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ERGONOMIC ANALYSIS OF TWO DIIFERENT OFFICE CHAIRS INCLUDED IN THE ATENEA PROGRAMME

by

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1. OBJECTIVES OF THE REPORT

In this report it is sought to analyze, from an ergonomical point of view, a sample of chairs of the Atenea series dedicated to the use for wide collectives and also for office work, made by the company DILEOFFICE SL, of Castalla (Alicante).

The ergonomic yield of these chairs has been considered in two different ways:

On one hand a comparative analysis of the usual anthropometrical variables has been made from the chairs, fixed and swivelled, for the Spanish and European population, comparing them with the measures in situ on the samples given by the company. Notice that the samples are test models, therefore, they can still suffer small changes in the phase of serial production. The carried out comparative analysis doesn't include to all the variants of seats that form the Atenea program, since only two models of chairs are studied, one with fixed legs and the other one swivelling, being manufactured in both cases the seat and the back in PP plastic material (polipropilene), with a fiber load of 15%, and supported by a steel frame.

For the information given by the company one can say that the two samples represent the pattern Atenea in their simpler concretion, for what the obtained results are perfectly applicable to the rest of the series, more complete in regulation mechanisms, upholstering, etc. We guess that the ergonomic characteristics of the improved seats overcome the performances of the two analyzed chairs.

On the other hand, we have been carried out different use tests under work conditions, answering an ad hoc questionnaire, all from the perceived sensations. The aim of the report, i.e. to establish the fulfillment of the basic ergonomic characteristics of a chair, usable as much for office as for wide collectives, has conditioned the quantity of people that should participate in the use tests. In reserve of a later more complete study, in which we should have a lot of people for these tests, so that the values and the statistical deviations of the ergonomic variables were representative of a certain community, this assessment was made by the authors of the report.

This report has been divided in several parts. In the first place it has felt convenient to make a brief summary of the ergonomic variables and their relationship with the comfort and prevention of gesture syndromes in seated people.

In second place, a physical description of the two chairs is made, where the illustrations always correspond to pictures that the authors have obtained directly from the samples. So, graphic information from the company has not been used in this report.

In third place, a comparative analysis of the measurements made was carried out on the two chairs in regard of the recommended values, obtained from

the Spanish and foreing legislations, besides considering the opinions of several internationally acknowledged authors.

In fourth place the results of the evaluations of use of the two seats are shown.

In fifth place a critical assessment of the results obtained in the two types of tests is made.

In sixth place, a summary of the results are shown, besides to some reasonable solutions to the few ergonomic inadequacies that have been observed, with the aim that they can be corrected in the definitive production process.

Lastly, several bibliographical references are added, in order to support and supplement the presented text.

2. GENERAL APPROACHES OF THE ERGONOMICS OF OFFICE CHAIRS AND OF CHAIRS FOR WIDE COLLECTIVES

Any object or device that it can be used by the human being should complete a series of conditions that they allow him to satisfy the function for which they have been designed: among them to have some proportional dimensions with those of their potential users besides that their form, texture, materials that is made, etc., must facilitate their use so that people can utilize them with the comfort, the security and the smallest energy cost besides that are pleasant aesthetically.

A chair, expressed in a generic way, serves so that people keep the seated posture. This posture is, together with the decubitus, one of the most comfortable, since allows to reduce the corporal fatigue, diminishes the energy expense of the person and increases its biomechanical stability, besides increasing the precision in the development of the actions that he/she can carry out with its superior members. On the other hand, this posture could be harmful for the health if they are not kept in mind other elements, on one hand those that intervene mainly in the actions that can be carried out in this posture, in connection with a table or work plane in its case, or with the possibility of changing position from time to time.

In most industrial activities the seated position is the most comfortable form of working, or in waiting in certain services (transportation, sanitary, offices, etc.); however, to maintain this posture during a lot of time can end up being very uncomfortable, since if the seat is inadequate it gives place to cervical or abdominal nuisances, disorders in the lumbar area of the back and alterations of the circulatory and nervous systems that affect, mainly, to the inferior members. In the labour environment it is advisable, for it, to alternate this posture with the standing posture and, of being possible, to walk.

In reference to the dimensions of the objects or tools that the human being uses it is necessary to appeal to the anthropometry, that is the branch of the human sciences that has to do with the corporal measures, such as the height, the form and the resistance of the human body. These measures should keep in mind not only the ethnic variability that exists between humans in general, but among

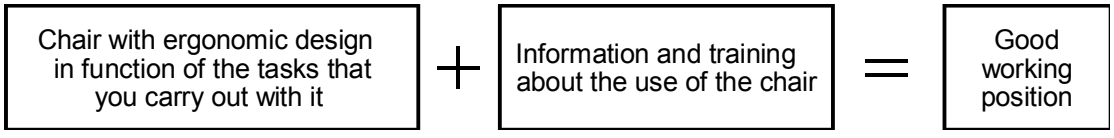
the members of the same community. Then we will be use the different parameters that are common in the description of a statistical sample: Mean value, population's percentages (percentiles) that possess a certain value of the considered parameter, range of the sample, etc. The chair should sized so that it can complete its mission efficiently for the biggest range possible of people, independently of its height, weight, etc.

The form ensures a primordial task in the ergonomic design of an object (form follows function), as can be the case of a seat whose mission is allowing a person to sit down in a comfortable way for long periods of time, like it happens with the office work, or with the waiting rooms of public or private organisms. The materials used in the chair also contribute to increment the users' comfort, although in certain cases, like in the wide collectives, the durability of the object is a restrictive factor in relation to the best desirable comfort. The upholstered seat, padded and with their perspiring fabric, will always be preferable to any other material, generally of polymeric type, more durable but less more comfortable.

Lastly, colour can also be a factor to consider in the chairs, for the greater or smaller level of visual fatigue that take place, reflections of lights, colour subjective sensation, etc. although the fashion tendencies and the personal preferences don't always converge for a better election, from the ergonomic point of view.

In summary, the aim of an ergonomic chair is to get the user to have a good seated posture in the workplace, in the waiting room or simply in the resting place. With that the tension in the vertebral column decreases and the blood circulation is favoured in the inferior extremities.

A final observation: a chair can be very good from the ergonomic point of view, since it can have a great variety of adjustments to adapt to each user, but if these adjustments are not used correctly (or they are not known how to use correctly), the anatomic-physiological consequences can be, at the long term, more harmful than those originated by a normal chair. For this reason, it is rewarding to perform the following formula:



2.1 ERGONOMICS IN THE OFFICE CHAIRS AND IN THE CHAIRS FOR WIDE COLLECTIVES

In the following sections we will consider the most important factors to keep in mind in a chair that is designed in agreement with the most broadly accepted ergonomic approaches. These approaches will be applied to the sample of chairs of the Atenea series that has been studied, which will allow us later to evaluate these products by the light of the same ones.

2.1.1 Seat height

The seat height of the chair should be adjustable, with the purpose of adapting to the different physical typologies of people. The ideal height is the one that allows that the person, when sitting down with the plane feet on the floor, have the thighs in horizontal position or forming with the body an angle between 90º and 110º.

It is important to control this variable, since if this is excessively high a compression takes place in the inferior face of the thighs; and if the seat is too low the contact area is reduced exclusively to the gluteus, since the legs are bent up, diminishing the angle formed by the thighs and the body, what gives place in both cases to an increment of the vascular and nervous compression of the inferior members.

2.1.2 Seat shape

The seat of the chair should have an almost plane surface and the front border rounded, to avoid the sharp compression in the inferior part of the thighs, mainly in those people for which the height of the seat is big and its feet are hanging or not leaning appropriately in the floor

2.1.3 Backrest of the chair

Their mission is to endow to the back of a support that it picks up part of the weight of the body, and for it should be coupled it in the best way possible to the profile of the spine, but with the care that this coupling doesn't impede the necessary mobility to carry out changes in the position of the body while it is seated.

The backrest of the chair should be adjustable in height and angle of inclination, to adapt to the different personal typologies.

For the office work it is fundamental the existence of a lumbar support that should be located toward the space understood among the L3 and L5 vertebras. It will diminish the anomalous bend of the spine (lumbar lordosis) and the muscular tension will be alleviated in the area. This function is improved with the help of a padding that helps to maintain the correct bend of the column. The backrest must arrive, as a minimum, just the half part of the back, that is to say under the scapulas, and it should not be too wide in its superior part for not substracting mobility to the arms. This is in order to maintain a correct work position that allows

to the trunk to be erect in front of the work plane and closest possible of the same one, maintaining an angle between elbows and knees of around 90 grades. The head and the neck should be upright as possible.

As for the angle seat-backrest, this should be adjustable, with a good election of the adjustment system. A good system is that allows the combined variation of the inclination of the seat and of the backrest, when exists the option of letting that the seat follows the movements of the user's back, giving this way support in the user's position. For it is fundamental that the same user adjusts the swinging tension to his weight, which implies that the system should be easily identifiable and comfortable of use. Some systems have a device antireturn that avoids the impacts when passing from a fine inclination to the option of the variable contact in a permanent way, which improves the benefits of the chair.

2.1.4 Chair stability

Obviously, the chairs should be stable. For the swivelling chairs, their support base will be formed, as minimum, for five support legs, each one with its respective wheels. It is important that the seats can rotate and to move without unnecessary efforts, so you can reach with easiness to the near elements to the work table. For it, the election of the wheels is fundamental in function of the floor type (terrazzo, carpet or of any other type), since they should be resistant, relatively flexible to absorb the irregularities of the floor and that they don't get jammed with easiness. In all the ways, a certain initial resistance is advisable, with the purpose of avoiding undesirable movements from the chair when the user is carrying out small modifications in its corporal posture.

2.1.5 Materials, linings and upholsterings, colours

The lining material of the chair is advisable of having perspiring fabric (to allow a good dissipation of the humidity and heat, mainly if are seats with tapestry in imitation to skin); also that it is flexible, and with a padding of 20 mm of thickness, as minimum. Likewise, it is desirable to avoid too much sliding materials.

As for the colour of the seats, it is demonstrated that the more valued colours by the users are the red, the blue, the black or the orange. The grey, green and garnets are the worst valued. The most advisable colours for our population would be the clear blue, the clear green and the beige, but it is clear that the colour aesthetics is a very dependent aspect of the user's election.

It is necessary to point out that this it is a very complex question that would demand a much wider and rigorous study, in which intervenes as a essential variable the aims that the seat is dedicated. This is only a reminder of the colour as a ergonomic variable that it could be analyzed more appropriately.

2.1.6 Regulation levers

The controls that regulate the height of the seat, angle of the back, angle back-seat, etc. should can to be manipulated in an easy and sure way, while the person is seated in the chair.

2.1.7 Armrests

Armrests are not indispensables, although advisables. They complete several functions: Although their main paper is to facilitate the changes of body postures and the actions of to sit down and to get up on the chair, they are also good to give support and resting to shoulders and arms, and to give stability to the hand. The shape should be plane with the contours lightly rounded, and they should be lined, or simply to be of a soft material.

The height of the armrests above the floor should allow the user to close his seat to the table. For it, their height should be limited, and if they are fixed they should not expand a distance bigger than 200-250 mm starting from the backseat.

Lastly, two elements will be commented that although they are not related directly with the ergonomics of the chairs in general, they have their importance mainly in the workplaces.

In the first place, footrests should be provided to allow people of smaller height to be adjusted to the work table. It becomes necessary in the cases where you cannot regulate the height of the table and the height of the seat doesn't allow the user to rest its feet on the floor. In the event of use it should be kept in mind that the basement be the widest possible; that the surface be nonsliding, both in the contact area with the feet like in that of contact base-floor; and that the angle of inclination of the footrest be regulated easily

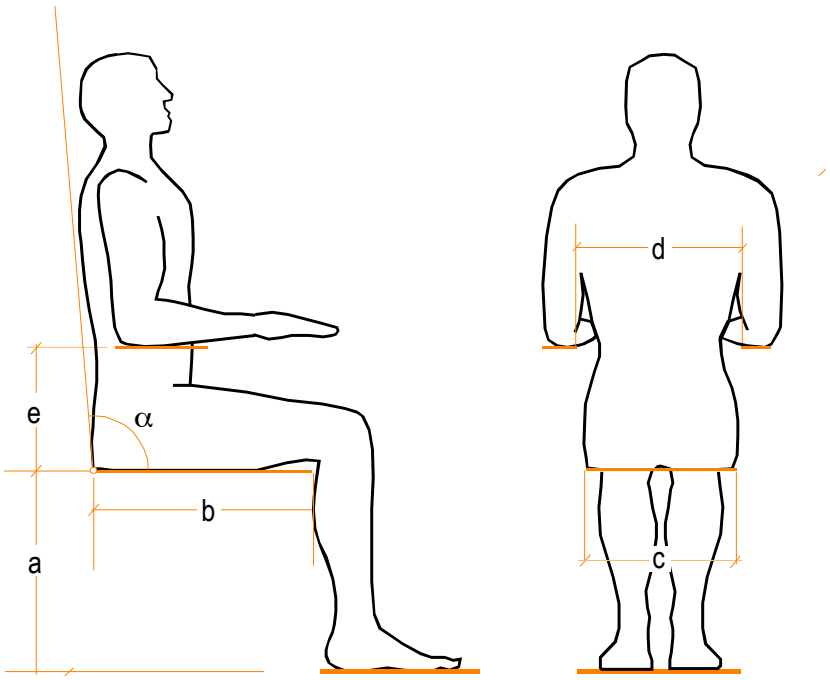
In second place, the work plane should be located keeping in mind the characteristics of the task and to the anthropometrical sizes of people. The height of the work surface should be related with the height of the seat, the thickness of the work surface and size of the user's thigh.

2.2 ANTHROPOMETRY AND ERGONOMICS IN THE DESIGN OF CHAIRS

Anthropometry is a branch of the human sciences that has to do with the corporal measures, such as the height, the form and the resistance of the human body. These measures are used in ergonomics, so that certain products, as the different types of chairs, they can be utilized by most of the possible users. Population's range that can use a chair of some certain dimensions will come given by the corresponding percentiles: P5, P50 AND P95.

Next we will comment the human being's anthropometrical parameters when he is sat down on a seat, and that they have relationship with the ergonomics of that object. In each case a brief declaration of the anatomic-functional factors will be made that can influence in the design, and that, therefore, they should be included in the same one.

The commented parameters will be in relation to the figure that is shown below.



Anthropometrical parameters of interest for a seated human

a: Seat height or popliteal height; **b**: Seat length;
c: Seat width; **d**: Width between armrests;
e: Distance between armrest and seat;
α: Angle between backrest and chair's seat

2.2.1 Seat height (a)

It is determined by the popliteal height, and their value should be such that it allows that the angle between the thigh and the leg be right (90º). in any event, and if this ideal angle is not possible to reach, it should be kept in mind that, in general, it is preferable to use a low seat better than a too high seat.

In this situation, the height corresponding to the percentile P5 of the feminine popliteal height, would be the appropriate one for the entire population, but it would be made at the cost of obtaining a too low seat for that same population's important part. For it, although the range of height of the seat is the distance among the percentile P5 (popliteal height for the feminine population's 5%) and the percentile P95 (popliteal height for the masculine population's 95%) it is necessary to arrive to a commitment since excessive heights they would produce vascular compressions in the inferior part of the thigh in people of smaller size and a sharp angle between the leg and the body besides a support surface reduced in the isquiotibial area in people of high size.

Consequently in this variable we follow the recommendations of the British Standard BS 5940 that advises a range of heights of 400 - 460 mm, and a minimum range of heights of 420 - 500 mm. In this same line Pheasant (2001), suggests a bigger range, since this would be understood between 380 and 535 mm.

From above it is easily deduced the convenience that the height of the seat be adjustable, what is recommended the maker as point of special interest.

2.2.2 Seat length (b)

It is in connection with the distance between the end of the gluteus and the popliteal fold (back of the knee). This is a decisive factor for the comfortable use of a seat. If the distance is excessive, the frontal border of the seat can compress the popliteal area, interrupting the blood circulation. To avoid this situation, the user spreads to move forward, a reason why the back is without the due support. If, on the contrary, the depth is scarce besides lending an insufficient support, it causes a sensation of uncertainty, for the tendency of the body to leave forward. A margin of until about 10 cm can be admitted as appropriate. The BS 5940 recommend not to overcome the 430 mm.

2.2.3 Seat width (c)

The seat width should be related with the width of the user's hips. According to the National Institute for Occupational Safety and Health (NIOSH) of USA, most of people needs between 457 and 508 mm. Keeping in mind that the dimensions of Spanish people are usually smaller, these widths would be also more than enough.

2.2.4 Seat shape

It is preferable a plane shape or lightly concave, better than with forms. He should have rounded the front border to avoid the pressure on the blood vessels of the thigh, as has been pointed out previously. Their surface should be covered of rough materials (to impede slips) and to be waterproof, although it is recommended that be transpirable. It is also advisable that the surface of the seat can oscillate about 5º ahead-behind, to be able to change the angle back-seat.

2.2.5 Backrest

The backrest should be adjustable, and to have, at least, 500 mm high; and it should be curved to serve from support to the lumbar curve, as much in resting as in working position.

If the backrest and the seat are not mobile, they should have among them an angle of about 105º. The tapestry should not allow slips and being transpirable

2.2.6 Width between armrests (d)

He will come given by the width among elbows. For the fixed chair with armrests and the swivelling chair will be kept in mind that people of more size should fit. Otherwise, this dimension would not allow the use from the chair to those people. The width of the seat is decisive for the minimum interior distance among the arms of the chair.

Ideally they should can to be rotated and to be adjusted as much in height as in inclination. The width of the arm should have a minimum value of 60 mm.

It should also be kept in mind, for work chairs in offices that the length of the armrests doesn't impede the closing to the work table. For that he should not have more than a total 660 mm above the floor (to be able to be located under the work table) and he should leave a minimum distance 100 mm until the border of the seat. According to the British Standard BS 5940 the armrests should not stand out more than 200-250 mm from the backrest.

2.2.7 Armrests height (e)

It is indexed to the height on the seat's plane and he is determined by the height of the elbow in seated position. It should be located between 180 and 200 mm according to Spanish Standard

2.2.8 Angle between backrest and chair's seat (α)

This angle should be greater than 100º (NIOSH). British Standard recommends 105º. As larger is this angle, the softer will be the compression on the pelvis and the lumbar vertebras.

As for the footrests that have been commented at the end of the section 2.1, the British Standard BS 5940 recommend the dimensions 450 mm long for 350 mm wide. The angle of inclination of the footrests should be understood between 5º and 10º.

3. DESCRIPTION OF THE SAMPLES OF ANALYZED CHAIRS

In this report two types of seats are analyzed, one with fixed legs and the other with swivelling motion. In the two models there are several common elements, as the seat, the backrest and the union plate, to those that are added, in their case, the armrests. The differences come from the support system, fixed in the chair of four legs and swivelling in the chair with five wheels. In the latter there are the possibility of varying the height of the seat by means of a gas mechanism. The analysis has been made on both chairs provided with armrests, being feasible to infer conclusions for the case that it was done without of the same ones, option that offers to the client commercially, given the modular construction of the two chairs.

In such a way that can be considered that is not two cases very different, but that they require some considerations for separate:

a) Chair with 4 fixed legs and armrests

b) Swivelling chair with armrests

3.1 CHAIR WITH 4 FIXED LEGS

It is considered in this report that the chair in question, doesn't have a specific design or concrete destination. Consequently a multipurpose chair will be considered with several applications, that is to say, it will be been able to dedicate to a great variety of environments and its use will be indiscriminate and with projection to any environment in that a chair is necessary.

This multiple aims supposes that its dimensions, structures and materials should be analyzed in the widest sense, so that there are an acceptable commitment between a good solution, that one could obtain in the case from a very concrete and limited ergonomic objective directed to a small and very homogeneous population's sample; and a solution of more amplitude, so that it can be considered sufficiently acceptable for most of the population that can use the chair in very different circumstances.

Since is expected that the population to that is dedicated this chair will diminish progressively starting from a point of maximum sales that can be located in Alicante, it will be analyzed dimensionally for the population of the South East of Spain, for the Spanish population in general, for the European population and for the population from United States of North America.

In the following page several views of the chair with four legs are shown: front sight, isometric sight and side sight. In the isometric sight the two possibilities are shown before mentioned: with armrests and without them.

Isometric sight

Frontal sight

Side sight

CHAIR WITH ARMRESTS

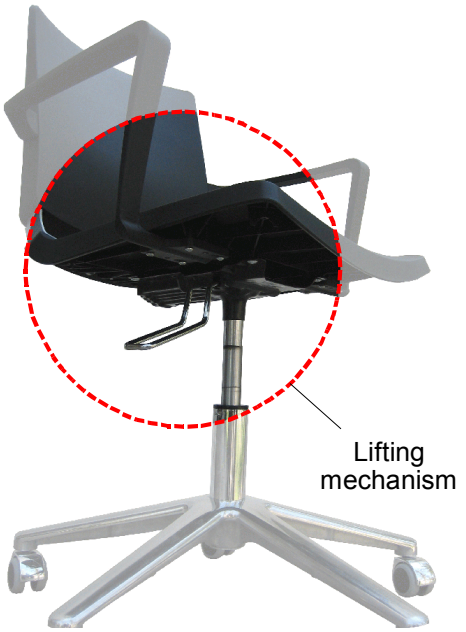
Isometric sight

CHAIR WITHOUT ARMRESTS

3.2 SWIVELLING CHAIR

The group of pieces that form the seat, the backrest and the union plate is the same one that the employee in the chair of fixed legs. This group is leaning on a column of variable length, moved by means of a cylinder of gas, intruded in a piece with five radial legs in whose ends are the swivelling wheels. In the following page are shown frontal, side and isometric sights of the analyzed chair.

Together with the plate that supports the seat there are the lifting mechanism, that can be acted by the user's right hand, just as it is stood out in the enclosed figure. The mechanism only controls the ascent and fall of the seat, since it doesn't allow the oscillation ahead-behind of the plane of the seat.



The wheels, just as it has been indicated in their moment, they should be robust and to rotate with easiness to allow the user's displacement with the smallest possible energy. However, the initial effort should be something higher to impede erratic slips when the user carries out small posture changes.

In the figure it is shown in detail one of the wheels, where the material in contact with the floor can be observed. This material, contributes the necessary flexibility to adapt to the small irregularities of the floor.

The wheels don't have blocking system, for what they can rotate freely.

Frontal sight

Isometric sight

SWIVELLING CHAIR WITH ARMRESTS

Side sight

4. COMPARATIVE ANALYSIS OF THE DIMENSIONS OF THE CHAIRS IN RELATION TO THE USUAL ANTHROPOMETRICAL MEASURES

Anthropometrical values of interest have been measured in the two studied chairs. The obtained values have been the following ones, where the letters corresponding to the magnitudes are referenced to the human figures shown in the page 9.

4.1 MEASUREMENTS PERFORMED ON THE CHAIRS

4.1.1 Chair with four legs, with armrests

Seat height (popliteal height):	a = 385 mm
Seat length (backside-popliteal length):	b = 400 mm
Seat width (seated hip width):	c = 430 mm
Backrest width (shoulders width):	390 mm
Backrest dip (spine-femur angle):	□ = 104º
Max armrests width (elbows width):	d= 560 mm
Armrests height (seated elbow height):	e = 220 mm
Lumbar deflection:	F_L = 10 mm
Covering material:	Polipropilene (PP)
Colour:	Black

4.1.1 Swivelling chair, with armrests

In this case, the characteristics are the following:

Changing height range:	a = 440 ÷ 550 mm
Backrest dip variation:	None
Wheeled legs number:	Five
There are footrests?:	None
Ergonomical position of lifting mechanism	OK

4.2 COMPARATIVE ANALYSIS

In the following Table is shown a comparative exhibition of the main variables that intervene in the ergonomics of a chair, comparing the values recommended in different sources (ISO 9241, BS 5940, other authors) with those obtained for the two chairs of the Atenea series. The figures that express the different lineal dimensions are given in mm.

VARIABLE TO CONSIDER	ISO 9241	BS 5940	Others	Atenea chair
Seat height (mm)	420 ÷ 530	420 ÷ 500	380 ÷ 535(1)	455
Seat width (mm)	430 ÷ 490		457 ÷ 508(2)	445
Seat length (mm)	400 ÷ 430	Max 430		410 ÷ 430
Padding (mm)	20 ÷ 30			None
Rounded borders	Yes			Partially
Backrest dip	-2º ÷ -4º			-4,5º
Backrest height (mm)	450 ÷ 510(3)	500		375
Backrest width (mm)	>420(4)			430
Backrest-seat angle	95º ÷ 110º	105º		103º
Armrests width (mm)	>60			Max 36
Useful armrests length (mm)	≥200	200 ÷ 250		270
Internal armrests separation (mm)	460 ÷ 500		460 ÷ 510	480 ÷ 500
Armrests height above seat (mm)	180 ÷ 200			193 ÷ 195
Armrests distance to seat frontal border (mm)	≥100	Min 100		105
Armrests height above floor (mm)	660			665

(1) Pheasant (2001)
(2) NIOSH
(3) Users preferred values. Spanish Standard fix a value of 360 mm
(4) Users preferred values. Spanish Standard fix a value of 360 mm

It has been considered of interest to incorporate another Table where the anthropometical data is drawn from of the personal database of one of the authors of this report (A. Panchón), together with the data of individuals of the United Kingdom of both sexes, and the results obtained for the Atenea chairs.

The data shown are mean values, and in parenthesis they offer, in their case, the percentiles P5 (value of the appropriate variable only for the considered population's 5%) or the P95 (value of the appropriate variable for the population's 95%). The P5 would be the advisable minimum value of the variable, and the P95 the advisable maximum value.

Variables, mean value (P5, P95)	**Man** (Spain)	**Woman** (Spain)	**Man** (UK)	**Woman** (UK)	**Atenea chair**
Seat height (P5)	428 (388)	399 (356)	440 (395)	400 (355)	455
Seat length (P5)	497 (451)	487 (450)	495 (440)	480 (435)	420
Seat width (P95)	364 (415)	367 (425)	360 (405)	370 (435)	445
Armrests width (P95)	477 (550)	420 (500)			490
Armrests height (P95)	226 (271)	223 (264)			194
Backrest height (P95)	590 (640)	556 (604)	595 (645)	555 (610)	375

5. EXPERIMENTAL EVALUATION OF THE COMFORT AND ERGONOMIC ADAPTATION OF THE CHAIRS

In this section we will be carried out an experimental evaluation of the comfort of each of the analyzed seats. For it the authors have sat down during long periods of time in the same ones, using them for the normal office activities, and starting from the received sensations the evaluation form that is shown next has been complimented.

As it has already been noticed previously, the demands for an office chair are stricter than for a chair for wide collectives, since this last one has a time of use very much smaller than in the case of the first one.

For the subjective evaluation of the comfort and adaptation of the chairs has been used the use guide for office seats published by the spanish Fundación Telefónica, in practical application of the Real Decreto 488/1997 and the Technical Standard ISO 9241 on diverse aspects of the Ergonomics of the workplace. Also has been used the one published by the department of Design of the University of Cornell but finally the first one has been preferred, because the valuation scale is qualitative and only limited to three points: positive, indifferent and negative. Given the purpose of the chairs, directed to multiple and very different users, we say that a bigger precision in the measure of the degree of comfort doesn't add a special interest to the chair maker.

USERS GUIDE FOR OFFICE CHAIRS			
1.Seat height regulatión	**YES**	**+/-**	**NO**
- Is it simple to make the regulation?	X		
- Can you make the regulation in the seated position?	X		
2. Backrest height regulation	**YES**	**+/-**	**NO**
- Is it simple to make the regulation?	IT HAVEN'T		
3. Backrest dip regulation	**YES**	**+/-**	**NO**
- Is it simple to make the regulation?	IT HAVEN'T		
- Can you make the regulation in the seated position?	IT HAVEN'T		
- After the regulation of the backrest height, does you stay leaned the back although you modify the dip backrest?	IT HAVEN'T		
- Does it hold the back when they lean on the hands on the table?	X		
- Do have the arms enough motion freedom? (if there are difficulties to move the arm respond negatively)	X		

4. Seat comfort	**YES**	**+/-**	**NO**
- Is the back of the knee free?	X		
- Can you insert without too much difficulty the hand between the front border of the seat and the thigh? (the blood circulation cannot be blocked)	X		
- Are you seated comfortably?	X		
5. The seat	**YES**	**+/-**	**NO**
- Is there a good shock absorption when you sit down? (if you feels the shock on the coxis respond negatively)		X	
- Does feel equally effective the shock absorbing in the lowest position of the seat?		X	
- Can you move freely and you don't feel nuisances when you sit down and get up? (if the clothes are hooked or they risk of being ruined, respond negatively)	X		
- Does exist enough space for the feet under the seat?	X		
- Does the support base remain stable when you bent down forward and the chair moves?	X		
- Being seated, can you rotate 180º easily?	X		
- Being seated, can you displace the chair easily? (a rehearsal should be made on the floor type in which you habitually work: carpet, parquet terrazzo, etc.)	X		
6. General comments	**YES**	**+/-**	**NO**
- Do you feel comfortable when you work? (the backrest dip should can to be modified so that you can achieve a comfortable resting or talking position)		X	
- Does have the chair a pleasant form?		X	
- The chair upholstering has a pleasant colour?	IT HAVEN'T		
- Is the material pleasant to the tact?	X		
7. If the seat is provided with armrests	**YES**	**+/-**	**NO**
- Can the elbows move freely? (when an office work is made)		X	
- Can the chair come closer enough to the table (or under the table) maintaining the back leaned?	X		
- Armrests are provided of fluffed lining?			X
- Armrests are designed for not hooking the clothes?	X		

6. ASESSMENT OF THE OBTAINED RESULTS

In view of the mensurations and valuations carried out, we can made on the chairs the following considerations, from an ergonomical point of view:

6.1 The seat height of the chair with fixed legs above the floor is within the accepted ergonomic margins.

The height regulation of the swivelling chair is within the acceptable one.

As for the surface shape of the seat, although it is not strictly plane, she has not a very remarkable bend. It is of noticing the lack of padding, although this deficiency is forced by the philosophy of this type of chairs, where its use for wide collectives impedes to the use of great durability materials.

It is inadequate the angular ending of the forward seat border. It will give place to an inadequate pressure on the blood vessels of the popliteal region in people of smaller body size (to see enclosed figure). According to the company, the presence of the bevel comes technically conditioned with the purpose of holding the padded panel that some variants of this seat have.

Chair seat front edge

The seat feels comfortable, since it doesn't press the popliteal area, and it allows to insert the hand between the front border and the thigh, so the blood circulation is not blocked.

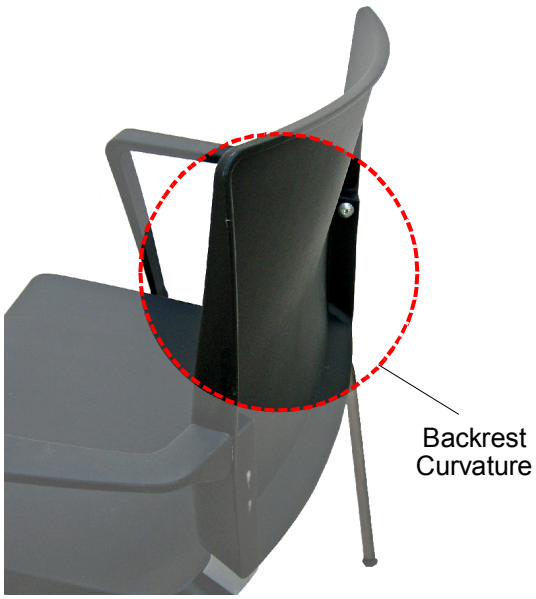
It also allows freedom of movements, without hooking the clothes, although the shock absorption when sitting down is more limited.

The space that there is under the seat is enough.

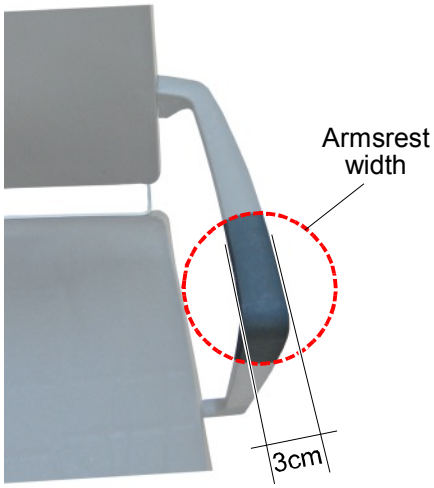
6.2 The seat width is within the acceptable one, although for certain populations (as in the USA) this width can be something short.

6.3 The seat lenght it is suitable for the two models of chairs analyzed of the Atenea program.

6.4 The backrest turns out to be something low, although the bend is the appropriate one (see enclosed figure). Likewise the backrest width is adequate, which also happens to the backrest-seat angle that is within the advisable values for chairs with the couple backrest-seat fixed.



6.5 Armrests have rounded forms, just as it is recommended, although they are something narrow, since they don't reach the 60 mm recommended value (see enclosed figure), as they have a mean value of about 30 mm.



Amrests lenght is within the acceptable one, as well as the height of the same ones regarding the seat plane.

Distance between armrests is within the advisable one, still for collectives whose heftiness has a mean value greater than of the Spanish individual.

It is also acceptable the distance that there are between the armrests end and the border of the seat, that which allows to introduce the chair with armrests under a work table, just as we have been able to check in situ.

Armrests limits something the elbow movements in the office work and when not being provided of a fluffed material they can produce a bigger grade of annoyance.

On the other hand, their size and design allow to bring the chair close enough to the work table and they don't produce hooks in the user's clothes.

6.6 The height regulation mechanism for the swivelling chair is simple and it allows an easy manipulation in the seated posture.

6.7 It is of pointing out the lack of a dip mechanism of the backrest in the analyzed chairs, although from the information given by the company it is deduced that inside the same Atenea program will exist models with this possibility.

6.8 In the swivelling chair a great stability is perceived when the user moves ahead - behind.

It also allows to rotate with easiness angles of 180º, and the displacement, in this case on terrazzo, it is soft and it requires little energy. The rolling band that each wheel has is of a material with the enough resilience so that in its contact with the floor absorbs the small irregularities of the same one.

6.9 The material of the seat and that of the back is a polymer with the inconveniences of not being fluffed neither transpirable, with the general problems that this represents. However, their surface has a very fine granulated ending that provides a high friction coefficient. The slips are avoided this way and the perspiration is facilitated.

The sensorial tests have been carried out in the warmest months in Alicante (July and August) and the sensation regarding these aspects has been moderately positive.

6.12 The samples black colour is not ergonomically the most advisable, although just as inform us the company the range of available colors for the market it will be very wide.

7. . FINAL CONCLUSIONS AND RECOMMENDATIONS

1. The final balance of the ergonomic analysis carried out on the two chairs of the Atenea program is positive, since the main dimensions of the same ones (Seat height above the floor, seat width and lenght, backrest-seat angle, distances between armrests, etc.) they are within the margins (ranges) settled down in different norms, so much Spanish as of other countries of our environment. Alone to point out that the backrest height is something short, since it has a value that is below the inferior bench mark of the ergonomic recommendation. The armrest width is also insufficient, although his roundness makes it comfortable.

2. On the other hand, the stability of the seats is very remarkable, so much in the version of fixed legs as in the swivelling one. This last one presents a soft rolling on the rehearsed floor - terrazzo - that you can consider representative of the reality. This softness seems to be due to the flexibility of the external band of the wheels, since of having selected a harder material (as, for example, nylon), the small irregularities of the floor would have been noticed much more.

3. The chair support surfaces, as much in the seat as in the backrest, have the appropriate curvature, mainly in the backrest. The only detected inconvenience resides in the beveled front end of the seat, that would be desirable it was more rounded. For the main foreseen purpose of these two chairs (use for wide collectives, where the time of use for a concrete person is relatively small, although the time of total use of the chair is very high) the non-existence of upholstering increases its durability and hygiene, although it is not the best ergonomic solution.

In accordance with that said previously it is deduced that the basic design of these chairs is within the recommendations and Spanish norms and of other nations of the western world and that, therefore, its production and commercialization is endorsed ergonomically by the carried out analyses.

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Tables from **Health and Safety Executive in the UK**

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