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Anthropometric Profile as a Factor of Impact on Employee Productivity in Manufacturing Industry of Tijuana, Mexico

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***Abstract*—**This paper presents an anthropometric study conducted to 300 employees in a maquiladora industry that belongs to the cluster of medical products as part of a research project to pretend simulate workplace conditions under which operators conduct their activities. This project is relevant because traditionally performed a study to design ergonomic workspaces according to anthropometric profile of users, however, this paper demonstrates the importance of making decisions when the infrastructure cannot be adapted for economic whichever put emphasis on user activity.

***Keywords*—**Anthropometry, Biomechanics, Design, Ergonomics, Productivity.

I. Introduction

To contextualize the importance of maintaining productivity levels high in the local industry include the following data. The 2012 closed with a turnover of 159,846 jobs in the manufacturing sector of Baja California, however, for July 2013 already had more than 241,553 according to INEGI. On the economic side, to October 2012 in Baja California was 1,703 million dollars of private investment, of which the maquila generated 46.8%, i.e. $ 797 million. At the level of the city of Tijuana, the industries continue to expand for many reasons, some of them to consolidate certain processes, in order to be more competitive (especially in the electronic, medical, aerospace and automotive branch).

According to the Association of the Maquiladora industry of Tijuana, expansion projects include not only the management of production and labor intensive, but also personal more staff and certified specialist, because companies have been focusing on the high value.

It highlights that: to keep the expected levels of productivity attention must be taken in the manner in which direct or indirect employees perform their daily tasks. Analyze these activities from the ergonomic point of view is a strategy for making decisions and so much more to contemplate the economic dynamics of the region.

Recently, methodologies and techniques for ergonomic and anthropometric studies have been becoming more important forms of analysis of the multiple factors that influence the productivity of the employees of the maquiladora industry. Many projects have been conducted to find the correlation between body composition of individuals and their performance to a certain task.

Also the anthropometric method with mathematical and statistical models that allow to view the co-dependency has been combining or interdependence between Somatotype and physical performance of the operator and the factors of performance (basically with his driving and technical capacity for work), however, those who seek a relationship with the productivity have been scarce, at least in the Northwest of the Mexican Republic.

The author of this article is working on a research project that, among other scenarios, intended to demonstrate taken by the interest to reduce the high costs for the attention to anthropometric, ergonomic factors and biomechanical within production processes in the maquiladora industries to start a revolution in the techniques and anthropometric procedures, in fact, some authors agree that Anthropometry is shaping up as a scientific branch of Bio-medicine, with a spectrum of application very strong in Sciences applied to sport. Without prejudice to the foregoing, the more agile of the concepts of prevention and work culture free implementation of ergonomic hazards is brewing in the manufacturing field [1].

This study is intended to be a methodological guide that supports decision making when production planning departments need to rotate to its employees and place them under conditions of work completely outside the recommended by international standards; remember that the idea is to reduce problems caused by Musculoskeletal and postural aspects mainly. But even more, it seeks to establish the importance of selecting the most suitable operators according to condition them physics prevailing in the company when they are unwilling to invest their resources in the design or redesign of ergonomic elements. This follows the traditional procedure of anthropometric evaluations.

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II. Anthropometric Evaluation

The reader should know that a technique which forms an integral part of the Ki anthropometry, also known as anthropometric technique and is used to capture different dimensions of the human body with the objective of estimating body composition [CC] through a protocol of measurement as well as the implementation of various equations for the estimation of the CC. This is a doubly indirect method, as well as the assessment of body composition techniques most used in practice.

Anthropometric measurements are made on the basis of the recommendations of the regulator normative body reference regulator Ki anthropometry international sweetened from the international society for the advancement of Ki anthropometry.

An anthropometric analysis in the manufacturing field gives the opportunity to control those parameters physicists-anthropometric that limit physical performance and productivity.

In the next section the author describes succinctly aspects to consider before doing fieldwork for a study of this nature, information itself that must socialize with all employees.

A high sense of responsibility by the executors of the measurements is required since it is known personal aspects of persons, aspects that not all people are willing to be valued by anyone.

A. Basic Considerations

The subject will collaborate must be informed of all measures that would be taken, then must fill out and sign a form verifying that they are in accordance with the activities; for example: which should occur with the least amount of clothing possible, very necessary activity as part of the experimental protocol.

Once the physical conditions are to start, the first thing that will be done is demographic marking and measuring session. [Scan will begin marking the anatomical landmarks and anthropometric references needed for the study.

Measures shall be taken in a practical and comfortable order as for example which marked the anthropometric returns].

To achieve the above, this subject should be kept upright, relaxed, comfortable arms at the sides, and the feet slightly apart [sometimes must collect completely feet].

The anthropometrist should move freely around the subject free-form measuring instruments to handle comfortably and efficiently. Some other basic considerations, [2]:

1) The exploration will take place in a sufficiently wide room and a comfortable temperature. The studied subject will be barefoot and with the minimum possible clothing (clothing), as shorts.
2) Body weight and height measures suffer variations throughout the day, so it is desirable to make them in the morning.
3) With the aim of allowing comparisons of measurements in any population group, will take place at right hemi-body. However in cases of limitation physical or dominance in the development of any limb, will be taken in hemi-body not dysmorphic.
4) Material will be calibrated and verified for accuracy before taking action.
5) Measurements should be repeated at least twice, and take a third if necessary. In the first case, the media is used and the second median. It is recommended to be able to get help from a scorer.

B. Data Collection

For the study was required as part of the profile of this auxiliary [note taker] know the techniques of measurement, since it must be able to verify the accuracy of the location of the site, and ensure the correct sequence of the points to be measured from the demographic dialing. It should be aware that there will always be errors in the measurements although the rules and procedures are followed to prevent them [3].

The most common cause is a miscommunication between members of the team of anthropometrics', ambient noise, etc. To minimize errors, the note taker may be repeated aloud the data which the anthropometrist has captured. Sometimes the measurements can be repeated and even take a third time. In the first case, the average value is used. In the second case the median for data analysis.

C. Equipment Anthropometry

The following items of equipment are essential for the anthropometrist tools.

Anthropometric Tape

It is used to measure perimeters. It is recommended that a tape is calibrated in centimeters and millimeters. In addition to measuring perimeters, it is also necessary to accurately locate different sites of skin folds, and mark the distances from the points or bony anatomical references.

Fig. 1 Anthropometric tape

Stadiometer

Used to measure height and sitting height. It is usually fixed to a wall, so subjects can align vertically in the right way.

Fig. 2 Stadiometer

Scale

The use of electronic scales is recommended.

Fig. 3 Balance

Anthropometer

This instrument is used to measure the vertical heights between locations or specific anatomical references in the subject and the floor or surface where sits.

Fig. 4 Anthropometer

Segmometer

Used for segmental length measurements. The Segmometer is designed to be used in replacement of the Anthropometer, although it is not suitable for measuring large bone diameter.

Fig. 5 Segmometer

Caliper

It is used for measuring skin folds. Must be well calibrated or otherwise tide measurements will be incorrect.

Fig. 6 Caliper

D. The Anthropometric Profile

According to the International society for the advancement of Ki anthropometry [ISAK], is taken as a general rule that there are two 'profiles' anthropometric general application commonly used for anthropometric evaluation, referred to as restricted and full profiles.

In this work the authors have opted to develop the Protocol for profile restricted according to the resources which are the conditions imposed by the company.

From country to country, some ways to describe segments to measure may vary; however, to promote standardization adopted the concepts by the ISAK.

E. Anthropometric Profile Restricted

In addition to height and weight, this restricted profile requires the following measures now denoted.

TABLE I
RESTRICTED ANTHROPOMETRIC PROFILE

Skin folds		**Perimeters**	**Diameters**
Triceps	Abdominal	Arm (relaxed)	Humerus
Sub-scapular	Thigh (front)	Arm (bent)	Femur
Biceps	Medial calf	Waist (minimum)	
Crest iliac	Armpit medial	Buttocks (hip)	
Supra-Spinal			Calf (maximum)

F. Total Anthropometric Profile

In addition to height and weight, this total profile requires the following measures.

TABLE II
TOTAL ANTHROPOMETRIC PROFILE

Folds	**Perimeters**	**Length**	**Diameter**
Triceps	Head	Acromial-radial	Biacromial
Sub-scapular	Neck	Radial styloid	Biliocres-tydeus
Biceps	Arm (relaxed)	Medioestiloidea-dactiloid	Transverse chest
Crest-iliac	Arm (bent)	Ileospinal to the floor	Anteropost chest
Supraespine	Forearm (max)	Trocanter to the floor	Humerus
Thigh (front)	Doll estiloidestal	Trocanter-tibial side	Femur
Medial calf	Chest mesoesternal	Tibial side to the floor	
Armpit medial	Waist minimum	Medial tibial-ankle	
	Buttocks (hip)	Length of the foot	
	Thigh 1cm of the buttock	Sitting height	
	Thigh med troc-tib-lat		
	Calf (max)		
	Ankle (minimum)		

G.Definitions of Some Fundamental Lines of Anthropometric and Ergonomic Parameters

Below are described according to the ISAK [6].

1) Yuguloxifoidea. D. straight between the fork of the sternum and the tip of the Appendix xiphoid.
2) Epigastric. D. straight from the epigastrium to the pubis.
3) Xifo-epigastric. D. of xiphoid appendage and epigastrium.
4) Upper limb (up to the wrist). D. from the birth of the arm (shoulder) to the styloid process of the wrist with the outstretched arm.
5) Lower limb (up to the malleolus). D. of the trochanter to the malleolus.
6) Transverse chest diameter. D. longitudinal antero-post chest measured at the height of the nipples.
7) Diameter Antero-posterior chest. D. internal chest measured between the breastbone and the dorsal 6th.
8) Hypochondriac transverse diameter. D. longitudinal antero-post chest measured at the height of the hypochondria.
9) Diameter hypochondriac antero-post D. internal chest measured at the height of the hypochondria.
10) Diameter bi-iliac crest. D. internal measured between the iliac crests.
11) Stature (height). D. vertically from the ground to the vertex, taken on a person's foot, upright and with the front-facing view.
12) Height from floor to eyes. D. vertical floor to the outside corner of the eye, taken a person's foot, upright and with the front view.
13) Height from floor to shoulders. D. Vertical shoulder floor to standing position.
14) Floor-to-elbows. D. Height floor going to the junction of the arm and forearm.
15) Minimum of arm. D. horizontal from the back of the seat to the vertical axis of the hand with the arm parallel to the middle line of the trunk and the forearm and clenched fist forms an angle of 90 ° with the arm.
16) Maximum range of arm forward. D. horizontal from the back of the seat until the vertical axis, to that occurs in the hand with a closed fist and holding an axis, when the individual has the outstretched arm.
17) Wide elbow to elbow. D. which separates the lateral surfaces of the elbows, measured when they are bent, slightly supported the body
18) From seat elbow. D. vertical from the seat to the elbow in 90 ° position.
19) Thigh from the seat height. D. vertical from the surface of the seat to the top of the thigh, next to the abdomen.
20) Sacrum-popliteal distance. D. horizontal from the outer part of the sacrum to the back of the knee.
21) Distance sacrum. D. horizontal from the outer part of the sacrum to the front face of the kneecap.
22) Width of hips. It is horizontal between the hips and sitting as far as.
23) Popliteal height. D. vertical from floor to the immediately posterior region of the knee with the seated individual erects trunk and legs at 90 degrees.
24) Height of the thigh from the ground. Vertical D. with the subject seated from the ground to the top of the thigh.
25) Lower limb (up to the malleolus). Vertical D. ranging from root of the thigh to external malleolus.

Although it is not the main objective of this work, the capture of these segments used to calculate also the Somatotype, body fat relative to [using a regression equation], the area index is body surfaces, the body mass index, ratio of waist to hip, distribution patterns of fat and perimeters corrected by skinfold measurement, estimating the bone mass muscle, fat and residual.

In addition, can be a parallel study of proportionality; comparative studies among several populations that are of interest. There is a great opportunity for analysis only performs an anthropometric study.

TABLE III
CLASSIFICATION OF SOMATOTYPE

	Endomorphism: [IN]Rel.: relative fat and carving.	Mesomorphs' bone-muscular strength / size.	Ectomorph's: [EC] rel.: weight with size.
Under 0-2.5	Low relative adiposity, low fat subcutaneous, with visible muscle and bone contours.	Under related muscle-skeletal development, bone narrow diameters; narrow muscle diameter; small joints in limbs.	Relative linearity, high volume per unit of height; round; relatively bulky limbs.
Moderate 2.5-5.5	Moderate relative adiposity; subcutaneous fat covers contours muscle and bone; softer appearance.	Moderate development skeletal muscle; greater muscle volume, with the bones and joints of bigger dimensions.	Moderate relative linearity; less volume per unit of height; more stretched.
High 5.5-7.5	High relative adiposity; abundant subcutaneous fat; roundness in trunk and extremities; increased accumulation of fat in the abdomen.	High development on skeletal muscle; large bone diameters; muscles of large volume; large joint.	Moderate relative linearity, low-volume per unit of height.
Very high ≥ 7.5	Relative adiposity is extremely high; very abundant subcutaneous fat and large amounts of fat in the abdomen and trunk; very proximal limb fat concentration.	Development on skeletal muscle extremely tall and bulky; skeleton and large joints. Muscle or skeletal mass can prevail; the development is not always similar.	Extremely high relative linearity; very stretched; thin as a pencil; minimum volume per unit of height.

On the other hand, applies also the somatotype anthropometric technique that offers a quantitative synthesis with very specific mathematical interpretation.

This deals with three indices which refer to endomorphic, mesomorph and ectomorph components.

When these three elements are known, you can generate multiple comparative analysis, planning and evaluation of different populations with ergonomic approaches or biomechanical [4].

To achieve a proper interpretation of the somatotype indexes should understand since it is through them that can be classified the values as low, moderate, high and extremely high.

A brief description would be that expressed in the above table [8].

TABLE IV
METHODS FOR STATISTICAL ANALYSIS OF SOMATOTYPE

	Individual analysis	Analysis by groups
Coordinates 'X' "AND"	SDD (dispersal distance of the) Somatotype). Uses the X, and individual to a Somatotype reference = no.	SDI (Somatotype Dispersion index) = (Σ SDD) /n = SDDSM (distance between Somatotype dispersion) INDEX "I" SM1 and SDI1 Vs. SM2 and SDI2
Component of somatotype	SAD (morphogenetic distance of the) Somatotype). You use the Endo, Meso and Ectomorfia = individual number regarding a somatotype reference	SM = (Endo - Meso - Ecto) SAM (Dispersion medium morphogenetic of the) (Somatotype) = (Σ SAD) /n

III. The Anthropometric Profile

The study carried out by this group of seven people [academics], sixteen auxiliary for the capture of data [students] in Industrial Engineering from the Autonomous University of Baja California, with the support of the company [two internal collaborators] is of type: *observational-transversal - prospective-not experimental.* The results of the measurements are exposed by taking into account that they are only averages.

The reader can access the databases generated by applying directly to the authors.

Ten sessions were held in blocks of 5 people to explain to them what the study. In the company there is a time called "time" during the day and consists in that the company gives 5 minutes a certain quantity of operators at intervals varied time so do physical exercises and relax your body. Taking advantage of this moment was measured forty-eight employees in a total of ten hours.

Measuring elements are mostly portable and it represented no problem transporting them. Was an agenda of measurements that all sessions were scheduled at a same time always in agreement with the Department of planning and control of production and under the right conditions for a work of this nature, that is, to ensure a suitable environment: quiet, private, illuminated, tidy and clean; with subjects measured previously informed of the activity.

A. Scientific Validity Methodologies Used

The protocol proposed by the ISAK is used for this study. In the case of an industry maquiladora with which our University has a specific agreement of collaboration anthropometrics' team obtained access only to perform protocol restricted profile of 17 variables.

Protocols for dimensioning of the equipment design are likewise taken COUPLED-PHESANT since data are easily combinable. They have clear restricted profile must develop a format for recording data.

In the literature there are many choices of formats, you can use several of them; However more importantly the technique to be used for the lifting of the measurements [5].

Always follow the established protocol and sequence, must be clear and fast measurements without sacrificing the quality of data. Once data are captured in a format [or calculation template] is the corresponding statistical treatment for the generation of the percentiles, also another template can be used for data conversion.

Finally, anthropometric tables that are generated will allow calculating the values required by the designs of the stations.

B. Software

1) Somatotype - calculation and analysis V1.1. A new program of the PDF platform easy to use comprehensive designed to calculate individual somatotype / group, import and export data from somatotype. Displays reports, statistics, somatotype-plots, categories and comparisons of individuals / groups.
2) HC_ Stype Calculation - 03.xls. A simple program to calculate the somatotype of Heath Carter Anthropometry. Useful for individual data or group.
3) Life Size. V1.0. developed by T. Olds and K. Norton. It is a tool that helps in collecting and anthropometric analysis has a database containing the rules of Somatotype, body fat and skin folds for the general population and specific sport groups. It is an explorative and interactive educational tool for students Anthropometry. Is what is used in this work [http://www.humankinetics.com].
4) B.O.R.I.S. Developed by Peter Alexander. Is software in Spanish for anthropometric evaluation that including the Somatotype.

C. Data Extraction

This activity was carried out using the Manual of the ISAK Kinanthropometry [6]. The samples were reviewed separately. Technical error estimate should have a tolerance of 5% in the folds and 2% for all other measurements.

Taking advantage of the amount of data, defined Somatotype [average] each of the built-in groups and the coefficient of dispersion between groups [SDD]. After all this is with the statistical analysis.

The data are studied through the software SPSS 13.0 and 16.0 MINITAB. It expects the Kolmogorov-Smirnov test results reveal a normal distribution in all of the captured variables, therefore use the Student T test to establish differences between the groups.

A correlation analysis is generated to determine the type and level of relationship between the variables. Any case, established a confidence interval of 95% for all cases.

Although there is no specific consensus of determined procedure must be followed for the analysis and construction of the somatotype-Charter, here is used the calculation: Heath-Carter attempting to always numerically describe the morphological configuration of women workers at the time of be studied.

Developers ensure that the type of people is influenced by external aspects such as: age, gender, growth, physical activity, food, environmental factors, socio-cultural environment and race.

Thus, following the Protocol, Somatotype letter is generated after obtaining the somatotype indexes [EN, ME, EC].

They are calculated two ordinates [x; and]:

$$x = EC - EN; y = 2ME - EC + EN \qquad (1)$$

With this somatotype can be located on a flat die. The author [8], refers us to a brief explanation of this concept when he mentions that an EC > in, gives a positive result in the x axis; to the right, indicating greater mass.

While moving to the left suggests more subcutaneous adiposity. To the axis of the supremacy of the ME on the EC and in takes the result towards the positive side indicating greater muscle bone mass. More full - bodied, a higher value on axis [7].

IV. Anthropometric Protocol

Below we present the procedure followed in this case. The reader should be careful to follow the sequence to avoid confusion in the interpretation of results.196 Employees who participated in the study have a very particular origin taking into account that in general terms the origin of the population of employees is widely dispersed geographically.

This is not surprising given that in the city of Tijuana, there is a very floating population and the residents come from all the States of the Mexican Republic and over 38 countries of the world.

For avoids the mix of cultures between measured employee [because among the sample selected are people of Japanese, Chinese, Korean and Mexican] resorted to a previous analysis to detect Mexican children of Mexican parents and grandparents Mexican.

All of them female gender [predominantly workforce is represented on the production floor for women]. The following table contains the information generated in this stage of the work.

TABLE V
Number of Subjects by Production Line, Shift

Group	# Line	Turn	#	%	Activity
TO	1	Morning	36	18.37	Jointer
B	4	Evening	28	14.27	Jointer
C	7	Night	30	15.31	Jointer
D	10	Morning	31	15.82	Jointer
E	13	Evening	32	16.33	Jointer
F	16	Night	39	19.90	Jointer
T O T A L			196	100.00	

All of the selected employees are assembling machines. Their tasks have a high degree of repetitive motions. The same is true of postural efforts.

Although determine or infer statistically ergonomic risk levels is not the objective of the study that shows that the benefits of the development of anthropometric tables. Fig. 7 shows the distribution of age groups.

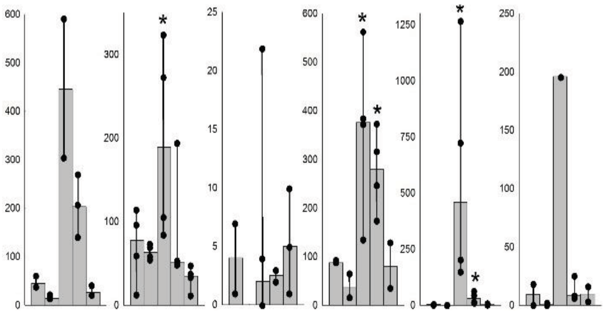

Fig. 7 Distribution of ages for production lines

The company has a total of 5600 employees who work 365 days a year. They have three floors in the city. Of the total number of workers: 4778 are classified as direct labor. It was taken as an object of study a plant where there are 1978 employees, 10 lines of an electronic component Assembly, 196 employees distributed over three shifts in the selected line. This production line is supervised by two engineers and three technicians. 100% Manual tasks are required by the type of component to assemble the cycle time is 28 seconds. Table VI presents the anthropometric data of the population by age.

TABLE VI
Distribution by Age Group

Age	n	%
18-30	69	35.21
31-40	88	44.89
41-50	30	15.31
51-60	9	4.59

TABLE VII
Anthropometry of the Assembly Worker

Parameter	Unit	Media	Range	DEM
Age	Years	36.7	21 60	2.37
Size	cm	158.4	151.2 169.5	7.3
Weight	kg	58.7	50.4 71.5	
Chest perimeter				
Rest	cm	98.16	94.2 104.5	3.7
Forced inhalation	cm	105.3	99.7 108.6	1.8
Maximum expiration	cm	94.3	90.9 99	2.1
Perimeter skull	cm	56.08	55.3 57.01	1.9

Tables VII and VIII include data of means, ranges, the standard deviations and statistical analysis with the acceptance or rejection of the parameter value, is used for this calculation the Shapiro-Wilk test.

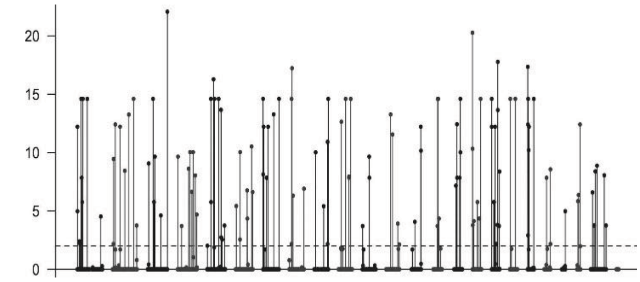

Fig. 8 Graph of distribution of data with the Shapiro test

Maid's ages were analyzed being distributed of the following way. 3724 Restricted profile data are captured and are housed in a database in Ms. Access.

There are variables that cannot be variability in these graphs demonstrate the usefulness of the test in order to optimize efforts in measurements.

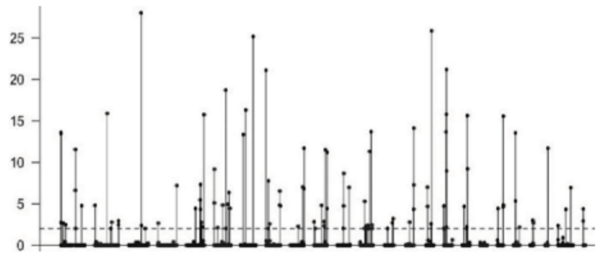

Fig. 9 Graph of deviations of data with the Shapiro test

Distance Somatotype attitude (SAD). The SAD is the difference in exact, in between two somatotype components units, where: ENDO = Endomorphs; MESO = mesomorphs; ECTO = ectomorphs.

$$SAD_{A,\ B,\ C,\ D,\ E,\ F} = \sqrt{\ } [[ENDO_{to} - ENDO_B -_C ENDO - ENDO_D -_F ENDO - ENDO_G]^2 + [ECTO_{to} - ECTO_B -_C ECTO - ECTO_D -_F ECTO - ECTO_G]^2 + [MESO_{to} -_B - MESO\ MESO_C - MESO_D - MESO_F - MESO_G]^2] \quad (2)$$

The average attitude of Somatotype (SAM) used here corresponds to the average of a group of Somatotype:

$$SAM = \sum SAD_i / n_x \quad (3)$$

where SAD_i is the somatotype of each subject least somatotype Middle group; $_x$ is the number in the Group of x. We also calculated the variance of the data:

$$SAV = \sum SAD_i^2 / n_x \quad (4)$$

Two equations are used for comparisons between independent samples. The first is known as T-RATIO in the literature where:

Ŝ is the average of the group concerned and SAD refers to groups properly:

$$t = \hat{S}_1 - \hat{S}_2 / \sqrt{\ } [\sum [SAD1^2] + \sum [SAD2^2] + \sum [SAD3^2] + \sum [SAD4^2] +][\sum [SAD5^2] + \sum [SAD6^2]] / [n1 + n2-2] * [(1/n1+1/n2)] + [n3 + n4-3] * [(3/n3+3/n4)] + [n5 + n6-5] * [(5/n5+5/n6)] \quad (5)$$

The second equation is the ANOVA, f-RATIO, where the subscripts: t = treatment, e = error; j = (j) groups; $_{Or}$ m = average somatotype general combination of groups:

$$F = [SS_t DF_t] / [SS_{ee} DF] = MS_t / MS_e \quad (6)$$

$$SS_t = \sum n_j [\hat{S}_j - M_{or}]^2, \text{ and } SS_e = \sum\sum [SAD_j^2] \quad (7)$$

$$SS_{t1} = n1\ [\hat{S}_1 - M_{or}]^2, \text{ and } SS_{t2} = n2[\hat{S}_2 - M_{or}]^2 \quad (8)$$

TABLE VIII
STATISTICAL ANALYSIS OF THE BASIC LINES

Anthropometric line (cm)	Media	VE	DEM	Shapiro Wilk
XifoideaYugulo	20.5	20.10 0.93	1.1	TO
Epigastricsymphysis	20.4	19.00 1.20	1.8	TO
EpigastricXifo	10.4	9.75 10.99	2.2	TO
Upper limb (up to the wrist)	53.2	52.25 3.56	1.7	TO
Lower limb (up to the malleolus)	73.6	71.45 8.00	3.8	R
Transverse diameter chest	26.8	25.20 7.10	0.5	TO
Diameter bitrocanter	29.8	26.70 0.90	1.8	TO
Diameter antero posterior thorax	20.3	19.85 1.84	1.4	TO
Transverse diameter Hypochondriac.	24.9	23.60 6.40	2.4	R
Diameter antero Subsequent hypochondriac.	18.7	17.82 9.51	2.4	TO
Bi-crest iliac diameter	29.4	28.20 9.70	2.4	TO

[SEES]: mean extreme values. [DEM]: standard deviation of the mean. Shapiro-Wilk test: Level of rejection p-value < 2 queues. Representation of the table: A = acceptance: value x: 0.01 and 0.099, R = rejection: Value x 0.10 to 0.49, RF = strong rejection: value x: > 0.50.

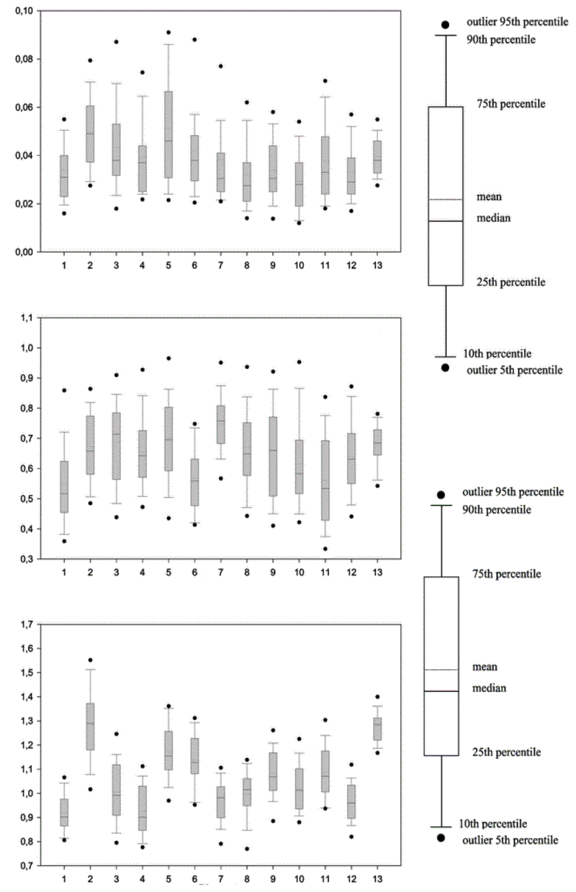

Fig. 10 Output graphic of the student t tests Test A

These data accepted by the aforementioned test presented a value of "x" between: 0.01 and 0.099. The interesting thing about the case is that they were also rejected three parameters: scope / vertical arm maximum, length hip and perimeter-cranium with the value of x > 0.50. Therefore, their values should not be considered.

TABLE IX
NUMERICAL RESULTS OF A TEST

A-Squared = 0.24	Minimum = - 3.12654
P-Value = 0.789	1st Quartile = - 0.26597
Mean = 27.89	Median = - 0.00048
StDev = 0.99751	3rd Quartile = 0.69697
Variance = 0.97823	Maximum = 2.78891
Skewness = 0.12366	95% CIM = - 0.178569 [0.207863]
Kurtosis = 0.078565	95% CIStDev = 0.78456 [2.36581]

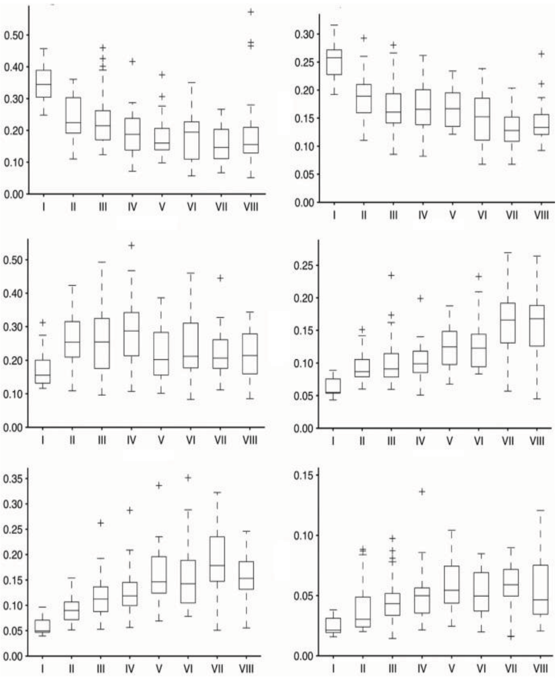

Fig. 11 Output graphic of the student t tests Test B

The previous figure displays information of the ten lines of production in the plant. Data to generate this graph is taken from the production planning department. You must select the second line by providing the best distribution in the tests A and B. The figure that are shown below contain information about fast outputs distributed in six blocks of experiments conducted to determine levels of variability among our six groups of selected employees. In Fig. 11 and 12 you can see clearly the variability that exists among the different groups of measurement both within each group and among them [9].

TABLE X
NUMERICAL RESULTS OF THE B TEST

A-Squared = 0.24	Minimum = - 3.12587
P-Value = 0.778	1st Quartile = - 0.265615
Mean = 26.99	Median = - 0.00059
StDev = 0.98998	3rd Quartile = 0.694589
Variance = 0.97789	Maximum = 2.77152
Skewness = 0.12256	95% CIM = - 0.178563 [0.207124]
Kurtosis = 0.07758	95% CIStDev = 0.78236 [2.36897]

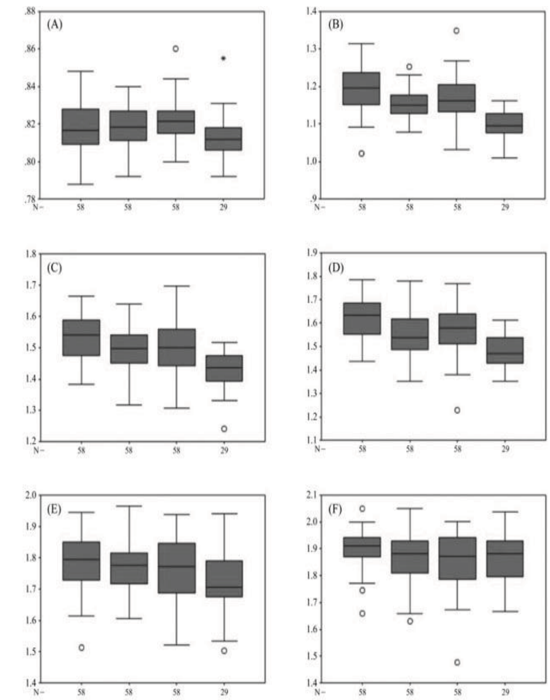

Fig. 12 Output graphics with student's t test SPSS

TABLE XI
STATISTICAL ANALYSIS OF THE ERGONOMIC PARAMETERS

Parameter (cm)	Media	VE	DEM	Shapiro Wilk
Height	158.4	151.2-69.5	2.37	TO
Height from floor to eyes	148.1	141.4-55.1	0.52	TO
Height of floor acromion	135.0	129.0-143.1	2.35	TO
Height from floor to elbow	65.3	62.3-5.7	3.01	TO
Sitting height	115.5	110.6-125.3	2.18	TO
Eye height, sitting	109.5	107.7-111.1	1.45	TO
Seat height to elbow	24.3	24.3-25.0	0.90	TO
Height popliteal fossa sitting	41.1	39.2-43.9	3.06	TO
Thigh height from seat (sitting)	13.0	12.5-15.0	0.40	TO
Thigh height from soil (seated)	54.0	52.8-55.3	2.65	TO
Max vertical range arm	207.2	202.1-220	4. 93	RF
Vertical reach min arm	201.9	197.0-113.3	1.01	TO
Reach maximum arm forward	73.8	69.9-78.4	2.05	TO
Scope minimum arm forward	43.0	39.5-47.0	1.16	TO
Wide hand	10.4	9.0-12.1	0.96	TO
Length of hand	17.1	16.5-18.1	1.70	TO
Wide foot	9.2	8.9-9.4	2.30	TO
Long foot	23.9	22.7-24.4	2.91	TO
Width of hips	36.5	34.5-38.0	4.74	RF
Distance sacrum-popliteal	46.0	43.0-48.5	1.56	TO
Distance sacrum-rotula	50.0	47.0-53.1	2.45	TO
Perimeter of the skull	56.08	54.3-57.6	5.41	RF
Deltoid perimeter	110.2	108-112.3	3.10	TO
Perimeter meso-stern	98.1	96.2-104.5	1.70	TO
Abdominal perimeter waist	88.4	85.0-95.3	3.84	R
Hip perimeter	91.5	89.0-96.1	1.06	TO
Half of relaxed arm perimeter	27.6	26.9-28.0	3.60	TO
Average perimeter arm flexed and taut	32.4	30.1-36.6	2.00	TO
Perimeter forearm	26.8	26.4-27.0	1.34	TO
Perimeter upper thigh	55.0	54.5-58.4	1.18	TO
Average perimeter leg	33.1	34.0-35.7	2.12	TO

TABLE XII
STATISTICAL ANALYSIS OF STATURE

Population: 196 workers/Assembly			
Age years		21-60	
Size cm.			
Minimum		151.2	
Quartile 1		154.6	
Media		**158.4**	
Quartile 3		166.7	
Maximum		169.5	
Deviation Std.		2.37	
Standard error		0.17	
Percentiles are calculated for this parameter according to the data entered for this analysis.	1	1	151.1
	2	5	153.3
	3	10	153.9
	4	20	155.2
	5	30	156.4
	6	40	157.2
	7	50	158.4
	8	60	160.7
	9	70	162.4
	10	80	164.1
	11	90	165.5
	12	95	167.8
	13	99	169.2

Percentile calculated according to: $n = Z^2{}_{\sigma/2\ d2\ *\ e2}$

Table XII shows an example of results. The parameter "size" whose ẋ = 1,584, with VE = 1.512 and 1,695 m, 2.37 standard deviation and standard error of 0.17.

With the help of http://anatronica.com/index.html and according to this data and designs of areas working areas that are more likely to be injured are shown below.

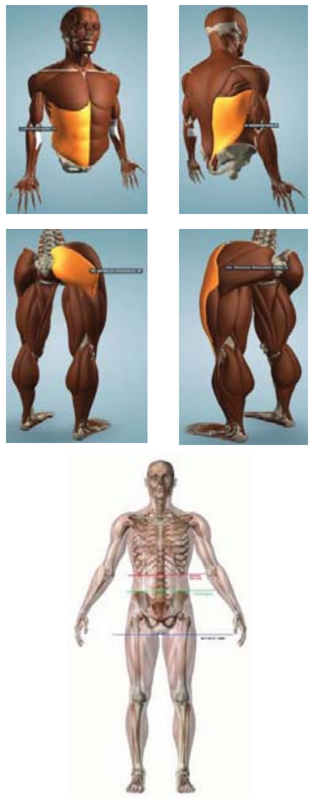

Fig. 14 Body areas proposed for future postural analysis

V. Analysis of Results

In the literature we find that anthropometric studies at national level have been made. We have the case of the anthropometric study made by the National Chamber of the clothing industry for the measures of the human body of the Mexican population.

Some of the results the study in February 2012 are: the average height of women between 18 and 25 years is 1.60 m; in relation to the weight, in women aged 18 to 25 years the average is 62.90 kgs, of the 40 to 50 years the average weight in women increases to 72.15 kgs. In women between 26 and 39 years, the average weight in the Center is of 72.62 kgs, while the other is 67.35 kgs. The average height of women in the downtown area is 1.62 m, in the North is 1.58 m and in the southeast of 1.55 m. No doubt these data support the measurements carried out by this research team.

Anthropometric analysis reveals all the information necessary to generate proposals for improvement in several respects.

VI. Conclusion

1) Ergonomic Design

During the execution of this work the team of collaborators could notice several situations that put at risk the health of workers, for example: Dimensions of working spaces are not the best, in fact they lack the basic elements for developing their daily tasks. In addition to this work tables are not flexible and therefore cannot be adjusted to the characteristics of the plate joiner leaving them in most cases very low. This leads to the need for postural studies.

2) Postural Analysis

In an interview with the Manager of the Medical Office of the company mentioned that so far the 2013 have record 38 cases of disability for injuries back. It is interesting that the company so far has not taken preventive measures to reduce the incidence of this taking into account that in Mexico [and in many countries] fines them and penalties imposed by health and governmental dependencies us quite costly. It has served these people in a very superficial manner since the objective of the office is not to take corrective action. As a recommendation, an analysis of positions should be done to detect the most critical areas for operators. This is a very objective background to start this analysis.

3) Lifting of Load

There are elements that exceed the limits recommended for cargo lifts within the distribution of the work area. If to this we add that the level of operations these activities rising is much reduced can ensure that the risk of injury is very high.

4) Environmental Aspects

Lighting, ventilation is poor. In this company the carmakers must wear headgear and covers-mouth. This aspect of his activity after already represents six hours working a serious problem. In fact, pate d in our work deals with the variables of inhalation and expiration maximum and enforced; this while maintaining a pace of breathing with these elements covering nose and mouth it is not pleasant. Variables data reveal this fact with forced inhalation ranging from 99.7 - 108.6 cm and maximum expiration that goes from 90.9 - 99 cm. chests throughout the workday. On the subject of lighting [that it is not so critical because the company is in the process of renewal of lighting system] unless it is recommended to take into account the specific activity in each season to calculate the optimum levels of lighting. Noise levels exceed those allowed by international standards for these tests, do not use the safety devices provided by the company, indicating the need to socialize the potential risks of not respecting the company's security policies. On the subject of temperature, not greater problem is detected. The average temperature in the warehouse goes from 21°C (70°F) at 22°C (72°F).

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