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An exercise circuit to stop a sedentary lifestyle in workplace environment

Christopher Sanchez 1, Gustavo López 2, Gabriela Marin 3

1 Universidad de Costa Rica; [christopher.sanchezcoto@ucr.ac.cr](mailto:christopher.sanchezcoto@ucr.ac.cr)

2 Universidad de Costa Rica; [gustavo.lopez\_h@ucr.ac.cr](mailto:gustavo.lopez_h@ucr.ac.cr)

2 Universidad de Costa Rica; [Gabriela.marin@ucr.ac.cr](mailto:Gabriela.marin@ucr.ac.cr)

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**Abstract:** Even with the amount of information and the available evidence of the adverse effects of not exercising enough, we continue having sedentary habits that, in most cases, are the tip of the iceberg for a broad number of diseases. In this paper we are going to propose a circuit of exercises to apply in the place where people spend most of the day, the workplace. We incorporate a series of exercises that involve most of the body, from the legs to the arms with different types of movements. The objective is help reduce the stress and put our bodies in a state of activity.

**Keywords:** exercise, circuit, sedentary lifestyle, bad habits

1. Introduction

Being sedentary is defined as spending excessive time sitting or in a reclined posture while participating in activities with an energy expenditure less or equal to 1.5 metabolic equivalents during wake time [1]. Having an active lifestyle has proven to be one of the most effective ways to reduce the possibility of chronic diseases. The workplace is, in many occasions, were people spend most of their daily time. That is why it is important to develop a common culture to have an active lifestyle even in our daily activities in the office. 8 to 9 hours is the average work time by day for an adult, and according to recent studies [1] just a few people achieve even the minimum time of physical activity and most spend excessive time sitting.

Obesity is becoming one of the major disabilities in the whole world and as mentioned before, the time people spend at the office might be a good starting point in order to decrease the sedentary lifestyle. Despite the large number of studies and recommendations, people are still having bad habits in their homes and workplaces regarding the physical activity they have to perform each day. They do not meet the requirements for a whole week of minimal physical activity. Having sedentary behavior, even affect people that accomplish the recommended time of physical activity per week, that according to [2, 3] is 150 min of exercise.

Workplace is an ideal place to implement exercises as it involves all kinds of people, some with sedentary behavior and some that exercise regularly. We are going to propose a series of exercises to be done in the workplace environment, in order to reduce the sitting time and be able to introduce physical activity that otherwise would not be even considered by some of the people. The chosen exercises cover most of the main areas of the body we need to move/exercise in order to reduce the sitting time. They involve stretching key points that will result in a better posture and will make our body to be in an active state.

Nowadays, even our watches remind us to stand up and move after several time of inactivity. We tried to propose simple exercises that do not take a long time to be executed. They are focus in braking the sitting time and making the people perform small amounts of physical activity.

As indicated in [4], there is still some people which does not take sedentary lifestyle as a serious problem in our society. We are trying to raise awareness and create a series of exercises that all of us can implement in our workplaces, that does not takes us a lot of time and will not interfere in our work activities, but will make us active for periods of time during the day.

According to studies, sitting for long periods of time without even standing have a negative impact in blood glucose [8, 9], this can be avoided with a bit of physical activity, or how they indicate it, with light-intensity physical activity (LPA), there is no need to have a complete exercise routine for every day, but have in mind that even a small time standing can help reduce the possibility of having deceases.

Studies like [5] reveal that workplace is an important environment for physical activities promotion and initiatives, and a key place for addressing these issues. Although there are a lot of factors that are responsible for obesity and physical deceases, we try to incorporate physical activity in a place where because of several factors like time, workload and/or space, people are going to be able to perform a little amount of activity that will help to achieve the minimum recommended time of physical activity without causing any disruption of the workplace.

It is worrying that people spend more than half of their waking time in sedentary activities as indicated in [7], some of the workplace environments do not encourage people to have physical activity during the day.

2. Related Work

Several authors describe the importance of having good habits. They insist in incorporating physical activity in a minimum of 150 minutes a week, creating a culture and understanding the bad results and dangers of having a sedentary lifestyle. Most of the studies focus in gathering data regarding how much time people spend inactive vs. how much exercise people do in their daily basis. Proposing a single exercise guide is the most look alike type of related work.

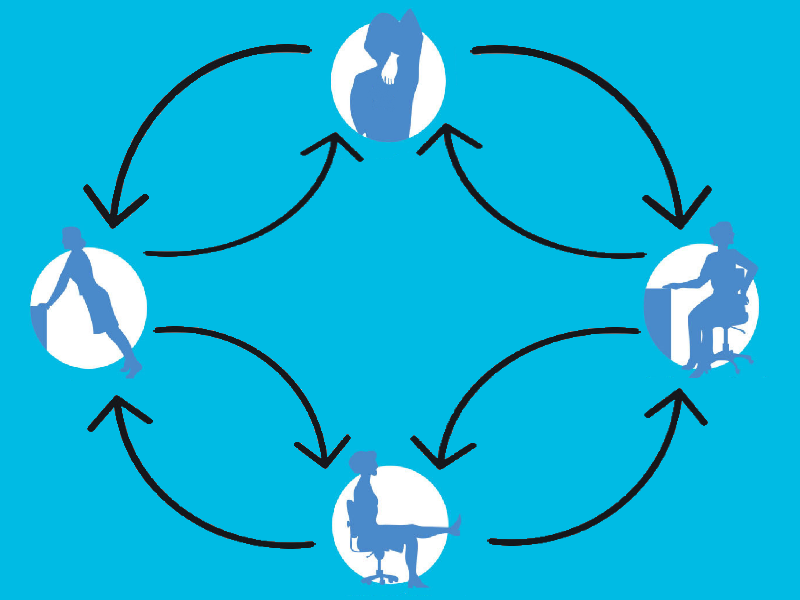
Gardner et al [4] providing a guidance noticed much of the people were not sure about the knowledge or where the information was taken from. Confusion and misapprehension are some of the words used to describe the knowledge of people regarding this problematic.

Our approach includes a series of individual exercises to be implement in workplace environments, and a way, not to measure, but to know if people are performing the exercises correctly. One by one, the exercises will need to be followed. When finish with one, you go for the next and so on until completion. With nowadays technology, we have all the means to remind us the exact time we need to move, or to stand up after a long period we had sitting, we want to define a circuit that people need to perform.

There is evidence of a recent consensus statement that provide some guidelines regarding the sedentary behavior, especially for desk-based employees in the United Kingdom [6].

3. Exercise Circuit Platform

Our circuit consists of a set of 4 exercises that need to be performed one by one. For each one, we will have a sensor or a set of sensors, depending of the exercise, to detect the movements required for successful completion of each. In Figure 1 we have the conceptual model of exercises set, not in any particular order as they can be performed as the user wants to.



**Figure 1.** Exercise circuit conceptual model

3.1 Exercise Interface

The interface that we use consists of an application that indicates the exercise that must be performed in each station. The application shows an image with the exercise to be performed in every station and provides a log with the information and set of events the sensor is receiving. It also provides the user with exercise messages. We will take a deeper look at the application shortly.

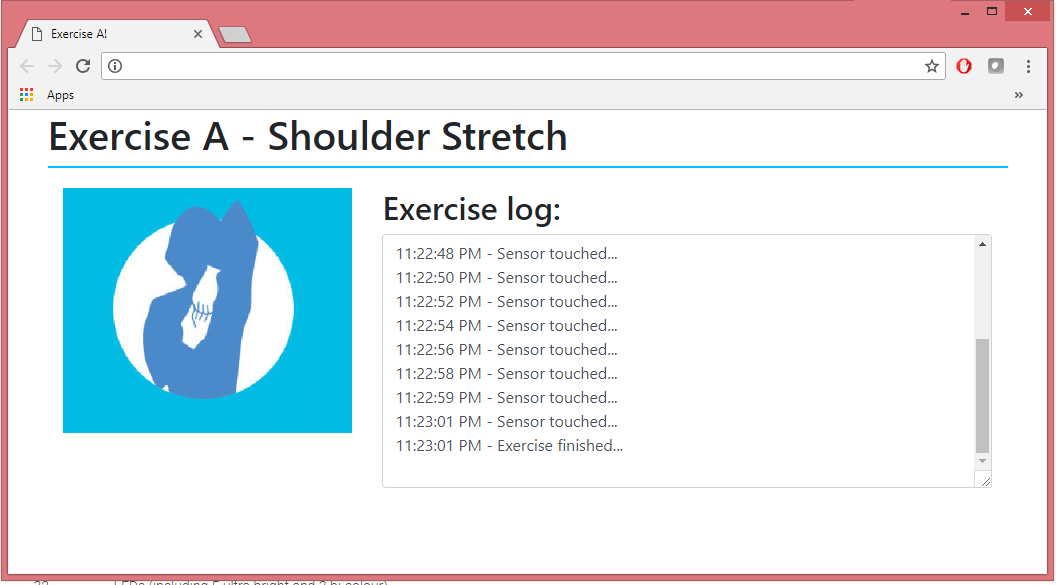
3.2 Set of Exercises

The set of exercises we chose can be performed by most of the people and should never make the user feel any kind of pain and/or discomfort. However, at anytime that the user experiences some severe pain or out of the ordinary, the exercises should be stopped at that moment. The exercises can be identified by a touch sensor that is positioned in the exact location of every station or exercise. Several touch sensors were are used for the exercises. Some of them in the desk, other in the chair in different positions. This way the user must be in the correct position and executing the tasks in a correct way.

The idea of incorporating sensors on items we have at the office like chairs and desks, is to integrate the sensors without being intrusive in the environment. Therefore everybody can continue their daily activities and just go to the station when needed. In this way we do not have the need to install or bring to the office any device. Everything you need is there and the exercises are very simple for everybody to perform without any excuses. The exercises are the following:

1. Shoulder Stretch
2. Leg Extension
3. Spinal Stretch
4. Knee Flex Push Up

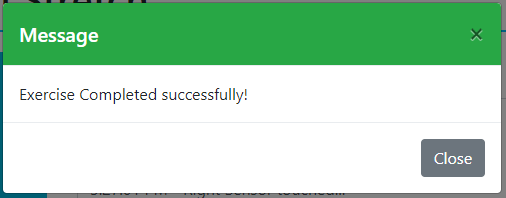
4. Interface Implementation



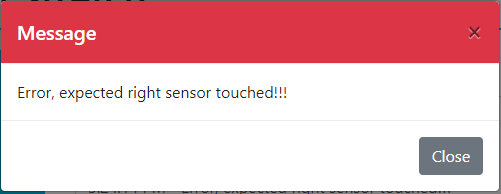
**Figure 2.** Exercise circuit conceptual model

Our implementation is based on the Phidgets Touch/Human input sensors. The application was created using simple HTML and the Phidgets libraries controlled through JavaScript. The very first screen of the interface is just a list for selecting the exercise to perform in that particular station. This allows to execute all of the exercises in any of the stations. The only requirement is to have the required sensor or sensors needed to that exercise. Figure 2 shows the basic interface for exercise A in particular, the interface is the same for all the exercises we are proposing here. On the left side of the application is the image for the current exercise, on the right hand there is the log field that will contain all the information of the events received from the sensor. On Fig. 2 we can see how the log field works, showing that the sensor was touched several times in a row and finally a message indicating the exercise is finished.

In this case, the interface is working for Exercise A that requires only a single sensor. If the exercise requires more than one sensor, the application will show which sensor was pushed at any given time. If the user touches the wrong sensor, the log will show an error message and a pop-up window will indicate the user about the wrong event received from the sensor.



**Figure 3.** Successful message



**Figure 4.** Error message

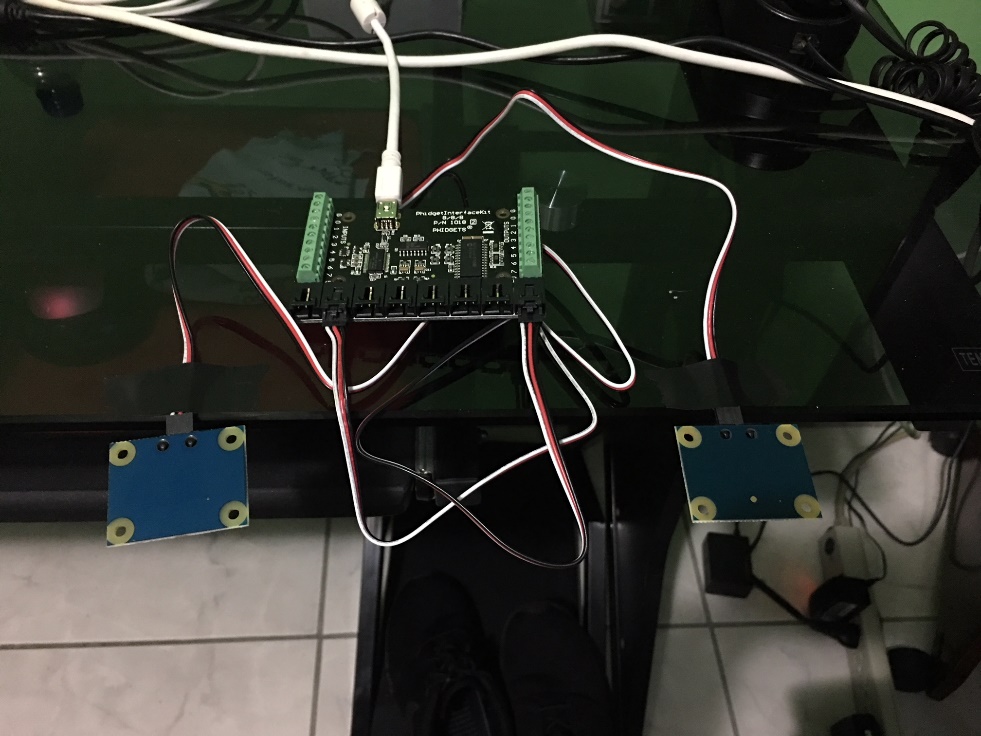
Figure 3 and 4 show the messages presented to the user depending if the exercise is completed or an error occurred, respectively. Phidgets provide libraries for different technologies like Java, C, C#; JavaScript was selected in order to be able to create a web application that can be seen from a more broad number of devices like computers, cell phones, tablets and any device with a web browser.

The sensors chosen for the physical implementation are the Interface Kit and the Touch Sensor we can see in Figure 4, however the user will only interact with the touch sensor. The interface is only for providing the necessary logic for the sensor to be able to recognize inputs and send them as messages to the libraries we are using. The Phidgets provide a wide number of sensors to be used in various applications among which we have touch sensors, such as in this case, slide sensors, rotation sensors, gyroscope sensors, among others, but for our purpose only touch sensors were used.



**Figure 4.** Phidget Touch Sensor

The only requirement for the application to run is to have the Phidgets Control Panel running on the computer, and there we have 2 options, the first one to use the current computer as the main device for the Phidgets, the second one, and the one we chose, to be able to create a Network server to work with JavaScript, the Network servers need a host and a client, the host is the computer where the Phidgets will be physically connected, the client is the computer from where we are going to open the application, for the purpose of this paper, the host and the client will be the same, so the sensor will be connected to the same computer from where it is going to be tested.



**Figure 5.** Sensors connected to interface kit

In Figure 5 we can see how the sensors connect to the interface kit. The interface kit provides 8 channels to connect the required sensors. Connecting more than one sensor requires a bit of configuration in the code in order to identify one sensor from another. For Exercises B, C and D, this configuration was required as we need 2 sensors, for exercise A is not required but the configuration was also implemented so we can perform exercise A without having to move or disconnect one of the sensors. The way the application is implemented allows to perform all the exercises in a single station without the need to modify or make connections between the sensors, just select the desired exercise from the initial screen.

5. Exercise Implementation

5.1 Exercise A

This exercise is focused for the upper part of the body. The shoulders and the arms are where more stress can be cumulated; resulting in disconformity and illness as well as some posture issues that will be very painful and difficult to correct if it is not taken in consideration when needed.

Once in the exercise station, the user has to raise his arm and put it behind his back and touch the sensor located in the back of the chair with each arm, one by one. With this set of movements he will be stretching his shoulders and his arms. The idea is to stretch the muscles as much as possible, and be able to reach the sensor that is located in a specific position. A single touch of the sensor is required for each user input to complete successfully one set for each arm.

The physical implementation is a touch sensor in the back of the desk chair which senses the user input, gets captured by the software and then shows a message in the screen. The user needs to perform this several times to complete the station and move to the next one, 5 times per arm. Only one sensor is used in this exercise because only one arm at a time will be needed and both arms need to reach the exact same position.

The idea of using the chair as the main device in an exercise station, is to use everything we have in the workplace environment and it is a natural position that will create no confusion at the time of the exercise execution. The chair is an item than can have a much more broad approach to the people wellness, as some studios already indicate, the correct posture can be the reason for many of the back pains.

It is very important to adopt a correct sitting posture at the time of performing the exercise. A good posture will enable a very comfortable position and a very easy exercise as the arms reach will be the necessary to complete the steps. If the posture is not the correct, the user might be facing issues reaching the desired point where the sensor will be located. If the user has long arms, there will be no issues reaching the sensor, by contrast, the sensor will be located in a position that is easily reachable for people with small arms.

The chair is sometimes the place where we spend most of the time in our daily activities, so it is a good idea to implement this exercise in the chair with a natural position for most of the workplace environments.



**Figure 6.** Shoulder stretch exercise

Figure 6 shows the basic idea for the arm movements, where the user needs to reach his arm to a certain position in his back in order to complete successfully the exercise. In this case that position is the sensor placed in the back of the chair.

5.2 Exercise B

This exercise is focused on the legs. Being in a sitting position for a long period of time affects the legs in ways we might not image. We need to have activity for the blood to reach every part of the body, and sitting brings pressure to the legs making it difficult for the blood to transit there. Executing a single exercise can activate the blood flow in our legs and to a long-term giving us a much more strong and healthy body. Excessive sitting with no physical activity is a real problem and can bring much more issues than people are aware of.

Sitting in the chair, the user has to raise his legs one by one until reaching below his desk where is able to touch a sensor. The legs should start in the normal and correct sitting position, and raise one leg to a horizontal position, then the other one. When each leg gets to the horizontal position, user should able to reach with his feet the located sensor for this task. In this exercise we introduce the desk as an exercise item as it is a key asset for every workplace in almost any kind of office and/or workplace. This exercise needs several touches of the sensors to be completed successfully. Same as the previous exercise, it is very important to be sitting in the correct position to raise the legs without putting pressure to the back.

The sensor must not be pressed more than one second, just a single touch and the user should be ready for the other leg. Another variant of this exercise can be keeping the legs in horizontal position for a period of time, but in this case, it is enough to be able to reach the desired position. This exercise has to be performed taking the necessary time to raise the leg without hurry. Performing this or any exercise with a hurry can result in not doing the exercise correctly.

The software implementation for this exercise is similar to the last one, but this time we have 2 sensors, in this case one sensor for each leg as they are not supposed to reach the exact same position. There is one correct position for each leg. The software waits for the user to make the inputs, once the first touch sensor sends the event, the application waits for the other sensor to be pressed. If the same sensor is pressed twice, the application will show an error message indicating that the same sensor was pressed more than once time and will indicate that the exercise needs to be restarted.

For the completion of this exercise station, the user needs to touch the sensors 8 times with each leg, alternating between the legs for every touch. Depending on the user physical state, the amount of repetitions can increased or decreased but we are proposing the exercises so anybody can perform them, regardless of their physical condition.

Physical implementation involves the chair and the desk to place the sensors. We are using the chair once again and now introducing sensors to be placed below the desk. The sensors should be placed at the exact position where the legs in horizontal position reach, this way it is very simple for the user to perform this correctly without any pressure or discomfort.



**Figure 7.** Leg extension exercise

5.3 Exercise C

In this exercise we are going to perform the spinal stretch exercise. Again this is going to be executed sitting in the chair. We already mentioned the benefits and how important it is to adopt a correct posture when we are sitting, especially in our workplace as we can spend there most of our day. Long periods in the same position can result is serious problems if our way of sitting is not the correct one. Our spine suffers directly the impact of a bad sitting position.

In this case, we focus in the spine, as it is a very important part of our body because it is the support point for our posture and our entire body when sitting, standing, at any time. The spine keeps the muscles and bones aligned correctly and preventing the risk of suffering muscular and/or bone pains. If the spine is not in the correct position, it can be affected and we will start experiencing symptoms as fatigue, muscular pain that will not only affect our back, but other parts of our body as well. Thus many of the nerve endings go through the back and are attached to muscles and our spine.

The exercise for this station will contribute directly to the spine, releasing pressure that might be generated there. With a simple movement, it is possible to relax and strengthen the muscles so that they can remain in an optimal state; for all the activities not only in our workplace, but in all the daily activities.

We begin this exercise sitting in the chair, again sitting with the correct posture looking straight forward without making any movement or turning our back. Next, the user needs to turn the upper part of his body, trying to not move from the chair, first turning to the right and reaching with the hand the sensor that will placed in this station. Next return to the initial position looking straight forward by turning the upper part of the body, again without trying to move the legs and keep sitting correctly. Now turn your body to the left the same way until reaching the sensor that will be placed on the left side, and finally returning to the initial position once again.

This set of movements must be performed 8 times in each direction in order to complete this exercise correctly. For this station, 2 sensors are used, one for each side located at the edge of the desk, left and right from where we are performing the exercise. We put the sensors in the desk for it is a natural height for the user to reach with the hands. The user only needs to reach the sensor and touch it. If the application detects the same sensor has been touched twice in a row, the user will see a message that the exercise is being performed incorrectly. The idea is to stretch the muscles connecting to the spine moving from one side to the other.



**Figure 8.** Spinal Stretch

In Fig. 8 we can see the basic idea for this exercise, turning the upper part of the body while sitting on the chair, the legs in the correct sitting position and the sensor should be touched with the hand when reaching to it. This exercise can be performed standing, but in this case, the desk results perfect to put the sensors in a perfect position for the user to reach them without an extra effort, more than execute the exercise.

5.4 Exercise D

For this last exercise station, we selected an exercise that not only includes the upper part or lower part of the body but both of them will be needed. However, this does not mean the exercise is very complicated o way too difficult for the user to execute. The reason for this to include the whole body, is because the upper part is going to work as support for the body meanwhile the lower part, in this case the legs, and especially the knee, are going to perform the movements.

All the exercises we proposed until now, are performed sitting in the chair. In this one we are going to make the user stand up in order to be able to execute the movements correctly. Standing up in the office is one of the most used practices these days to stretch and release some stress. Even in many occasions it is recommended to take a small walk between sittings for a long period. Stand up is very important, so much that now, some office desks allow the user to work in a standing position.

In order to perform this exercise, the user must be standing and have to walk away one step from the desk, put the hands in the desk border without moving from the initial position. A knee flexion movement must be performed to be able to reach the sensors that will be place in the lower border of the desk. These sensors are responsible of detecting the user movements by sending the signal when the user touches them with the knees in order to complete successfully the exercise.

In this case, we are also using two touch sensors, one for each knee. The movement must be performed moving the knees straight forward, this way the knees are not going to reach the same point.

To complete this exercise station, the user have to raise his knees 8 times each and reach the corresponding sensor. If the application detects a sensor to be touched twice in a row the user will be notified of the failure and has to start again. Fig 9 can give us an idea of the correct position that must be adopted; not too far from the desk but enough in order to be slightly reclined to put the hands in the desk. Only by adopting this position, the user will notice the whole body will be part of the exercise, and not only the knees that perform the movements.



**Figure 9.** Knee flex push ups

6. Evaluation

The Exercise circuit was evaluated in an office at the Computer School of the University of Costa Rica. The users received a brief explanation and why it is important to introduce physical activity to our lives and the exercises in the workplace environment. Some of the users mentioned they are aware of how important physical activity is for reducing the possibility of developing deceases due to having a sedentary lifestyle.

One of the users mentioned in her workplace, which is Intel, there is an application that encourages the user to exercise after several time sitting or depending on their schedule they have to meet a minimum of exercise time by week, and the results are shown at the end of the month or the week. The key difference between that and our work, is that we have a way to know for sure if the exercise is being performed, by using the sensors. Resulting from this case study, we noticed it is necessary to have an application that indicates the user when it is time to perform the physical activity.

For the evaluation the user was presented with the 4 exercises we proposed, in no specific order as the circuit was intended from the beginning, the user picked which exercises he wanted to test first and so on. The first one executed is the Shoulder Stretch. In this case we proposed the sensor to be put in the back of the chair so the user will not have to wear any special device to place the sensor. The position of the sensor might need to be modified depending of the arm’s reach, at the beginning the user was not able to reach the sensor in a comfort position so we adjust it. Also not all the chairs are fitted to place the sensor in the correct position. Some chairs have the back in a lower position or are very small for our purpose. The rest of this exercise resulted very straight forward and the user was able to complete the activities without any issues. In Figure 10 we can see how we placed the sensor in the chair and the user reaching for it.



**Figure 10.** Shoulder Stretch Exercise

The second exercise chosen was the Leg extension. We placed the sensors below the office desk where the user was able to reach them when the leg was in a horizontal position. For this exercise, moving the chair a bit back was needed to reach perfectly the sensors. We faced here the first problem with the sensors. The input was not recognized using shoes. The sensors recognizes changes in the voltage when a touch is received. Shoes did not provide the necessary input to be readable by the application. Apart from that, the exercise was performed with no issues and the user was able to complete it. In the following image we can see the exercise being performed.

(a) (b)

**Figure 11.** Leg Extension Exercise. (a) shows the user with shoes. (b) shows the user after taking off the shoes to make the sensors identify touches. Socks worked fine with the sensors.

The third exercise was the Spinal Stretch. We found that the position for the sensors can be an issue as not all the desks have the necessary form to place them correctly. The sensors have to be placed at each side of the user that is sitting on the chair. For this paper purpose, we placed one sensor in a chair and the second was placed in the desk. In the following images we can see how the user has to move in order to perform the exercise.

(a) (b)

**Figure 12.** Leg Extension Exercise. (a) shows the user touching the left sensor. (b) shows the user touching the right sensor located in a chair.

At this point the user indicated we was starting to feel the activity he already performed, the body was already warm but without any sweat. The fourth and last exercise was the Knee Flex Push Ups. After indicating the position that needed to be adopted, the movement was pretty straight forward. At the beginning of this exercise we thought we might have the same issue of the sensors not recognizing inputs with shoes, in this case with the pants, but the sensors we able to detect the inputs without any issues through the pants. In the next image we can see the user performing the last exercise.



**Figure 13.** Knee Flex Push Up Exercise

From all of the exercises, we noticed that depending of the users speed, the sensor might not be able to recognize the input. In some scenarios, the user touch was recognized by a sensor but when touching the next one, the error message indicated the same sensor was touched twice in a row was shown to the user. This behavior was only present when the user performed the movements way too fast. For the purpose of the activity, the exercises need to be performed at a moderate speed in order to be well executed. From the beginning, the users indicated the application needed to show a more detailed description of the exercise, which arm or leg to start with? How many repetitions are needed to complete the exercise? Those were the most asked questions regarding the interface.

In conclusion, at the end of the exercises the users were asked their general comments, among which they highlight that it is a good way to ensure that activity is done at work, but in the same way many improvement options were indicated. For the purpose of this paper, with each exercise the position of the sensors was changed and in this way we only use at most 2 sensors at the same time. In order to integrate all the exercises without the need to move the sensors 7 sensors would be needed and in our case, an interface kit to connect them, which is perfectly possible since the kit interface allows to connect 8 sensors at the same time.

The users indicated they liked the idea to integrate sensors to detect the movements that must be performed. If there are no sensors, there is no way to make the user perform the movements, this is the scenario one of the users mentioned above, having an application that locks the computer to perform exercises, but without any means to detect if the user is really executing the exercises. More information is something that should definitely be present in the application interface so that the user knows which arm start with, or if he can start with any arm, at any position.

7. References

1. Sedentary Behaviour Research Network. Standardized use of the terms “sedentary” and “sedentary behaviours”. Appl Physiol Nutr Metab. 2012. doi: 10.1139/h2012-024..
2. Biswas A, Oh P, Faulkner GE, Bajaj RR, Silver MA, Mitchell MS, et al. Sedentary time and its association with risk for disease incidence, mortality, and hospitalization in adults: a systematic review and meta-analysis. Ann Intern Med. 2015. doi:10.7326/M14-1651.
3. van der Ploeg HP, Chey T, Korda RJ, Banks E, Bauman A. Sitting time and all-cause mortality risk in 222497 Australian adults. Arch Intern Med. 2012. doi:10.1001/archinternmed.2011.2174.
4. Gardner, B., Smith, L. & Mansfield, L. BMC Public Health (2017) 17: 47. <https://doi-org.ezproxy.sibdi.ucr.ac.cr/10.1186/s12889-016-3974-0>
5. Thor, A.A., Healy, G.N., Winkler, E. et al. Int J Behav Nutr Phys Act (2012) 9: 128. <https://doi-org.ezproxy.sibdi.ucr.ac.cr/10.1186/1479-5868-9-128>
6. Buckley JP, Hedge A, Yates T, Copeland RJ, Loosemore M, Hamer M, et al. The sedentary office: a growing case for change towards better health and productivity. Expert statement commissioned by Public Health England and the Active Working Community Interest Company. Br J Sports Med. 2015. doi:10.1136/bjsports-2015-094618
7. Matthews CE, Chen KY, Freedson PS, Buchowski MS, Beech BM, Pate RR, et al. Amount of time spent in sedentary behaviors in the United States, 2003–2004. Am J Epidemiol. 2008;167:875–81.
8. Buckley JP, Mellor DD, Morris M, Joseph F. Standing-based office work shows encouraging signs of attenuating post-prandial glycaemic excursion. Occup Environ Med. 2014 Feb;71(2):109–11.
9. Thorp AA, Healy GN, Owen N, Salmon J, Ball K, Shaw JE, et al. Deleterious associations of sitting time and television viewing time with cardiometabolic risk biomarkers: Australian diabetes, obesity and lifestyle (AusDiab) study 2004-2005. Diabetes Care. 2010 Feb;33(2):327–34.

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