect the urban one, $P = 0.02$) which was replicated when using as the more precise indicator the coefficients of component variance of LF and HF, i.e. the CCV-LF:HF (- 0.32 with respect the urban one, $P = 0.001$). This suggests that the exposure to blue environments leads to the ANS being dominated by the parasympathetic nervous system.
Now translating these previous experimental results towards the response of the autonomic nervous system of our coastal cruiser RCp, the fact that, at the end of the navigation he presented reduced peak values, induced by the CPET, regarding SABP and DABP while the HR did not vary significantly, allows us to state that a neurovegetative adaptation oriented towards a reduction in the orthosympathetic tone could have occurred. This statement is also reinforced by the remarkable decrease in MABP, TPVRI and HR while, in the last cruising day, the RCp was engaged in a hard sailing navigation in comparing to the sailing at the cruise beginning with a similar RPE.

4.6 EXERCISE ENHANCING HEALTH-RELATED QUALITY OF LIFE IN RC PATIENTS

The so called health-related quality of life (HRQoT), in patients who have undergone RC surgery is a biomedical-sociological issue that still needs to be satisfactorily framed. Already almost fifty years ago, a publication of the urology section of the University of Texas - Houston [83], concerning a study of 214 cases of clinical complications after single stage radical cystectomy and ileal conduit diversion surgery, showed a high intraoperative mortality rate (3.3%) caused by complications such as wound dehiscence, uretero-ileal leak or wound infection. But among the survivors of surgery there were around 29% of patients operated on with serious and various early complications (among other pneumonia, enteric fistula, pulmonary embolus, acute renal failure, septicemia, etc.) occurred and 41% of late complications who were followed 6 months or longer. These authors reached a not encouraging conclusion regarding the HRQoL of the post-CR patients for whom mental or uncompensated physical incompetence, severe pulmonary or cardiovascular disease, non-correctable renal or hepatic insufficiency, could remain for an indefinite time. Just 40 years later, in a study concerning HRQoL on 51 patients over 75 years hold (the age group in which our RCp

is placed) who had undergone RC surgery with urinary diversion and ileal conduit [84] using specific and validated disease questionnaires, at mean follow-up of 60 months with a scale from 0 to 100 (this last value as maximum negative) observed the following mean score values: emotional functions = 80; cognitive functions = 81; associative functions = 85/100; general ERQoL = 89. These results confirm that, after 5 years the evaluation of ERQoT in CRps is still far from being satisfactory. Moreover, a substantial number of RC patients have a very poor performance status together with a not optimal nutritional status already before surgery due to be elderly, to previous chemotherapy or to cancer itself, and this contribute to enhance the risk of a pre-surgery very poor general condition which is reflected in a low post surgery HRQoL.

Starting from recent observations in which a moderate physical activity can prevent dysmetabolism [85] and improve chronic pain in older adults [86] as well as that a more active lifestyle seems to exert some positive influence on the gut microbiota of long-lived individuals [87], it can be added such evidences that physical exercise improves physical function together with physiological and psychological status in cancer's patients [88].

In this regard, a study from Porserud et al. [89] was made on 9 RC patients of about 70 years hold which took part in a group "exercise training program" consisting in 45 minutes twice a week over 12-week period of individually tailored strength and endurance training exercises, made within a specifically assigned Hospital block. A group of other 9 RC patients not participating to the training program and assigned to another Hospital block were considered as the control group. As a result, one year after surgery, with respect the control group patients, trained patients had significantly increased ($P = 0.01$) the distance walked in the six-minute walk test. Recently [90], the same group of research reconsidered the issue of the possible benefit of post RC physical training by studying 120 patients with a protocol identical to the previous one but with the difference that the exercises of the training group were performed at home and with secondary outcomes of measures such as: gait speed, handgrip strength, leg strength, habitual physical activity, fatigue, psychological wellbeing and others which resulted in a marked improvement in HRQoL.

It is not negligible that these later results reported above fully agree with those of our results here presented which report what concerns the benefits for the HRQoL of RC patients generated by prolonged physical activity performed through coastal sailing activities. Furthermore, it is possible that in our RCp, thanks to the physical activity of sailing, the age-dependent condition of sarcopenia characterized by the progressive and generalized decrease in skeletal muscle mass [91] could be counteracted.

4.7 SEA SPRAY AEROSOL AS POSSIBLE FACTOR FOR THE COASTAL CRUISING WELLBEING

In agreement with what recently stated by Murrin et al. [92], it can therefore reasonably be concluded that, since PAL_{RC} was quite modest to justify the substantial cardio-respiratory and metabolic improvements caused by this prolonged physical activity in the "Blue Areas" setting, "*Physical activity carried out within typically coastal blue marine areas plays an amplifying role of the action that this type of natural environment which, already by itself, promotes towards the general health*".

That what Murrin et al. [92] have sentenced above might have a scientifically assessable foundation can be speculate from what follows.

1) As is known, the angiotensin-I-converting enzyme (ACE) promotes the conversion of angiotensin I to the potent vasoconstrictor angiotensin II in raising blood pressure by producing a severe peripheral vasoconstriction [93]. Therefore, the inhibition of ACE activity is a useful treatment for controlling hypertension and thus maintaining blood pressure within a normal range.

2) It has been found that *Sardina Pilchardus*, a fish species known for its rapid growth, high fertility, low cost, and high concentration of essential amino acids beneficial for human health [94] is common in the Mediterranean Sea and, especially during the good season, can be found in shallow and coastal waters.

3) Recently, Shao et al. [95] showed in these fishes that the low molecular mass fractions (<3 kDa), obtained through ultra-filtration, exhibited more effective ACE inhibition by which were identified based on high biological activity scores, non-toxicity, good solubility.

4) It is known that at the interface between the sea surface and the air, nano-particles are formed containing biogenic and geogenic compounds (biologically active peptides?) with concentration distributions along thermocline lines. So, the sea surface, the atmosphere and the clouds form a dynamic interconnected system through the release and deposition of chemical species within the nano-particles. The phenomenon that connects these three environments is the so-called sea spray aerosol (SSA) [96, 97].

5) It must be considered that, as for all living organisms, the biological cycle of sardine fishes contemplates their death and hence the dissolution in sea water of the body into nano-particles which could also containing biologically active peptides with ACE inhibition capacity.

6) So, It may be that this occurrence would lead to the possibility that nano-particles originating from sardines, loaded with peptides having ACE inhibition properties, become part of the sea spray aerosol floating in the coastal path travelled by our RCp who, both during the day while sailing and during the night while he slept in the boat moored in the sea, could not help but inhale them.

7) It would therefore be reasonable to hypothesize that the post-cruise reductions in peripheral vascular resistance and therefore in systolic and diastolic arterial pressures, shown by our patient, could be due, at least partly, to the presence in his blood of bioactive peptides with ACE inhibition activity.

The occurrence of a condition of this type could explain the relatively small PAL_{RC} value shown by our RCp while sailing near the coast, compared to his robust cardio-dynamic variations observed at the same time, as his E_{Tot} expense could be benefited/reduced by the contribution provided to

the him efficiency by the SSA. This might justify, in this way, what was also stated by Murrin et al. [92] with regard to the quantifiable benefit supplement brought by the Blue Areas environment, by itself, to the improvement of the general condition of not only mental but also functional well-being of the organs and systems involved in this activity.
Further experiments will be needed to confirm or not this fascinating hypothesis.

5 CONCLUSIONS

The remarkable technological innovation brought about by this experimentation to the knowledge relating to the cardio-dynamic adjustments occurring in a coastal sailing subject, consists in the assessment beat-to-beat, remotely and in real-time, of these variables through a home-made mechatronic IoT equipment, i.e. the E-Physio tool. The technology implemented in this equipment as been already applied in a variety of materials and conditions [25, 38, 42, 98, 99, 100, 101, 102] and, this equipment has made it possible to greatly expand the availability of functional variables, directly measured or acquired through calculations, which knowledge contributes to improving the HRQoL of aged subjects who have undergone RC surgery and who decide to embark on a coastal sailing cruise.
More specifically, in considering that the main metabolic and respiratory variables, i.e. V_p, B_f, V_t, VO_2 and VCO_2, when assessed from our patient at the end of the CPET performed before cruise, showed respective peak values that behaved within a range from -49% to -4% (see corresponding data in the results paragraph) with respect the expected ones, it could be reasonably deduced that one year about the RC surgery our patient had a nor very good HRQoL, especially concerning his exercise capacity. On the contrary, when the patient repeated the CPET after the coastal cruise, the same metabolic-respiratory variables showed peak values that not only achieved the expected values but often greatly exceeded them, thus inducing a tangible improvement in his HRQoL. So, the take home message that comes from the results of this case study is that of encourage patients who have undergone RC surgery to practice coastal sailing.
Finally, in considering that the SSA has long been investigated with the aim of extracting bioactive peptides from it, originating from different marine organisms suitable for the therapy of different types of cancer [103, 104, 105], the possibility of extracting from the SSA which is generated near the Mediterranean coasts other molecules with anti ACE activity, represents a major challenge.

EXPERIMENTAL LIMITATIONS

The most obvious limitation of this experimental work is that it was implemented in a single patient. However, the current lack of knowledge regarding the possible systemic and clearly quantifiable beneficial effects on cardio-metabolic system of sailing along the sea coast in the context of blue spaces, in fragile patients such as those who have undergone a radical cystectomy, may allow this case study to, however, give a tangible impulse to deepen this knowledge.

AKNOWLEDGMENTS

The authors thank the captain of civil ships, Dr Pietro Gaviati, for the fundamental contribution he made to the implementation of this experiment.
Furthermore, the authors are also very grateful to the Ichnusa rowing association of Cagliari in Italy, for the hospitality granted to the boat and researchers in its port facilities.
The authors would also like to thank Professor Mauro Giovanni Carta, Head of the Psychiatry and Psychosomatics Liaison Service at the University Hospital of Cagliari in Italy, for his precious advice regarding tools for mood assessment.

ABBREVIATION GLOSSARY

ACE: angiotensin-I-converting enzyme.
ACSM: american college of sport medicine.
A/D: analogic/digital converter.
AT: anaerobic threshold.
BCoM: body centre of mass.
B_f: respiratory rate per minute.
BIA: body impedance analysis.
BM: body mass.
BMF: body fat mass.
BMI: body mass index.
BMM: body muscle mass.
BMR: base metabolic rate.
C&C: control and command device.
CGI: common gateway interface.
CO: cardiac output per minute.
CPET: cardio-pulmonary exercise test.
C_{Tran}: daily mean metabolic cost to transport BCoM.
DABP: diastolic arterial blood pressure.
DP: double product.
D_{Tot}: distance covered while walking.
dZ/dt: chest's bioimpedance first mathematical derivative.
E_{Act}: energy expenditure in displacing the BCoM.
ECG: electrocardiogram.
EDA: electrodermal activity.
E_{oxy}: aerobic efficiency index.
E_{Tot}: daily total energy expenditure.
EVI: maximum ventricle ejection velocity index.
GPS: global positioning system.
HBO_2: percentage of saturation in O_2 of the haemoglobin.
HF: high frequency power of ECG.
HMEI: heart's mechanical efficiency index.
HR: heart rate per minute.
HRQoL: health related quality of life.
HRV: heart rate variability.
HWI: heart's mechanical work index.
IC: impedance cardiography.
IPC: inter process communication
IoT: internet of things.
LF: low frequency power of ECG.
LSV: left ventricle stroke volume.
LVEDV: left ventricle end diastolic volume.
MABP: mean arterial blood pressure.
MCI: myocardial contractility index.

MET: metabolic equivalent of task.
O_2P: oxygen pulse.
PAL: physical activity level.
PEF: peak expiratory flow.
PEP: ventricular pre-ejection period.
PHQ-9: patient health questionary-9.
PCO_{2ET}: end tidal carbon dioxide fraction.
PO_{2ET}: end tidal oxygen fraction.
RC: urinary bladder radical cystectomy.
RCp: radical cystectomy patient.
RDS: remote device server.
RER: respiratory exchange ratio.
RPE: rating of perceived exertion.
R-R: time interval between two R waves in the ECG
RSBI: rapid shallow breathing index.
SABP: systolic arterial blood pressure.
SBC: single board computer.
SD: standard deviation.
SPI: serial peripheral interface.
SSA: sea spray aerosol.
SWA: sense wear armband.
T_{Eact}: time spent at the E_{Act} erogation.
T_{Etot}: time daily spent dressing the SWA.
TFI: thoracic fluids volume index.
TPVRI: total peripheral vascular resistance index.
Ty_t: tympanic temperature in C°.
U_d: urine density.
VCO_2: carbon dioxide per minute.
VCO_{2exc}: excess of carbon dioxide production.
VEPT: volume of electrically participating tissues.
VET: left ventricle ejection time.
VI%: variability index in percentage.
VO_2: oxygen consumption per minute.
VO_{2AT}: oxygen consumption at the anaerobic threshold.
V_p: expiratory ventilation per minute.
V_t: respiratory tidal volume.
V_{Tran}: daily mean velocity of transport the BCoM.
W_{Eact}: daily energy spent per hour exercising.
W_{Etot}: daily energy spent at each hour.
WHO: world health organisation.
W_{Met}: daily metabolic power output.
WR: work rate.
Z_t: thoracic bioimpedance.

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