# In-chair Movements of Healthy People during Prolonged Sitting

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Abstract: This paper describes a program designed to detect and give a classification of the in-chair movements done by healthy people while seated for long periods of time. The purpose of this work is to identify the frequency, duration and typology of movements performed by subjects that need to remain seated for a prolonged time. The software finds the time instants of each movement, its duration and whether it is in the sagittal or the lateral plane; in particular it distinguishes between a left and right movement (in the lateral plane) and a forward or backward trunk movement. This information can be useful in many different domains: first of all to monitor the fidgeting phenomenon and consequently the feeling of discomfort in the office environment; it can be adopted to evaluate the fatigue of car and truck drivers; but the most important outcome concerns the clinical setting, in which it can be very helpful for the medical staff in determining an appropriate and personalized rehabilitation strategy for patients with motor limitations in order to prevent the development of pressure ulcers.

## 1 INTRODUCTION

Pressure ulcers are defined as areas of localized necrosis and tissue damage of the skin, that result from prolonged excessive loading on a support surface (Mak, Zhang and Tam, 2010). Pressure sores are frequent in subjects with motor and sensory-motor limitations; among them, people with spinal cord injuries, who are thus wheelchair bound. Their treatment is based on pressure, shear and friction stress reduction, on attention to bacterial contamination and on nutritional deficit correction (Scena and Steindler, 2011). In fact, these individuals, especially those with limited trunk stability and limited motor function, sit in a wheelchair for long, consecutive periods of time, mostly in one posture. As a consequence, pressure ulcers can develop because of an unbalanced match between the external load and the ability of the skin and subcutaneous tissue to withstand that load (Reenalda et al., 2009).

Data on prevalence of pressure sores gathered in America and in Europe help comprehend the dimension of the phenomenon. Prevalence values in general are high and have been reported to be 15.5% in U.S. healthcare facilities, with 28.0% of the pressure ulcers located at the sacrum and 17.2% at the buttocks (Vangilder, Macfarlane and Meyer, 2008). In Canada, the total prevalence is estimated in about 26% (Woodbury and Houghton, 2004), while prevalence values of 18.1% have been reported in European standard and academic hospitals (Vanderwee et al., 2007). In particular, in The Netherlands and in Germany the prevalence has been estimated in 11,1% in hospitals and 11,8% in nursing homes (Tannen et al., 2004).

Current clinical practices for assessing the risk of pressure ulcers focus in monitoring the intensity and duration of interface pressure (Sakai et al., 2009), which is defined as the pressure on the skin occurring by contact with a surface such as a mattress or cushion (Braden and Bergstrom, 1987; Jones, 2005). However, despite the fact that much research has been performed on the aetiology and prevention of pressure ulcers, a threshold value for the development of deep pressure ulcers, in terms of magnitude or duration, is still lacking (Reenalda et al., 2009). Moreover, developed pressure time curves predict that pressure ulcers will develop even with optimal pressure distribution (Kosiak, 1959; Reswick and Rogers, 1976).

It is important to note that maintaining a prolonged seating position is not a natural condition for human beings, thus the body structure is seriously affected by the amount of time during which this position is sustained. However, it is

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demonstrated that healthy people are able to perform unconscious mechanisms that preserve the integrity of tissues (Hermann, 2005; Branton, 1969). The little postural adjustments done to acquire a new comfortable posture are identified as “fidgeting” (Fenety and Walker, 2002; Fenety, Putnan and Walker, 2000).

From a clinical point of view, the most significant method for pressure ulcers prevention is that of training patients to change their posture frequently (Merbitz et al., 1985); however, there are not many data on the correct periods for these manoeuvres, thus useful input can be obtained by studying the spontaneous kinematic behaviour of healthy subjects during long periods of sitting (Scena and Steindler, 2011). In fact, the constant adjustment of the seated position in general is realized through numerous movements of reduced entity on the seat, with the aim of redistributing the pressure stresses on the seat surface and of searching comfort. The periodic movements on the support are denominated *in-chair movements* (ICM) and they represent the factor that prevents the development of decubitus ulcers (Hermann, 2005). Without ICM, every subject forced to remain in a seated position for many hours would quickly develop pressure sores, in particular in the ischial tuberosities (Fenety, Putnan and Walker, 2000). However, it is not possible to indicate a specific exposure time interval that can be stated as the critical time for the development of such ulcers, because it varies according to various factors depending on the subject and on the situation.

For this reason it would be appropriate to execute a continuous monitoring of the interface pressure distribution on the seat surface, in order to immediately identify potential risk situations.

This procedure could be very useful not only in the clinical environment, but also to evaluate the fatigue (Nakane, Toyama and Kudo, 2011) and the discomfort of individuals, in an unobtrusive way, during office work and during prolonged periods of car or truck driving (Marenzi, Bertolotti and Cristiani, 2012).

The aim of this work is to develop a program that identifies the time instants, duration and type of in-chair movements executed by a seated subject. The software has been tested on a group of 10 people to evaluate the efficacy of the program. After the introduction to the problem of decubitus ulcers and their prevention through the evaluation of healthy sitting behavior, the parameters used for the movement identification are described, together with the monitoring device. The third section explains the detection algorithm, followed by the results obtained on healthy subjects seated on a foam chair and, at last, by conclusions and future developments.

# 2 IN-CHAIR MOVEMENT DETECTION

The characterization of the behaviour of seated people concerns the identification of the number, frequency, duration and type of movements executed; thus we designed an algorithm that calculates all these features, given the data regarding interface pressure distributions recorded during a prolonged time.

## 2.1 Centre of Pressure (CoP)

From the analysis of previous studies it can be observed that the centre of pressure (CoP) is one of the most used parameters for studying human posture (Bertolotti et al., 2012) and it is defined as the point of application of the resultant of the vertical forces that act upon the support surface (Hermann, 2005), in this case the seat. It can be measured in a non-invasive way and there isn’t a unique method of calculation, because it depends on the requirements of the specific application (Marenzi et al., 2012).

In biomechanics, clinical settings, motor and rehabilitation sciences, the CoP is often used to study the feet-ground interface of a standing person; in fact this parameter allows the recording of little postural sways related to motor control. Other studies use the CoP to analyse the seated position: every time a person moves (doing the so-called ICM) the CoP position changes too.

In this work we decided to use CoP as a parameter for the monitoring of postural changes during the seated position, in fact it is demonstrated that there is a linear relationship between the localization of CoP and the trunk lateral flexion and tilt angles (Fenety, Putnan and Walker, 2000). A change in CoP position can be considered the reflex of a movement, given the following conditions: the seat has to support the majority of the body load (backrest, armrest and ground should have the minimum contribution); the dynamic components (such as the accelerations during postural shifts) should be minimal, in order to consider the seated posture as a succession of static positions.

When a person moves some body segments, a pressure redistribution at the seat interface occurs, for this reason it is possible to register the CoP movements in a non-invasive way through the use of sensorized mattresses and this makes this parameter particularly useful in evaluating the sitting behaviour of healthy people. The coordinates are calculated as follows:

$$x_{CP}(t) = \frac{\sum_{i=1}^{n} P_i(t) x_i}{\sum_{i=1}^{n} P_i(t)} \quad (1)$$

$$y_{COP}(t) = \frac{\sum_{i=1}^{n} P_i(t) y_i}{\sum_{i=1}^{n} P_i(t)} \quad (2)$$

t is the time in which the sample is acquired; n is the total number of sensors of the mattress; $P_i(t)$ is the pressure on the $i^{th}$ sensor; $x_i$ and $y_i$ are the coordinates of the $i^{th}$ sensor

Together with the CoP, the CoP speed, that is the amount of activity required to maintain stability (Geurts et al., 1993), is very useful in detecting the ICM of a seated person; the following equations show how it is obtained (Bertolotti et al., 2012):

$$v_{x_{COP}}(t) = \frac{dx_{COP}(t)}{dt} \quad (3)$$

$$v_{y_{COP}}(t) = \frac{dy_{COP}(t)}{dt} \quad (4)$$

$$v_{COP}(t) = \sqrt{v_{x_{COP}}^2(t) + v_{y_{COP}}^2(t)} \quad (5)$$

## 2.2 Materials and Methods

The algorithm has been defined using a commercial sensorised mattress: the purpose of the work is in fact to develop a solution that is used after the recording done by the mattress, to evaluate the seated posture and to give suggestions on the anti-decubitus device and the repositioning strategy. The device is the Novel Pliance® Sensor Mat 392 (Novel Inc.), composed of 256 square capacitive sensors, distributed on a 16x16 matrix. To obtain the pressure data useful to develop the algorithm, 10 healthy subjects sat for one hour on an office chair, with no armrests and with a 5 cm thickness foam support and they could not lean on the backrest.

The Pliance Mat records pressure distributions at a sampling frequency of 50 Hz and produces two different text files: the first contains the time instant in which the sample is registered (the first column), together with the pressure of every sensor (one row contains a single and complete pressure map); the second one shows, for every sample, the CoP coordinates (in centimeters) and the total force exercised on the mattress. We analysed these files with Labview and designed a program that is able to identify the ICM after a test. This program could be used not only with the Novel Pliance Sensor Mat but, with minimal adjustments, with every commercial device that produces ASCII files of the pressure data. It can be used also with a prototype device that has been developed in the laboratory in order to obtain a more robust, but at the same time less expensive (compared to the other devices on the market), electronic instrument (Marenzi et al., 2012).

## 2.3 Movement Detection Algorithm

The first step in identifying the detection algorithm is to adjust the ASCII files produced by the Novel software into a format that is compatible with Labview. Together with this, it is useful to reduce the number of samples to analyse, since seated subjects, as observed in previous works, move at frequencies approaching 0.5 Hz (Fenety, Putnam and Walker, 1995). In this way, we created new files of the interface pressure distributions and of the CoP coordinates, using a new sampling frequency of 2 Hz, to respect the Shannon Theorem. This procedure better highlights the pressure variations on the same sensor and on adjacent capacitors. We also considered only the CoP coordinates and not the force column, since the latter is not useful for our purpose. Once the files are compliant with our system, we didn't analyse the first minute of registration (the first 120 samples) because this is the period in which a person first seats and reaches the most comfortable posture.

### 2.3.1 CoP Speed Calculation and ICM Identification

After the pre-elaboration previously described, we calculated the CoP speed, according to equations (3), (4) and (5), for every sample, in particular the coordinates are recorded in centimeters using the lowest point at the right of the matrix as the reference, as it can be observed in Figure 1. We used this parameter to set up a threshold that can perform a first and basic identification of the ICM and we chose to use 15 cm/s, because we observed that it is appropriate to discriminate between pressure changes due to the device reading and effective movements. Therefore, only if the speed is above this value, it is considered an ICM and further processing is done (Figure 2).

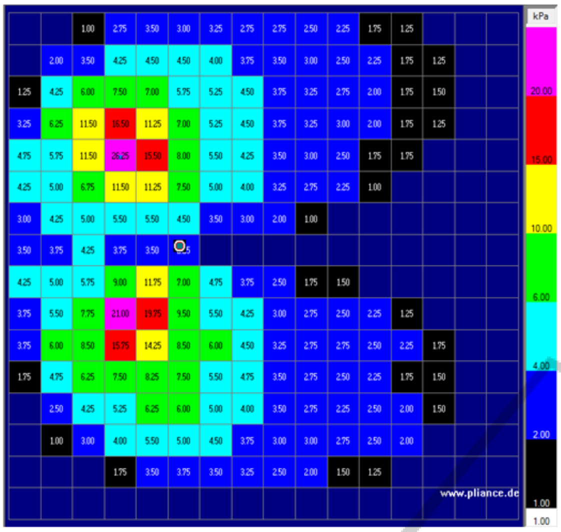


Figure 1: The image shows a pressure map, recorded with the Novel Pliance, of one of the subjects used for the tests: the sensors are numbered from 1 to 256, starting from the lowest right capacitor, going ahead on the rows. The column on the right is the pressure legend (only the lower pressure limit of every range is written, but the matrix can sense 60 kPa at maximum), while the grey circle positioned between the tuberosities represents the CoP. In the image, the ischial tuberosities are clearly visible, with the highest pressures.

The speed value (when above the threshold) and the corresponding time are recorded and if two or more instants are consecutive, they are considered as part of a single movement and only the instants to the extremes are stored. From this procedure, we find all the initial and final instants of the movements according to the threshold, that form the rows of a new table. These values however don't represent the real time intervals, because the CoP speed above the threshold represents only a sufficient condition in detecting the movements. The later elaborations are necessary in order to define the true time duration. Every row coincide with one ICM, thus a portion of the file storing the pressure maps is extracted, and more specifically, the rows comprised in the time interval defined by the instants found, together with the 10 s before the initial time and the 10 s (20 samples) after the final value.

From the matrix thus obtained, we have eliminated three groups of sensors: the ones that are not loaded or that never change their pressure during the ICM and the capacitors that show variations of only ±0,25 kPa (because in this case the difference in pressure could not be directly correlated with a movement but it could be due to the instrument). In the new data set we have found all the indexes of the

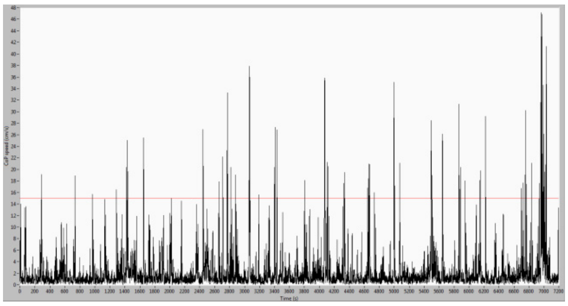

Figure 2: This graph, obtained with Labview, shows the CoP speed during one test (in black), with the threshold value of 15 cm/s, in red: only the values above the red line are considered for successive elaborations.

array in which there is a pressure variation and we have selected three of them: the index that is exactly at half the time interval, the preceding and the following ones. This choice is made because at least one of these values should coincide with an instant of movement detected by the CoP speed: if this isn't the case, that means that the pressure variation is not related to a movement, thus the corresponding sensor doesn't have to be considered. Therefore we have checked if at least one of these indexes satisfies the requirement. For every movement in this category and for every sensor that varies the pressure in the temporal interval selected, we have divided the array of the indexes: the first sub-array contains the first set of indexes, up to the mid-interval one; the second comprehends all the others. This is useful to identify the real instants of the movement: the first element of the second sub-array is subtracted with the last element of first sub-array and, if they are not consecutive, it means that the first index of the second sub-array coincides with the initial instant of the movement. If this isn't the case, this procedure is repeated in decreasing order in the first sub-array until we found two non-consecutive indexes; then, the greater of the two represents the initial instant. An analogous procedure has been implemented to find the final instant of the ICM but in this case only the second sub-array is used and we proceeded from the beginning until we found two non-consecutive indexes: here, the lesser is chosen as the final instant. At last, for a single ICM we obtained two arrays of time indexes: the first contains the initial value from every sensor considered and the second stores the final indexes. To define the real interval, we chose the minimum in the array of the initial times and the maximum of the second array. However, since up until now we have worked only with indexes, we converted the indexes obtained for all movements in the corresponding time values. At the end we found a matrix composed of two columns: the initial and final time instants of all ICM. From the observation of these results, it can be stated that sometimes two or more movements partially overlap, mainly because the instants identified with the CoP speed are close to each other but not consecutive, consequently the system treats them as separate situations. This however represents a complex or prolonged movement, therefore in this case we jointed all these rows to form a single ICM, with the initial instant coinciding with the initial value of the first movement and the final instant that is the final one of the last movement. This procedure will be completely automated in the next version of the software.

### 2.3.2 ICM Classification

With all the ICM identified, we calculated the total number of movements registered in a test, the duration of each one of them, the time interval between successive movements and the typology. A portion of the file resulting from the elaborations is shown in Figure 3.

| | | | | |
|---|---|---|---|---|
| 142,520 | 146,020 | 1,000 | 3,500 | 221,000 |
| 367,020 | 368,020 | 2,000 | 1,000 | 115,000 |
| 483,020 | 485,020 | -1,000 | 2,000 | 158,500 |
| 643,520 | 649,020 | -1,000 | 5,500 | 62,000 |
| 711,020 | 726,020 | 1,000 | 15,000 | 98,000 |
| 824,020 | 827,520 | -2,000 | 3,500 | 393,000 |
| 1220,520 | 1226,520 | -2,000 | 6,000 | 100,500 |
| 1327,020 | 1332,520 | 1,000 | 5,500 | 22,000 |
| 1354,520 | 1356,520 | 2,000 | 2,000 | 28,000 |
| 1384,520 | 1390,520 | 1,000 | 6,000 | 13,000 |

Figure 3: Output file of the movement detection software: the first two columns represent the initial and final times of an ICM, the third column shows the type of movement (as described in detail in Figure 4), the fourth column is the duration of the movement, while the final column reports the interval between the current ICM and the following one.

For this last feature we used again the CoP, in particular, for every ICM we considered the CoP at the beginning and we calculated the distance between this value and all the successive CoP coordinates during the movement. We selected the maximum distance and thus the corresponding CoP coordinates, in order to calculate the tangent of the angle.

According to the value obtained, we considered four different movements (each of them indicated with a code number), two in the lateral and two in the longitudinal plane (Figure 4): a movement on the right side of the body; a movement on the left side; a movement forward; a movement backward.

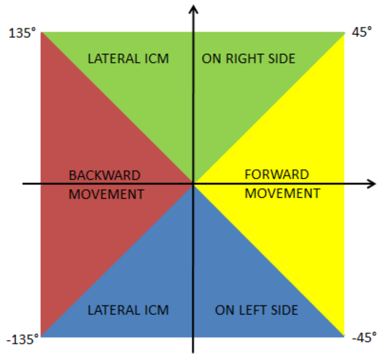


Figure 4: The image shows how the movements are classified according to the tangent value: if the angle is between ±45° the ICM is forward (on the longitudinal plane, with code number of "2"); if the angle is between 45° and 135° the movement is lateral on the right side (code "1"); if the angle is between 135° and -135° the ICM is backward ("-2") and if the angle is between -135° and -45°, the movement is lateral on the left (code "-1").

## 3 EXPERIMENTAL TESTS

### 3.1 Evaluation Tests

After completing the program, it was necessary to test its correct functioning. For this reason, we developed a protocol for a simple but effective evaluation: two of the 10 healthy subjects engaged for the successive tests (a man and a woman) sat on the same foam chair and were asked to perform the four ICM described at the end of chapter 2.3 in the order in which they are written, and at prefixed time instants (with a time interval of at least 10 s between consecutive movements). An operator observed the execution of the test while indicating to the subject the instant in which to perform the repositioning and the type of movement. Before the execution of the first movement, after performing the last one and between two consecutive displacements the person remained still for 10 s or more. This sequence of movements was repeated 10 times in each test, resulting in 40 movements per person. The aim of these experiments was to compare the results of the software with the experimental conditions of the protocol and then to determine the efficacy of the software. The results are shown in Table 1: in one of the subject all the movements are detected and classified correctly, while in the other experiment the first movement is seen as two separated ICM, thus 41 displacements are recorded. In the second subject the detection of lateral ICM, and in particular between right and left displacements, is good with only one ICM (the first one is not a real ICM) on the right side is considered as a left side displacement, compared with the identification of forward versus backward movements.

Table 1: Number, time duration, interval between consecutive movements and typology for both subjects involved in the tests.

| ICM | Subject 1 | Subject 2 |
|---|---|---|
| Total number | 40 | 41 |
| Lateral, right side | 10 | 9 |
| Lateral, left side | 10 | 12 |
| Forward | 10 | 18 |
| Backward | 10 | 2 |
| Time duration | 1.675 | 3.85 |
| Time interval | 13.55 | 11.67 |

Probably subject 2 performed the longitudinal movements with slight oscillations of the trunk that resulted in an incorrect classification of the ICM. However, in general, the program can detect all the ICM performed and it can discriminate between movements in the lateral plane from those in the sagittal plane. Lastly, regarding the intervals between movements, the seconds subject shows a mean value that is closer to the 10 s indicated, but in both cases, the values are near the reference. One ulterior important comment is that the 10 s time interval is not reported by a watch or a similar instrument as the fixed amount of time that has to elapse between two consecutive movements, but represents only the minimum time that has to pass before executing the new ICM; thus values greater than 10 s are correct.

## 3.2 Tests on Healthy Subjects

The program has been used on a group of 10 healthy subjects that were asked to seat on a foam chair for 1 hour while performing some office task at the PC (e.g. reading a document, browsing the Internet). The group is composed of 5 men and 5 women, with age of 37 ± 12 years. We recorded height, weight and BMI (Body Mass Index) for everyone, as shown in Table 2, while the total number of ICM done by the subjects during the tests and the statistical values are shown in Tables 3 and 4.

In all cases the standard deviations are high, even when the two subjects with highest number of ICM are eliminated from the calculus. This indicated that the number of movements (and thus the feeling of discomfort) is highly subjective, thus it is not sufficient to evaluate the behaviour of seated people. Maybe the number of ICM performed is correlated with some anatomical characteristics of the subjects:

Table 2: Physical characteristics of the subjects tested; the first column indicates the gender.

| SUBJECT | WEIGHT (kg) | HEIGHT (m) | BMI |
|---|---|---|---|
| M 1 | 65 | 1.74 | 21.47 |
| F 1 | 59 | 1.68 | 20.9 |
| M 2 | 65 | 1.77 | 20.75 |
| M 3 | 90 | 1.85 | 26.3 |
| M 4 | 70 | 1.85 | 20.45 |
| M 5 | 85 | 1.77 | 27.13 |
| F 2 | 55 | 1.70 | 19.03 |
| F 3 | 53 | 1.65 | 19.47 |
| F 4 | 55 | 1.68 | 19.49 |
| F 5 | 65 | 1.63 | 24.46 |

Table 3: Total number of ICM performed by the test people during the 1hour recordings.

| SUBJECT | NUMBER OF ICM |
|---|---|
| M 1 | 41 |
| F 1 | 19 |
| M 2 | 167 |
| M 3 | 18 |
| M 4 | 84 |
| M 5 | 29 |
| F 2 | 59 |
| F 3 | 27 |
| F 4 | 78 |
| F 5 | 102 |

Table 4: Mean and standard deviation for all the subjects and for the two genders, also without one subject in both genders that is considered an outlier because the number of ICM is significantly higher compared to the other people.

| SUBJECTS | MEAN | STANDARD DEVIATION |
|---|---|---|
| all | 62.4 | 47.04 |
| males | 63.4 | 46.11 |
| females | 58 | 31.55 |
| all with outliers | 53.5 | 30.59 |
| males no outliers | 55.1 | 30.07 |
| females no outliers | 55.6 | 28.61 |

to verify this hypothesis, a new set of experiments are planned and related results will be presented in a further publications. The duration of the ICM also has been evaluated (Table 5): depending on the person, the interval of movement can be homogeneous or quite different, but in this case there is no such difference among the subjects, like in the case of the number of ICM. In particular, it can be observed that the mean duration varies between 2.32 s and 6.74 s, but the majority of the people performs movements that last about 4-5 s in general. Regarding the time interval between consecutive movements (Table 6), it can be noted that the lower the number of ICM done, the higher the time intervals are, and vice versa. This leads to conclusions analogous to the case of the total number of movements: in fact, among the people involved in these tests there is high variability. At last, we considered the typology of ICM executed by every subject (Table 7): in general, the most common ICM are the lateral displacements (372 out of 618, more than half the total movements), with prevalence on the right side. This is a symptom that the ischial tuberosities, being the areas with the highest pressures, in a prolonged seated position, need to be unloaded and the lateral ICM seems to be the better solution.

Table 5: Mean time duration and statistical parameters of all the ICM, for every subject.

| SUBJECT | MEAN (s) | STANDARD DEVIATION |
|---|---|---|
| M 1 | 6.74 | 5.54 |
| F 1 | 2.32 | 2.45 |
| M 2 | 4.24 | 5 |
| M 3 | 5.69 | 2.76 |
| M 4 | 4.11 | 2.8 |
| M 5 | 3.5 | 2.83 |
| F 2 | 4.42 | 3.2 |
| F 3 | 3.33 | 1.9 |
| F 4 | 3.22 | 3.77 |
| F 5 | 2.71 | 2.07 |

Table 6: Mean time intervals between consecutive movements for every subject.

| SUBJECT | MEAN (s) | STANDARD DEVIATION |
|---|---|---|
| M 1 | 6 | 5.87 |
| F 1 | 182.44 | 397.57 |
| M 2 | 17.19 | 19.87 |
| M 3 | 102.77 | 91.9 |
| M 4 | 39.01 | 39.49 |
| M 5 | 123.75 | 139.41 |
| F 2 | 57.23 | 68.57 |
| F 3 | 130.08 | 181.3 |
| F 4 | 43.32 | 44.55 |
| F 5 | 31.9 | 42.65 |

However, also the discomfort plays a role when a person seats for long periods of time, therefore even movements in the sagittal plane are necessary. The fact that the forward displacements are fewer than those backward, can be explained by remembering that the subjects could not lean on the backrest, thus they were induced in a curved forward position; therefore, the better way to relieve the spinal column was to move backward.

Table 7: Total number of movements for every typology, for every subject and in all the tests.

| Subject | Right lateral | Left lateral | Forward | Backward |
|---|---|---|---|---|
| M 1 | 13 | 6 | 6 | 10 |
| F 1 | 6 | 7 | 1 | 5 |
| M 2 | 76 | 52 | 5 | 34 |
| M 3 | 5 | 9 | 2 | 2 |
| M 4 | 32 | 19 | 12 | 21 |
| M 5 | 12 | 7 | 3 | 7 |
| F 2 | 11 | 18 | 8 | 22 |
| F 3 | 2 | 2 | 5 | 18 |
| F 4 | 23 | 19 | 21 | 28 |
| F 5 | 34 | 19 | 21 | 28 |
| Total | 214 | 158 | 74 | 172 |

# 4 CONCLUSIONS AND FUTURE DEVELOPMENTS

This paper describes a program that identifies the in-chair movements, that can be used in various domains: from the clinical environment to prevent pressure sores, to the automotive field to evaluate fatigue and discomfort, and in ergonomics for the design of office chairs and armchairs. In particular, regarding the clinical setting, it is believed that studying the behaviour of healthy seated people could be useful and important in evaluating effective strategies for the prevention of pressure ulcers (mainly in the decubitus area). The software is able to detect the ICM and records the time extremes of each movement, its duration, the typology and the interval between consecutive movements. It has been tested on two subjects to evaluate the effectiveness of the algorithm and after that, 10 healthy people were enrolled in a prolonged test. The results show that the system can correctly detect the movements and also differentiate between different displacements, thus it can be implemented with bigger sets of pressure data. Future developments of the program can involve a better detection of the appropriate movement typology, with the aim of finding a more precise way to define it. The software will be also applied for further experimental tests with healthy people, in order to better characterize their behaviour in many more conditions. Regarding medical applications, the program will be implemented in clinical experiments involving patients hospitalized in rehabilitation structures, in order to evaluate and compare the behaviour of people with motor limitations and disabilities. The aim is twofold: on one hand it is very important to prevent the development of decubitus ulcers, thus it is necessary to find the appropriate and personalized prevention strategy, that can involve self-repositioning and the use of new devices for the redistribution of the body load on the seat support. On the other hand, this program can be useful for the medical personnel to monitor the various phases of the rehabilitation and to help in evaluating the progresses made.

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