# Week-Long Multimodal Data Acquisition of Occupational Risk Factors in Public Administration Workers

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Eduarda Oliosi[1,2], Phillip Probst[1], João Rodrigues[1], Luís Silva[1], Daniel Zagalo[1], Cátia Cepeda[1] and Hugo Gamboa[1]
[1]LIBPhys (Laboratory for Instrumentation, Biomedical Engineering and Radiation Physics), NOVA School of Science and Technology, NOVA University Lisbon, Caparica, Portugal,
[2]Faculty of Sports of the University of Porto, Porto, Portugal
Email: [1]{p.probst, lmd.silva, c.cepeda, h.gamboa}@fct.unl.pt, [1]{d.zagalo, jmd.rodrigues}@campus.fct.unl.pt,
[2]mariaeduardaoliosi@icloud.com

***Abstract*—Work-related disorders are a growing issue for office workers and represent a significant burden to public health. Work aspects such as sitting for prolonged periods and occupational stress are modifiable risk factors highly associated with occupational disorders in office workers. The PrevOccupAI Project (Prevention of Occupational Disorders in Public Administrations based on Artificial Intelligence) objectively investigates relationships between a variety of occupational risk factors and physiological outcomes. For this purpose, a data acquisition protocol was carried out at the Portuguese Tax and Customs Authority. Physiological, movement, and environmental signals from office workers were acquired during five consecutive workdays using a smartphone, a smartwatch, and two electromyography sensors. Additionally, demographic, occupational, and pain information were collected through questionnaires. The present manuscript provides a detailed description of the PrevOccupAI acquisition protocol. The collected data is used to gather knowledge regarding modifiable factors at the individual and organisational levels.**

***Index Terms*—data acquisition, biosignals, intelligent offices, multimodal risk evaluation, occupational health.**

## I. Introduction

Occupational disorders, more specifically work-related musculoskeletal disorders (WMDs), constitute a major public health problem [1]. These negatively impact workers with physical and mental complications, and stand as the leading cause of decreased productivity and increased absenteeism, generating a considerable medical burden and economic cost to organisations [2]. In total, it is reported that 7.4% of European workers suffered from occupational-related health problems, with a higher prevalence in musculoskeletal, stress, depression and anxiety related problems [3]. These reports also follow the demographic shift of increasing computer and desk-based work and its impact in workers' health, due to prolonged sitting, and extended screen time [4], [5]. Due to the complex multifactorial nature of musculoskeletal and mental disorders [6], [7], it is necessary to implement goal-oriented prevention strategies that address various factors, such as exposure to physical, psychosocial, and environmental risks [8], both at the individual and the organisational level. Smart technologies that can easily be integrated into the workplace could be a promising solution for adequately assessing occupational health risks related to the working environment, desk setup and worker's behaviour. Furthermore, prevention and mitigation strategies could be developed from this, and recommended to workers.

Intelligent or smart offices bring numerous opportunities for delivering prevention and control measures for health issues associated with office work [9]. Smart technologies, such as wearables, Internet-of-Things (IoT) or machine learning (ML) models, contribute to the overall development of intelligent office environments that bring more awareness over employees' context. They allow for assessing which are the targeted needs, thus ultimately playing a significant role in integrated health status monitoring systems that enable the application of structural changes by the employee and/or organisation [9]–[14].

Smart offices constitute a subject of interest for many researchers, some of which are worth highlighting. One of which is *Liu et al.*, [15], who proposed for the development of an intelligent office chair prototype that integrates sensors, micro-controllers, and vibration actuators accompanied by a mobile application, which provide vibrotactile and visual feedback to monitor the user's posture and improve their sitting behaviour [15]. *Aryal et al.* (2019) [16] investigated intelligent desks, suggesting methods for office workers' future productivity and well-being. Several aspects were highlighted, consisting of different application modules for improving worker comfort, well-being, and productivity by providing recommended thermal comfort, visual comfort, and sit-stand desks. Sensing and actuation devices can be integrated on different furniture of the office or existing wearables, such as office chairs and smartwatches [16], [13]. The boosts in device capabilities offer many new opportunities for monitoring, momentary ecological assessment, and intervention [17], [18].

The mentioned research focuses mainly on systems and strategies that exclusively work either on an individual or on an organisational level. While these approaches are still valid solutions for their respective problems, they are not able to appropriately address the multifactorial nature of occupational diseases (e.g. psychosocial factors such as stress can have influence on the development of WMDs and vice versa). Furthermore, prevention strategies made on an individual level can only have an impact to a certain extent as there may be organisational problems that can not be tackled by individual workers. Similarly, focusing primarily on changes on an organisational level may result in management decisions that are not received favourably by workers. Thus, a comprehensive approach that can identify and assess occupational risk factors on an individual and organisational level is needed to appropriately address occupational risks and provide prevention strategies for both. Implementing such an approach would ultimately lead to an intelligent office environment that results in data-driven decision making that benefits both the workers and the organisation.

The 'Prevention of Occupational Disorders in Public Administrations based on the Artificial Intelligence' (PrevOccupAI) project aims to characterise daily working activities, working conditions, and potential risk factors associated with the occupational environment, on an individual and an organisational level, within the Public Administration. This paper presents the data acquisition procedure used in an ongoing study conducted within the Lisbon Metropolitan Area with workers at multiple locations of Autoridade Tributaria (AT), the Portuguese Tax and Customs Authority. Acquisitions were carried out for five consecutive work days. The length of the data acquisition was chosen based on two criteria, (1) capturing changes in worker behaviors over multiple days, (2) availability of workers to participate. We included signals like Heart rate (HR), Accelerometer (ACC), Gyroscope (GYR), Magnetometer (MAG), Rotation vector (RV), and ambient noise utilising a smartwatch and a smartphone as well as Electromyography (EMG) using proprietary sensors. Furthermore, subjective data was collected through validated questionnaires that address, among others, demographics, workplace conditions, pain intensity, and psychosocial factors.

The main contribution of this paper is to describe the used data acquisition protocol with the principal aim of acquiring multimodal data in real-time in a worker population. Furthermore, we present our reasoning for how the variables measured in the acquisitions were selected and some preliminary population statistics. We conclude the paper with future directions towards our vision for risk assessment in occupational environments.

## II. Methods

### A. Review on Occupational Risk Factors

We conducted a non-systematic literature review to identify multimodal risk factors and instruments to assess WMDs and their essential potential factors. From this review, both intrinsic (i.e., health status) and extrinsic (i.e., environment characteristics) were taken to support an evidence-based WMDs risk assessment tool.

The review process started with collecting information on which demographic variables should be considered in the study. The review showed that variables such as age, body mass index (BMI), and gender were relevant indicators for assessing computer users [19], [5].

In a subsequent step the influence of physical activity was found to be relevant as people with sedentary lifestyles are associated with being more prone to work-related illnesses such as musculoskeletal disorders [20], [21], [22], [23]. A recent report issued by the European Agency for Safety and Health at Work (EU-OSHA) has concluded that the second most frequently reported risk factor in the EU-27 (61%) was prolonged sitting [24]. These results can be seen as a consequence of trends that have been developing over the past 30 years, as physical activity decreased by more than 25% in that time period. In the same time span the number of people working while seated at a desk has increased in several countries [25].

According to the International Labour Organisation (ILO) [26], interventions in the workplace must take into consideration the interaction of multiple elements due to the interdependence to which the worker is subjected, such as leadership issues, job demands, social support, working-time arrangements, work-life balance, and communication, among others [27], which reinforces the necessity to evaluate the individual at the organisational level. To encompass these aspects, we assessed diverse psychosocial outcomes, ranging from self-efficiency, sleep quality, burnout and specific outcomes of work conditions [27], [28], [29], [8], [4].

Ergonomic interventions include improving the equipment and environment of the workplace. Most office environments do not adequately support office worker health, nor do they maximise work performance. Indoor environmental factors, such as noise, air, lighting, and adjustable furniture, which do not fit the individual's needs or support occupational requirements, can directly affect office workers. Promoting an optimal environment and adequate rest time allows recovery and reduces the risk of long-term damage. Therefore, we include the examination of the occupational setting, such as work arrangements adequacy, privacy, design, and air quality [30], [31], [32], [4], [5].

Previous research has suggested that professions involving more physical variation most likely have a reduced risk for the development of WMDs, compared to jobs where similar movements are performed repeatedly [5], [33], [34], [35]. This is the case for office workers, who often maintain static postures and perform repetitive actions throughout their workdays. Thus, the movement variability has been essential to prevent WMDs [33], [24] and pain experiences in office workers [5].

In summary, through the review process, we identified as vital to include in our acquisition protocol the following domains: demographics, physical activity, psychological factors, occupational environment factors, and pain experience. The selected domains allow for characterising risks both on an individual and organisational level. To be able to capture all the mentioned risk factors, a comprehensive data collection process is necessary. This process consists of employing both subjective and objective data acquisition strategies. Subjective data collection was realised through the usage of validated structured questionnaires. Objective data was acquired by utilising wearable sensors. By collecting both subjective and objective measures we hope to capture a broad spectrum of rich data that allows for an identification of the aforementioned risk factors. The validated tools and wearable devices used are described in detail in the following two sections.

### *B. Questionnaires*

For the assessment of subjective measures, validated questionnaires were employed. As such, we used the the International Physical Activity Questionnaire Short Form (IPAQ-SF) [36], Copenhagen Psychosocial Questionnaire II (COPSOQ II) [37], Rapid Office Strain Assessment (ROSA) [38] and Numeric Pain Rating Scale (NPRS) [39] [40]. These assess different dimensions, like physical activity, psychosocial factors, work-related and pain experience, respectively. Additionally, a questionnaire was developed to retrieve information with regards to demographic variables. The validated tools and the additional questionnaire are described in detail as follows.

**Physical Activity:** Physical activity (PA) information was evaluated through the IPAQ-SF [36], which consists of seven items. These are days and time spent doing vigorous and/or moderate PA, days and time spend walking, and time spent sitting during weekdays. All items are asked with respect to the last seven days. The final score is reported as low, medium, or high as well as level of PA per week through the metabolic equivalents [41]. It is an instrument developed for monitoring PA levels among 18 to 65-year-old adults in diverse settings. This tool has been validated and considered reliable ($\alpha$ .80) [36].

**Workstation Assessment:** ROSA [38] was employed as the ergonomic and biomechanics subjective assessment (e.g., chair, mouse, and overall workstation). ROSA [38] is a questionnaire to quickly quantify risks associated with computer work and prove an action level for change based on reports of worker discomfort [42]. The risk factors included in ROSA are encoded as increasing scores from 1 to 3, final scores ranging from 1 to 10, with higher scores representing elevating risk factors. In previous studies, it was shown that the final scores obtained with ROSA significantly correlated with body discomfort [38]. Mean discomfort increased proportionally with ROSA scores, with a significant difference between 3 and 5 (out of 10). ROSA's scores give targeted meaningful changes to the office setup that can potentially reduce long-term discomfort and serve as a tool to understand which elements of the individual desk should be changed. This tool has been shown to be an effective and reliable method for identifying computer use risk factors related to discomfort. Moreover, ROSA final scores exhibited high inter-and intra-observer reliability (ICCs of 0.88 and 0.91, respectively). The Portuguese version of ROSA is currently only available in Brazilian Portuguese [43]. Thus, we are in the process of validating ROSA for European Portuguese.

**Psychosocial Factors:** The COPSOQ II [44] analyses psychosocial risks (e.g., self-efficacy, burnout, and sleep quality). In a previous study, the Portuguese COPSOQ II was validated by issuing it to 745 Portuguese employees from organisations across several economic sectors. The questionnaire was employed twice, once as a baseline and a second time as a follow-up two weeks later. The test-retest reliability estimated by the intraclass correlation coefficient (ICC) showed higher reliability for most scales. Thus, the long Portuguese version of COPSOQ II [37] is a reliable and validated instrument [45] for assessing psychosocial risks in the workplace. The Portuguese middle version comprises nine domains (demands at work, work organisation and job contents, interpersonal relations and leadership, work-individual interface, values in the workplace, personality, health and well-being, and offensive behaviours), 29 dimensions (also called scales), and 76 items.

**Pain Experience:** The proposed protocol assesses the three dimensions of pain perceived experience. These are pain intensity, pain-related distress, and pain-related interference. These three dimensions are assessed using the NPRS [39]. The pain intensity denotes the strength of the subjective pain experience ('how much does it hurt?') for a specific body parts (e.g., neck, shoulders, upper dorsal region, among others). For this purpose the NPRS considers a 11-point rating scale ranging from zero to 'no pain' to 10, 'worst pain imaginable' [39]. The pain intensity is evaluated on a daily basis, using an interface in the application, depicted in Fig. 1, where subjects can draw on a body map the corresponding pain intensity using a predefined color mapping [46]. The interface allows for indicating pain ratings from 1 to 10. All uncolored regions

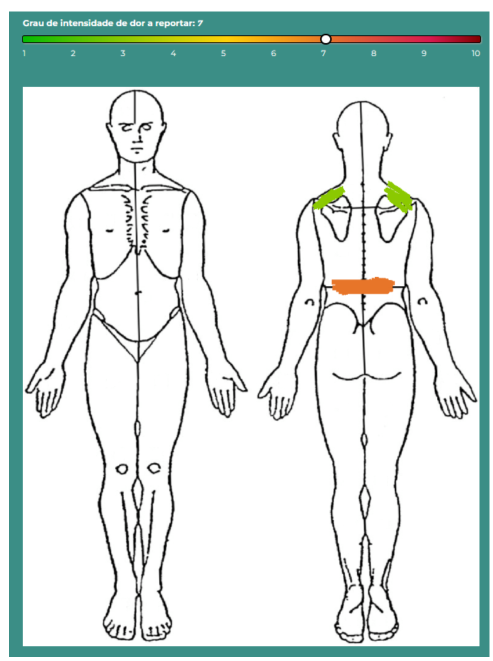


Fig. 1: Pain location and intensity assessment interface.

are considered to be 0 pain.

Pain-related distress is evaluated with regards to the previous week. Here, unpleasant emotional experiences of cognitive, behavioural, emotional, social, or spiritual nature related to recurring pain are assessed based on the same 11-point numerical rating scale. Pain-related interference describes how much the pain interferes with daily activities and participation. Where, the 11-point rating scale ranges from zero ‘no interference’ to 10 ‘unable to carry on activities’. Rating is done with regards to interferences over the last week [39], [47], [40]. Using the International Classification of Diseases (ICD-11) temporal criteria, we included a single question to quantify the duration/chronicity (acute <three months or $\geq$ chronic three months) [46], [48].

**Demographics:** To retrieve demographic variables the following questions were compiled into a single questionnaire: age (years), gender (female, male or other), height (cm), weight (kg), dominant hand (right-handed, left-handed or ambidextrous), marital status (single, married, divorced, widowed, unmarried partner), if they have children under the age of 16 (yes/no, and if yes, how many), educational level (elementary school, high school, technical-professional education, university education (bachelor), postgraduate (master or doctoral degree), type of profession, years and months working the current work position, working hours per week (average) were compiled into a single questionnaire.

**Additional Questions:** Currently, there are no specific risk assessment questionnaires for WMDs and the risk of developing WMDs, which may potentially progress into chronic symptoms [8]. Thus, Table I describes all investigated potential risk factors, how they were measured, and how they were coded in the analyses. The possible factors were measured using previously published [8], [49], [5], [50], and validated questionnaires. Additionally, relevant questions detected in our review by our team of experts were included. These questions are integrated at this stage of the project but will eventually replaced or removed later based on our validations.

TABLE I: Additional Questions.

| Domain | Question/Statement | Answer |
|---|---|---|
| Environment | 1. The windows, skylights and glassed walls have adequate sun exposure.<br>2. The lighting conditions in the workplace are appropriate to execute the tasks that need to be performed.<br>3. Natural lighting conditions are predominantly used at the workplace.<br>4. The natural or artificial air renewal at the workplace does not expose workers to harmful air pollutants and ensures the rapid elimination of these.<br>5. The air temperature and humidity at the workplace are suitable for the health of the workers.<br>6. Is the ambient noise adequate at the workplace?<br>7. How do you feel about the overall design of the workplace? | Yes/No |
| Workplace organisation | 1. Is the workplace (in general) clean and well organized?<br>2. Is your personal workspace clean and well organized?<br>3. Is the height of cabinets and their shelves appropriate for your body stature?<br>4. Are the dimensions and the shape of your desk appropriate for the tasks you need to perform?<br>5. Your workspace is at an adequate distance to your co-workers.<br>6. Do you have a designated work space where you work?<br>7. Your workspace is positioned in accordance with your duties (e.g., you work close to the people that are in your team). | Yes/No |
| Workplace Privacy | 1. Do you consider that the design of the workplace allows you to have enough privacy while working?<br>2. Is it possible to have confidential conversations at your workplace?<br>3. Is it possible to work for prolonged periods of time without being interrupted? | Yes/No |
| Psychosocial Factors | 1. I can plan my breaks at work.<br>2. I can divide my working time.<br>3. I can decide when to take a break.<br>4. After breaks I change my work tasks.<br>5. During breaks, I do not use a computer.<br>6. After two hours of work I take a break for 10 minutes.<br>7. I think that my breaks are sufficient. | Always/ Frequently/ Sometimes/ Never |

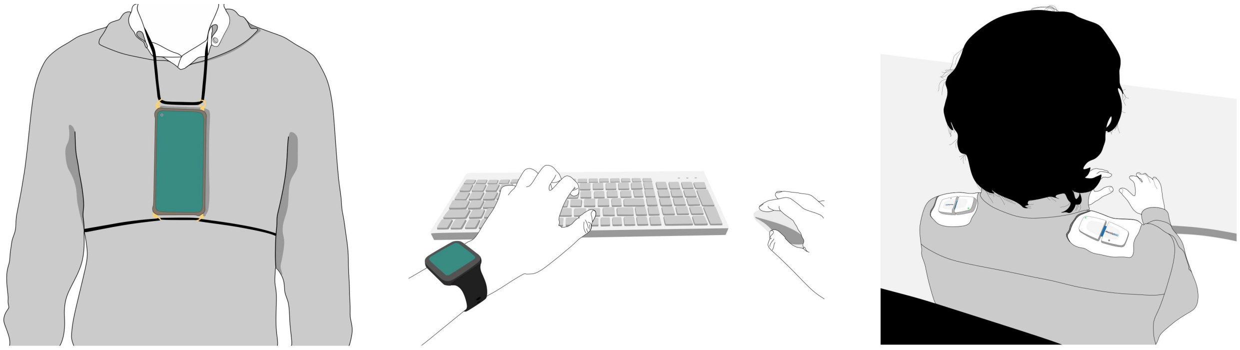
*C. Equipment Setup and Placement*

The equipment to collect biosignals from the subjects include a smartphone, a smartwatch, and two EMG sensors. The smartphone and a smartwatch were chosen as these are widely available devices that contain a variety of sensors. The EMG sensors were chosen as previous studies have shown its efficacy in the assessment of pain [12] and stress [51], [52].

**Smartphone:** ACC, MAG, GYR, RV, and ambient noise were acquired using a Xiamoi Redmi Note 9. The Redmi Note 9 runs the Android operating system. The Android OS restricts the ACC, GYR, and RV to 100 Hz, while the MAG is sampled with 50 Hz. Ambient noise was acquired in decibel using a 1 Hz sampling rate. The smartphone was placed on the subjects chest using a harness, as shown in Fig. 2a.

**Smartwatch:** Smartwatch acquisition was done using an OPPO 41 mm watch that was, as illustrated in Fig. 2b, placed on the subject’s non-dominant hand. The sensors used in the acquisition were ACC, GYR, MAG, RV, and HR. The sampling rates for ACC, GYR, and RV were 100 Hz, for MAG 50 Hz, and HR is restricted by the android system to 1 Hz. For the HR sensor a separate acquisition scheme was implemented as this sensor depletes the smartwatches battery quickly if it is used continuously. Therefore, the HR sensor was programmed to acquire data every three minutes for one minute.

**EMG Sensor:** EMG signals were acquired from the left and right trapezius using two muscleBANs (PLUX Wireless Biosignals). The muscleBAN is a wearable sensor unit that in addition to the EMG also contains a tri-axial ACC and a MAG sensor. The placement of the two muscleBANs, shown



(a) Smartphone (b) Smartwatch (c) MuscleBANs

Fig. 2: Equipment placement.

in Fig. 2c, was done according to the SENIAM guidelines [53]. Prior to placing the two muscleBANs, the hair at the placement location was removed, if necessary, and the subject's skin was cleaned with alcohol. The sampling rate of the muscleBANs was set to 1000 Hz for all sensors.

Given the limitations of the smartwatch's and muscleBAN's battery capacity, these devices were scheduled to acquire four times a day for a time span of 20 minutes. The smartphone, on the other hand, acquired data throughout the entire workday. An overview of the device types, used sensors per device, and the data acquisition procedure is presented in Table II.

### *D. Participants and Setting*

Participants were included when they satisfied the following criteria: Adults 18 years of age and older, without any associated pathology (e.g., neurological, orthopaedic, rheumatic, oncological or cardiorespiratory), and that do not take psychotropic drugs or any other recurring medication.

The present protocol is being carried out as part of an ongoing study in the Lisbon Metropolitan Area, Portugal, on the premises of Autoridade Tributária (AT), which is part of the Portuguese public administration. Workers were recruited randomly through a campaign carried out by the HR team of AT. As an incentive for participation, workers received a detailed analysis of their collected data consisting of a risk analysis utilising appropriate visualisations and recommendations with risk mitigation strategies. The study was approved by the Universidade Nova de Lisboa Ethics Committee (No. CE/FCT/005/2022). This project was conducted under the Declaration of Helsinki and complied with the General Data Protection Regulation. Personal data like contact information was stored separately on an external hard drive and was only accessible by the principal investigator. All other data (sensors and questionnaires) were pseudonymised. Participants have the right to desist from the study at any time and if requested their data is deleted.

TABLE II: Acquisition procedures.

| Device Type | Sensors | Acquisition Procedure |
|---|---|---|
| Smartphone | ACC, GYR, MAG, RV, ambient noise | Whole workday |
| Smartwatch | ACC, GYR, MAG, RV, HR* | 4 times per day for 20 min (*every 3 min for 1 min within the 20 min) |
| muscleBAN | EMG, ACC, MAG | 4 times per day for 20 min |

### *E. Acquisition Protocol*

All data collection was done using the cross-platform application described in [54]. The application generates a user access for each participants. The application allows for filling out questionnaires either on a computer or a smartphone. Furthermore, the smartphone component of the application is able to acquire sensor data from all three device types (smartphone, smartwatch, and muscleBANs). Acquisitions can be scheduled in advance through the application interface. When scheduling acquisitions, it is possible to choose the devices from which data should be acquired, the start time, and the duration of the acquisition.

In a preliminary session that took place prior to the week in which sensor acquisitions were executed, the subjects were informed about the project, its aims, and the acquisitions. After this, subjects gave informed consent and a profile was generated for each subject. Subjects were asked to subsequently fill out all questionnaires, except for the daily pain questionnaires.

For sensor acquisitions, a separate room was prepared at each AT location to which subjects could come in for the placement of the equipment. Participants were asked to come in before starting their workday. First, the participants were asked to fill out the daily pain questionnaire. Then the four 20 min acquisition times at which the smartwatch and muscleBANs would be recording were scheduled in the PrevOccupAI application. Subjects were advised to choose acquisition times at which there is a high chance that they would be working seated at their desks. If possible, two acquisitions were scheduled in the morning and two in the afternoon. For the smartphone, the acquisition was set to start as soon as the workday would begin and was scheduled to stop at the end of the workday. After scheduling the acquisitions, the equipment was placed. Participants then proceeded to go to their offices and executed their usual work tasks until the end of the workday. When the participants came back, the equipment was removed and disinfected. Finally, subjects were asked to fill out the daily pain questionnaire a second time. The workflow of the acquisition procedure is illustrated in Fig. 3.

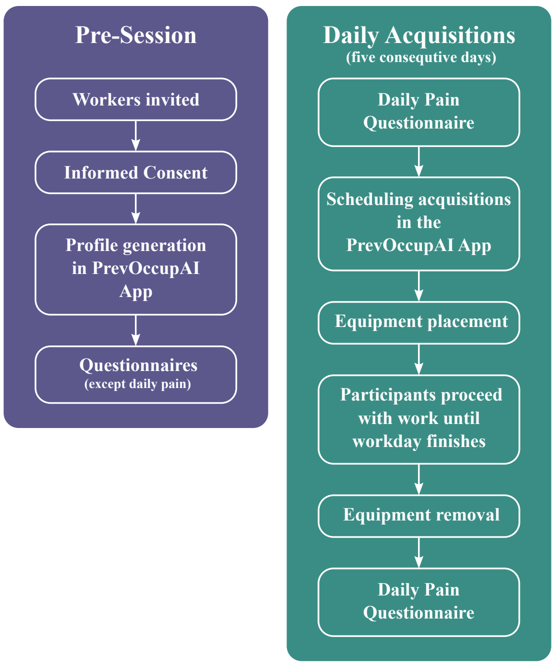



Fig. 3: Acquisition protocol procedure.

## III. Preliminary Results

The protocol is currently being used in an ongoing study. For now, data acquisition was undertaken at four AT offices within the Lisbon Metropolitan Area. At each location data was acquired from 10 different subjects for five consecutive days. Thus, a total of 40 participants took part in the study up to now. A fifth acquisition is planned for the near future. Once the acquisitions have been concluded, it is planned to publish the entire database in an open science format.

The preliminary findings of the demographics questionnaire are shown in Table III. The results with normal distribution are present by the mean and standard deviation (SD), and with non-normal distribution, median and interquartile range (IQR).

## IV. Expected Results

We expect that the acquired data will contribute with crucial evidence to identifying the relevant risk factors that contribute to occupational diseases. Furthermore, the data acquisition protocol will provide information on workers' responses to the office environment for an entire week, but can also, if necessary, be adjusted to accommodate any arbitrary time periods. Prevention strategies based on the collected data will be promoted for both the workers and AT. The quantification of risk factors for WMDs will help to provide a point of reference for measuring disorders shifting patterns, delivering policy development data, and guaranteeing that intervention activities at population levels are appraised suitably for effectiveness. Evaluating risk factors will allow for the dissemination of improved, human-centred and safer occupational environments.

TABLE III: Preliminary population statistics.

| | Age (years) | BMI (kg/m2) | Working hours per week | Years in profession |
|---|---|---|---|---|
| Mean | 58.18 | 25.34 | 35.00* | 19.64 |
| SD | 5.47 | 4.40 | 5* | 12.32 |
| Min | 21 | 17.47 | 30 | 1 |
| Max | 63 | 38.62 | 60 | 43 |

*median and IQR.

The resulting dataset will be used together with data analysis and machine learning models to further develop our platform/app, assess, characterise, and estimate occupational risk factors, and reduce medical leave and costs, thus preventing potential WMDs. Consequently, it contributes to supporting decision-making in the public health perspective. A better understanding of health outcomes related to work, from an individual level perspective, will be crucial to enhancing the approaches in occupational health. This research would provide information to help integrate the risk factor reduction concept for managing WMDs.

The present protocol will allow us to use subjective information to characterise the sample in terms of prevalence. We expect a high occurrence of neck, low back, and shoulder pain in the workers, in line with previous research [55], [56], [19]. Moreover, it will then permit analysis of potential differences, correlations, and relationships, as well as identifying clusters between the multimodal variables and groups of AT via ML methods.

Workplace physical risk factors concerning computer workstations have been investigated using inertial sensors, including prolonged sedentary hours, and worker posture. Measuring postural behaviour captured by wearable motion sensors may identify a higher risk of an office worker [57]. We hypothesised that the workers with fewer physical activity levels, breaks, posture invariability and reporting more quantity of psychosocial-related complaints and pain should be more prone to WMDs. Analysing the collected data will allow us to investigate the validity of our hypothesis.

Previous studies that used biosignals for stress detection on office workers reported a significant correlation between negative stress ratings and EMG activity during work. For example, high muscle tension is a sign of stress [10], [12]. Furthermore, the EMG of trapezius muscle activity is higher when performing computer tasks that demand a high or low mental workload. Neck and shoulder pain induced as the physiological stress response is associated with increased EMG activity in the trapezius muscle and HR [58], [11], [12]. In addition, HR is the most prominent feature that significantly increases during stress [11], [12] and mental load [59]. Hence, we expected that multimodal objective information will allow for characterising the essential physiological information previously tested by other researchers and that the fusion of biosignals improves our occupational risk assessment model.

With regards to organisational risk assessment, we expect to use the collected data to find patterns on broader levels (i.e., comparison between different offices). Analysis on an organisational level will ensure that identifying individual participants is impossible (e.g. reporting of group-wise pain statistics, mean noise-levels, mean stress levels, among others). The resulting information will allow us to identify which occupational risks are prevalent throughout the different locations or within the entire organisation and based on that develop appropriate mitigation and prevention strategies.

Our study has some potential limitations that are important to be acknowledged. We are undertaking a cross-sectional study in which the study sample will be recruited from a public company setting and may not represent the characteristics of the general office worker population. Consequently, our observations can only be generalised to office workers attending public administration facilities in Portugal.

## V. Conclusion

The quantification of individual and organisational occupational risk factors for WMDs will help provide a point of reference from the patterns of detected symptoms, deliver data for policy development, and guarantee that intervention activities at population levels are appraised suitably for effectiveness. We also provide a protocol and setup to promote the design of intelligent offices with existing technology, which can be used to monitor occupational variables at the individual and organisational levels. Thus, planning to prevent WMDs in office work requires considering multiple potentially modifiable influences, including factors relevant to the workplace and the individual worker. This research would provide information that would help integrate the concept of risk factor reduction for early screening and prevention.

Finally, it will provide a valuable base for hypothesis generation, longitudinal studies, and randomised controlled trials. It is anticipated that this protocol can be amended and trialled in other national and international occupational care contexts. These findings will be of significant interest to occupational research and organisations looking to develop more integrated and holistic models. It will help prevent WMDs, increase instructional efficiency, and create an environment for successful outcomes. Key stakeholders and end-users should also be involved through the design, development, and evaluation phases to ensure the risk assessment content and organisational strategies are developed to achieve workers' needs.

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