

Study of Furniture in Public Education in Relation to the User's Anthropometric Measurements. Case: UFPS Colombia

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Abstract

A study is presented on the ergonomic criteria associated with the university chair and the anthropometric measurements of the users. For this purpose, a study was carried out with a simple random sample of 376 students from the University Francisco de Paula Santander, two instruments were designed to collect the information, a perception survey that would show the discomfort and difficulties generated by the furniture, and an anthropometric study of the seated position; In addition, the dimensions of a random specimen were taken to make a typological evaluation in contrast with the NTC 4734, according to the results it was demonstrated that 100% of those surveyed said they suffer at least one discomfort due to the posture and materials of the university chair, the most significant pain is present in the buttocks, the current chairs are 9.09% smaller than allowed by the norm and according to the anthropometric requirements, the dimensions of the university chair should increase in proportion 14.2%. It is concluded from the information collected that the university chairs do not meet the ergonomic requirements of comfort and functionality.

Keywords: Ergonomics, university chair, sitting position NTC 4734

1 Introduction

Classroom furniture has undergone a major change over the last century, from school benches, to shared seating, to today's chairs and tables [1], these changes stem from the trend of the twentieth century or Modern Movement that gave priority to the functionality of things and the ease of mass reproduction; At the end of the Second World War, the knowledge resulting from the enormous investment in research and development for war purposes was adopted by the industries for the manufacture of all kinds of products, including school furniture, this caused that the curved shapes of the old benches were left in the past and designed furniture without unnecessary or superfluous elements to simplify production and lower the cost. As a result of technological development, it became necessary to study man in relation to the machine, which resulted in the design of seats that adapted to the body of the person [2]; as a result of this evolution, the design of school furniture is currently subject to ergonomic studies that limit the dimensions of the furniture to the anthropometric measurements of the population that needs them, but in practice it is another reality and seems to ignore the extensive meaning of these concepts, in the first place ergonomics is understood by the International Ergonomics Association as: the scientific discipline related to the understanding of interactions between humans and other elements of a system, as well as the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance[3], therefore the concept is applied to all man-made artefacts with the aim of facilitating the work, mitigating the risks and avoiding related diseases, is a fundamental tool to offer people the possibility to improve living conditions and optimize work [4] and in addition anthropometry is the study of the dimensions of the human body on a comparative basis. Both disciplines work hand in hand to avoid poor working conditions and ensure that work is productive [5].

In the classroom, students must adopt the same prolonged posture in the university chair that is not designed under anthropometric standards, without adequate ergonomic conditions, as a consequence, the person is forced to periodically correct his or her posture until finding an inadequate state of rest or vicious posture. According to Rojas [6], a correct posture is defined as one that does not overload the spine or any other element of the locomotor system and as a vicious posture that overloads the bony, tendon, muscular and vascular structures, among others, permanently eroding the body, in one or more of its elements, affecting the spine and harmonious posture above all.

The average university student sits for 4 to 6 hours per day in a position that generates discomfort, due to the inconvenience of the educational furniture, this problem is not so noticeable in private universities that generally have adequate furniture, in contrast, public education does not offer this model in all classrooms,

more than in some auditoriums and advanced computer rooms, for this reason, this research was carried out taking as a reference the students of the University Francisco de Paula Santander as the most recognized Public Institution in the department.

2 Methodology

The population is made up of 15.424 undergraduate students enrolled in the period, with an age range of between 16 and 30 years. For a confidence level of $Z=1,96$ (95%) and a maximum permissible error of 0,05 (5%), a sample of 376 students is obtained.

First, a questionnaire was used to establish the students' perception of the comfort of the furniture and the physical discomfort generated by the body posture during class hours.

The second part of the research consisted of evaluating the ergonomic criteria of the current furniture design, for this purpose anthropometric measurements were taken in the seated position of the respondents to compare the results with the sample of the randomly selected university chairs and the ergonomic references. With the information obtained, an analysis of dispersion measures, averages, variances and standard deviation of the results was performed and compared with the theoretical references.

3 Results

The results are presented in three sections: first, the students' perception of the comfort and discomfort conditions, then the evaluation between the university chair and NTC 4736 [7] and finally a dimensional evaluation between the furniture and the sample student population.

3.1 Students' perception of furniture comfort conditions

The results of the evaluation questionnaire show the students' perception of the current furniture and the most significant discomfort caused by the posture. As for the furniture in question, the aspects evaluated were: the seat, the backrest, the table, the angles and the material of the surfaces, in table 1 it is observed that with respect to the general measurements it was observed that only 12.8% of the cases "always" manage to find a university chair that adapts to the body generating the sensation of comfort; in front of the angles 69.9% say they are "asymmetrical" demonstrating that the backrest does not follow the pattern of inclination backwards and the table does not rise in the recommended reading angle. In addition, the material used in the university chair was perceived by 62.2% as "too hard".

Table 1. Students' perception of furniture comfort conditions.

1. In general measures (seat height, height and distance from the table to the trunk) the university chair adapts to your body:			
Option	Answer	Total	Percentage
a)	Always (the university chair meets all proportions)	48	12,8%
b)	Sometimes (some of the measures are disproportionate)	119	31,6%
c)	Never (no proportions)	209	55,6%
2. The general angles (inclination of the backrest and elevation of the table) of the university chair are as follows:			
Option	Answer	Total	Percentage
a)	Appropriate (provides back support, makes writing easier and does not slip on the table)	7	1,9%
b)	Asymmetrical (do not follow the pattern of tilting the backrest backwards and lifting on the table)	263	69,9%
c)	Very straight (rigid posture carving)	94	25,0%
d)	Very sloping (relaxed posture that pushes you out of the seat)	12	3,2%
3. Regarding the material of the university chair it is:			
Option	Answer	Total	Percentage
a)	Too soft	5	1,3%
b)	Adequate	104	27,7%
c)	Too hard	234	62,2%
d)	No answer	33	8,8%

Regarding the size of the table, the trend shows that today the notebooks are being replaced by folders with a larger size making it necessary to have a larger area to write comfortably. Table 2 shows that 67.5% consider the size and shape of the table "inadequate", making it uncomfortable to carry out activities such as writing or using a laptop computer.

Table 2. Size, shape and requirements of the table

Option	Answer	Total	Percentage
a)	Adequate	13	3,5%
b)	Inadequate	253	67,5%
c)	Wide	76	20,3%
d)	Narrow	33	8,8%

As for the discomfort generated by the seated posture, the most common are shown in table 3, in which pain in the buttocks is found with 28.3% being the most common, followed by low back pain with 27.0%; it was also shown that 50.8% of the cases say they suffer from "all" of the pains analyzed.

Table 3. Students' perception of physical discomfort from posture

Option	Answer	Total	Percentage
a)	Lumbar pain	256	27,0%
b)	Pain in the buttocks	269	28,3%
c)	Pain at the neck and trapezius level	228	24,0%
d)	Pain in the legs	196	20,7%
Option	Answer	Total	Percentage
a)	None	5	1,3%
b)	Only one of the inconveniences	60	16,0%
c)	Most of them	120	31,9%
d)	All	191	50,8%

3.2 Dimensional evaluation of the university chair

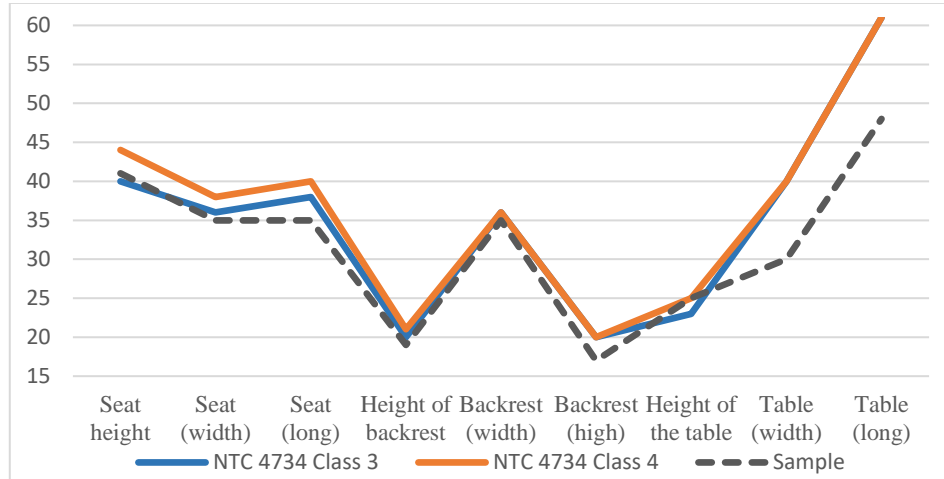
The NTC 4734 establishes two sizes of furniture whose assignment is made by means of the criteria of age, grade and height, table 4 shows its main differences, the most representative being the height of the seat, where type S3 or "Class 3" has a height of 40 cm and type S4 or "Class 4" is a seat 44 cm high, according to these data, the test specimen does not fit into any of the classes, showing that the dimensions do not fit the standard.

Table 4. Dimensional evaluation between the NTC 4734 and the university chair of reference

Component	NTC 4734		Sample
	Class 3	Class 4	
Seat height	40 cm \pm 0,2 cm	44 cm \pm 0,2 cm	41 cm
Seat	38 cm x 36 cm	40 cm x 38 cm	35 cm x 35 cm
Height of baskrest	20 cm \pm 0,1 cm	21 cm \pm 0,1 cm	19 cm
Baskrest	20 cm x 36 cm	20 cm x 36 cm	17 cm x 35 cm
Height of the table	23 cm	25 cm	25 cm
Table	61 cm x 40 cm	61 cm x 40 cm	48 cm x 30 cm
Seat angle	0° a 5°	0° a 5°	0°
Table angle	4° a 6°	4° a 6°	8°
Backrest angle	95° a 106°	95° a 106°	93°

The angle of the backrest is 2° tighter than the minimum value allowed, showing that it can carve over the soft tissues of the back causing discomfort and lumbar pain; the seat should have an angle $>0^\circ$ that allows the thighs to be supported to the bottom to prevent the student from slipping.

Figure 1 shows that the specimen tends to be smaller than allowed in class 3, on average it is 3.22 cm lower than "class 3" and 4.44 cm lower than "class 4", the table being the element that shows a significant change reducing up to 40% in area over minimum allowed values.

Figure 1. Dimensions of the university chair vs NTC 4734

3.3 Evaluation of the anthropometric criteria of students

Table 5 represents the statistical data of the anthropometric dimensions and the percentiles of the same ones that allow to know the part of the population that can be adapted to the dimensions of the desk.

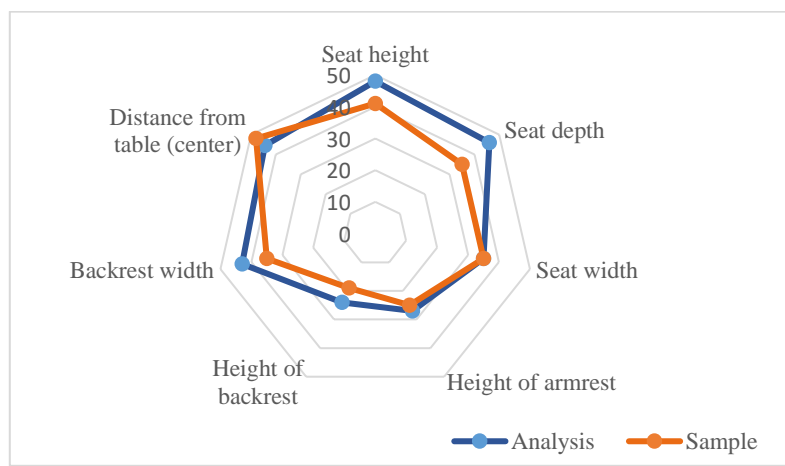
Table 5. Anthropometric measurements of students in a seated position

	Percentiles		Average	Median	Minimum	Maximum	Deviation	Variance
	5	95						
Seat height	42	60	48,7	48	38	62	5,31	28,15
Seat depth	40	52,95	46,03	46	31	58	3,91	15,32
Seat width	28	42	34,94	35	24	48	4,17	17,37
Height of armrest	21,05	32,95	27,21	27	18	39	3,22	10,37
Height of backrest	19	30	24,16	24	15	34	3,19	10,16
Backrest width	36	49	42,83	43	33	50	4,16	17,29
Distance from table (center)	35	57,9	45	44,5	34	60	6,79	46,08

The results obtained from the anthropometric study confirm the need for university chairs suitable for the anthropometry of the students, which facilitate the use of the furniture by a greater number of users, as a result of which one of the greatest drawbacks is the height, as shown in the 5th percentile, it has a popliteal height of 42 cm with a range from 38 cm to 62 cm, whose average is over 48 cm, 4 cm above the "class 4" chair; Another element that stands out is the width of the backrest, the current size of the chair is 35 cm, which is short for the average width of the students which was 43 cm. To minimize these problems, furniture must have adjustable features that allow it to be adapted to different activities and users [8].

Figure 2 shows the dimensions given by the study, which are 14.2% higher than the current university chair, confirming the need to redesign the university chairs with the active participation of the target users, adapting their dimensions to the anthropometry of the students and not subjecting the user to the dimensions of the furniture [9].

Figure 2. Comparison between the results of the study and the current university chair



Conclusions

The results obtained show that university chairs do not have the adequate dimensions to adapt to the anthropometric measurements of the population under study, therefore, they generate discomfort in the lower back, buttocks, neck and trapezius; the numbness of the legs is caused by right angles that cut blood flow to the lower part of the body. The model of university chair used does not meet the minimum specifications established by the standard, being 9.09% (4.44 cm) smaller than class 4 and 6.70% (3.22 cm) lower than class 3, these values are very high considering that the tolerance of the standard is ± 0.2 cm.

With regard to the discomfort generated by posture, it was evident that 28.3% of the students surveyed suffer pain in their buttocks and 27.0% suffer from low back pain, due to the significant imbalance in the dimensions of the chair and the materials used in its manufacture, as shown by the 62.2% who perceive it as "too hard". Not counting a soft surface increases the discomfort rates due to the compression that the tissues suffer when supporting about 75% of the weight in only 25 cm² of buttocks [10].

The presence of these pressures causes fatigue and discomfort in the student, stimulating the periodic change of posture to relieve discomfort, this reflex is necessary because otherwise, remaining in the same position and under the same state of forces can lead to cervical discomfort, abdominal discomfort, lumbar disorders and vascular and nervous compressions [11].

The result of the perception of the angles showed that 69.9% of the students had problems, because they were not in harmony with the shape of the body. This was evident in the analysis of the chair, since it was 2° below the permitted height, which resulted in an overly straight back, forcing a straight or leaning forward posture that caused fatigue, and to relieve it, there should be obtuse angled backrests that helped to stabilize the rotation of the pelvis, and the seat without inclination gave the sensation of expelling the user from the chair.

Finally, research on the anthropometric measurements of the target population shows that the dimensions of the current design of the university chair are 14.2% below, which prevents the thighs of the individual from being placed in a horizontal position and the lower legs from being vertical, making the feet rest flat on the floor. In this connection, it is necessary that the area under the thighs should not remain under compression caused by the front side of the seat, for this purpose seats with heights between 43 cm and 50 cm, maximum width of 45 cm at an angle of 3° must be designed, and the backrest providing lumbar support must be located at a height from the seat of not less than 45 cm, width from 33 cm to 48.3 cm and an angle of 103 ° to 112 °[12]. For the work table, it is desired to be at a height of 24 cm at 30 cm above the seat level, with an inclination from the armrest of 10° [13].

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