

# USES AND CHARACTERISTICS OF THE HUMAN MODELING SOFTWARE ManneQuinPRO™V10.2 IN ERGONOMIC STUDIES

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**Resumen:** Este documento presenta una investigación sobre las características del software ManneQuinPRO™ V10.2 y su uso en análisis ergonómicos. Pretende facilitar el conocimiento y el empleo de este software de modelación humano. Este software ayuda a realizar análisis básicos durante el diseño, validación y comunicación en cualquier etapa de un proyecto de diseño. Se utilizaron varias fuentes de información, incluidos sitios de internet, manual del software y el sitio oficial del software. Dentro de sus características incluyen varias herramientas biomecánicas como la ecuación revisada de levantamiento NIOSH 1991, bases variadas de datos antropométricos y múltiples cálculos biomecánicos como masas de segmento, volúmenes, ubicaciones de centro de masas, fuerzas conjuntas, momentos y momentos de inercia. Otro propósito de esta investigación es mejorar las actividades educativas y promover el uso de esta herramienta de diseño de proyectos ergonómicos.

**Palabras Clave:** MannequinPro™, Maniquí, Software, Opción, Espacio de Trabajo.

**Abstract:** This paper presents a research about the characteristics of the ManneQuinPRO™ V10.2 software and its use in ergonomic analyses. It pretends to facilitate the knowledge and employment of this human modeling software. This software helps to perform basic analysis during the design, validation, and communication on any stage of a design project. Several information sources were used, including internet sites, the software's manual and the official software site. Within its characteristics includes several biomechanical tools such as the Revised NIOSH 1991 Lifting Equation, varied anthropometric databases and multiple biomechanical calculations including segment masses, volumes, center of mass locations, joint forces, moments and moments of inertia. Other purpose of this research is to enhance educational activities and promote the use of this design tool in ergonomic projects.

**Keywords:** MannequinPro™, Mannequin, Software, Option, Workspace.

## 1. INTRODUCTION

This project presents important characteristics and utilities of the digital human modeling software named MannequinPro™ using its last version 10.2; also, it pretends to give an objective introduction of some functions, components and tools of the software in order to facilitate the knowledge and use for ergonomic analysis.

In addition, this study pretends to introduce this software into educational activities and to encourage the use of MannequinPro™ tools to execute basic analysis on any phase of a design and ergonomic projects among students.

### 1.1 Objectives

The objectives that arise in this work are divided into one general goal and two specific objectives which are presented below:

#### 1.1.1 General Objective

To give an objective introduction of all the important functions, components and tools of the software in order to facilitate the knowledge and its use in an ergonomic analysis.

#### 1.1.2 Specific Objectives

- Introduce this software into educational activities.
- Encourage the use of MannequinPro™ tools to execute basic analysis on any phase of a design and ergonomic projects among students.

### 1.2 Justification and Scope

This research will provide information to researches and students about the characteristics of a Human Modeling software named MannequinPro™ and its advantages to design a work area due to its useful to simulate a certain condition.

The scope of this investigation is applied to any kind of investigation which requires Human Modeling.

## 2. LITERATURE REVIEW

Computer Aided Design (CAD) became available for aerospace and automotive manufacturers in the early 1960's (Hickey, 1985). The development and implementation of the CAD resulted in the construction of design in less time than usual; also allowed the search of a broader range of design solutions (Porter, 1990).

Main advantages of human modeling are reducing the time of the design process and optimize the human machine interface, automotive and aviation industries recognized its potential and started to use this tool since the late 1960's (Das, 1995).

On the other hand, traditional way to evaluate the design of a workspace has different approaches. First, the utilization of two-dimensional drafts mannequins in order to evaluate the workspace in the early stages of the design. Typically, these mannequins only represent a single view of the human, however more and different types of the human's view are also use in the assessment (Roebuck, 1995). Likewise, with the purpose of guarantee the proper view of most of the humans, and the totally reach of the controls, it is common to represent the 5<sup>th</sup> and 95<sup>th</sup> percentile statures in transparent mannequins to overlaid them on the drawings of the work area and evaluate them.

To assess a workspace in later stages of the design, the construction of a model and the use of mannequins based on anthropometric databases it's needed. These models give the researches the opportunity to recreate, simulate or analyze movements like walking, running, jumping or stepping over obstacles (Baritz, 2008), so Human Modeling is a useful tool in ergonomics due to it incorporates human body in the design of a wide range of products, facilities and equipment.

## **2.1 Modern Human Modeling Tools**

There are many models proposed to study the human body biomechanical behavior. All those models require elaborated analysis. The most important software description for this investigation is encouraged to MannequinPro™.

### **2.1.1 Human Modeling Software**

Between the most common software for Human Modeling it can be found SafeWork™, Jack™ and Mannequin Pro™ (Elliot, 2002).

#### **2.1.1.1 SafeWork™**

This software has a mannequin with more than 100 anthropometric variables and 148 degrees of freedom. It contains modules for postural analysis, ergonomic analysis, clothing, animation and collision detection and vision.

#### **2.1.1.2 Jack™**

Jack™ is a Human Modeling and simulation software that helps varies industries to improve the ergonomics of product designs and refine workplaces task. It has additional toolkits for workplace task analysis, motion and capture playback.

#### **2.1.1.3 MannequinPro™**

This software is a PC-based, 3 dimensional human factors, and human modeling software. MannequinPro™ has been available since 1990 and its price is around US\$1000 (Laws, 1997). This software package helps you perform basic analysis during the different stages of any space design project. Some examples of a design project could be an office, the inside of a vehicle, or any manufacturing floor.

Within its characteristics consist of numerous biomechanical tools that are used to evaluate and authorize human interfaced designs. Several of these tools embrace the Revised NIOSH 1991 Lifting Equation, multiple biomechanical calculations including segment

masses, volumes, center of mass locations, joint forces, moments and moments of inertia, and varied anthropometric databases.

In order to generate adult and child mannequins, MannequinPro™ uses multiple anthropometric databases. With this application the manipulation of a mannequin into the precise position that the design needs and includes a broad posture library with pre-defined postures. A mannequin can be created with following characteristics:

- Male or Female
- Adult or child
- From the 2.5, 5, 50, 95, 97.5 percentiles
- Of any size, when manual dimensions are entered

Furthermore, with MannequinPro™ the import of CAD sketches of any kind of spaces with or without mannequins (if necessary, the addition of new mannequins to the design) it is possible. The importation of CAD sketches allows the performances of several tasks to test mannequin's ability to reach an object or point, walking a mannequin along a prearranged path, and the use of a range of viewing angles and alternatives to determine whether or not peoples are compatible with the space.

MannequinPro™ with all it features and applications helps to adapt the design space to the wanted population characteristics, counting those who are physically challenged.

## **2.2 MannequinPro™ Case Studies**

This human modeling software has been effectively applied to different and extended range of problems. MannequinPro™ benefits Engineers, industrial designers, safety practitioners, and a variety of professionals to assess the human body dynamics in the design process of any facility, equipment or product. Two examples of this software tools are presented below.

### **2.2.1 Prevention of Occupational Hazards Onboard Fishing Vessel Using Ergonomic Digital Human Modeling**

This study presents the methods to improving the occupational health and safety of Spanish fishermen and the redesigning the work area onboard small fishing vessels. By used of ergonomic human modeling MannequinPro™ software, all fishermen's postures were computer-generated and evaluated. Moreover, risk factors on board fishing containers were founded and solutions for redesigning the work area on board in order to prevent occupational hazards in fishing activities were also established.

### **2.2.2 Ergonomics Wheelchair Design for the Aging People**

Among aging people are the diseases at the lower part that make difficult or impossible to walk or run. Therefore, a wheel-chair is needed for those aging people who have some disability in the lower part of their body. This study pretended to improve or redesign the wheel-chair in order to benefit aging people.

With MannequinPro™, product dimension and seating position were considered. An improvement resulted since the force needed to move the recommended wheelchair is

smaller than the current design. Another benefit is that gives an enhanced movement control and seating position. Likewise, product dimensions have improved and presented a better fit with the standard anthropometric dimension.

### 3. MANNEQUINPRO™ OVERVIEW

This section provides an introduction of the principal characteristics and tasks of the software along with pictures to facilitate its understanding.

#### 3.1 Introduction to Main Screen and Menus

##### 3.1.1 Main Screen

This software's main screen was designed with the purpose to be compatible with Microsoft Windows. This means that primary sections, hot keys, menu items, toolbars and project windows stay very similar to other Windows applications and software.

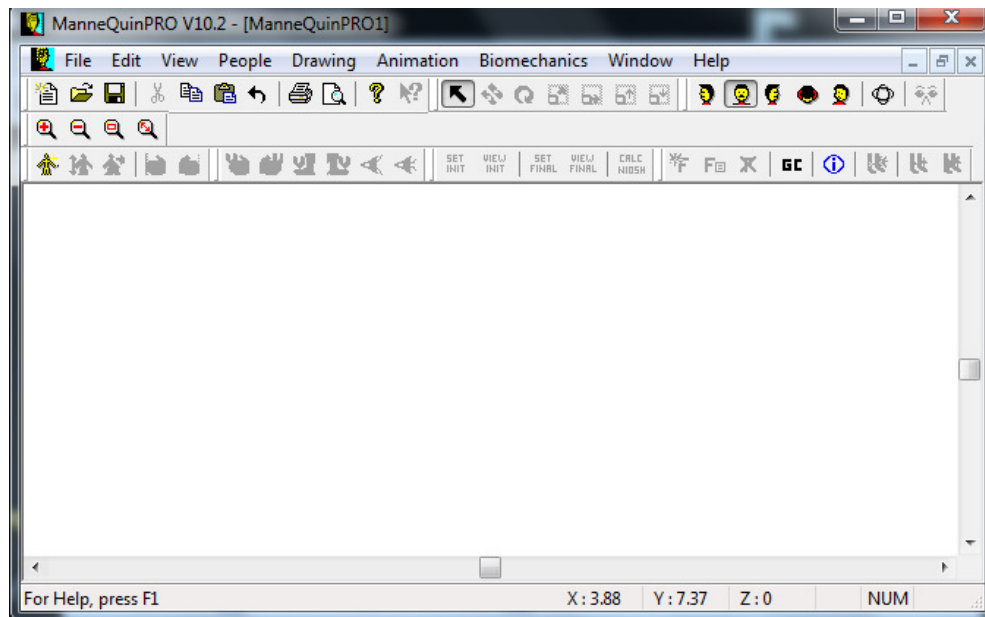


Figure 1. MannequinPro™ Main Screen.

##### 3.1.2 Menu Items

MannequinPro™'s menu items are organized into nine categories and each category has its list of functions and subcategories. The nine categories are: FILE, EDIT, VIEW, PEOPLE, PEOPLE, DRAWING, ANIMATION, BIOMECHANICS, WINDOWS, and HELP.

#### 3.2 MannequinPro™ Features and Tasks

This section focuses in the description of the different tasks and features that this human modeling software offers. This description would include the import of 3D CAD drawings, the creation of mannequins, and the performance of different analyses along with other functions.

### 3.2.1 Importing a CAD Drawing

MannequinPro™ allows importing 2D or 3D models from any CAD program such as AutoCAD. The formats that this software supports are .DXF format (Drawing Exchange Format) and .3DS format (3D Studio). This software is compatible with the early mentioned format in AutoCAD™ versions 11, 12, 13, 14, 2000 and 2002; also the importation of .MQP (MannquinPro™ format) files is possible.

The instructions to import any file are:

1. Go to File menu and select import.
2. Select the file format (.DXF, .3DS or .MQP)
3. Find and select the file from the directory
4. Set the units (inches, feet, millimeters, centimeters, or meters)

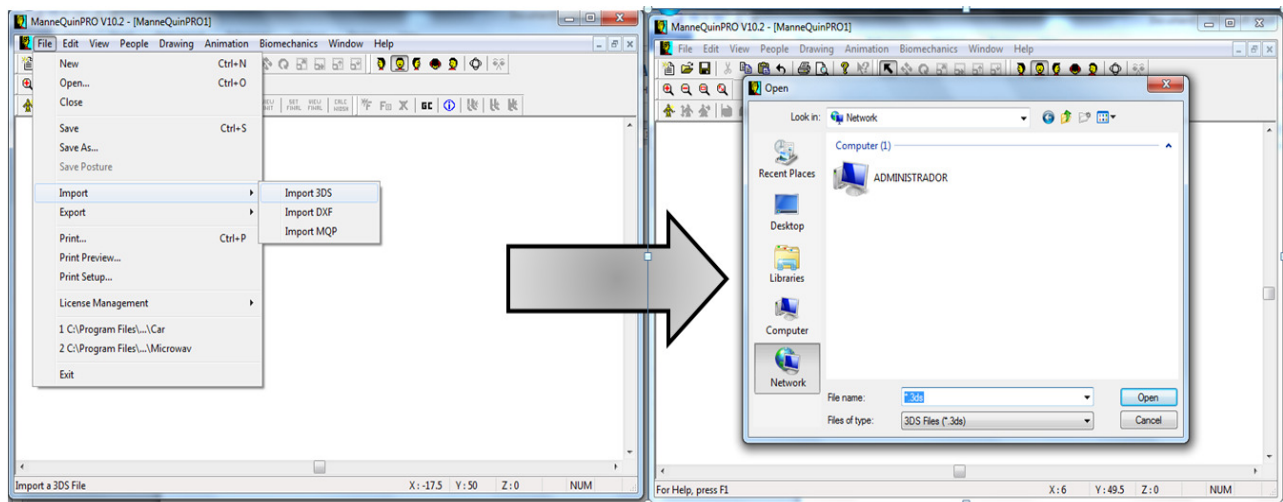


Figure 2. File menu and Open Dialog Box.

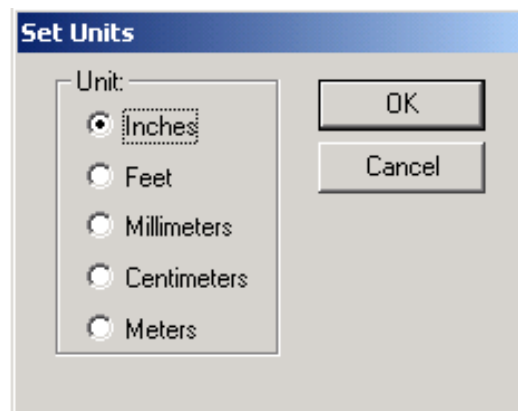


Figure 3. Set Units Dialog Box.

### 3.2.2 Creating a new mannequin

Once the importation of a drawing into MannequinPro™ has been completed, the next step is creating a new mannequin or mannequins to interact in the workspace. This software allows

creating a three-dimensional mannequin with different anthropometric characteristic that were mentioned earlier (section 2.1.1.3).

The steps to create a new mannequin are:

1. Chose People menu and select New Mannequin or click on the New Mannequin icon.
2. The Anthropometric customization dialog box appears. This dialog box gives the options to create the mannequin with the require characteristics for the analysis. These characteristics are described underneath.

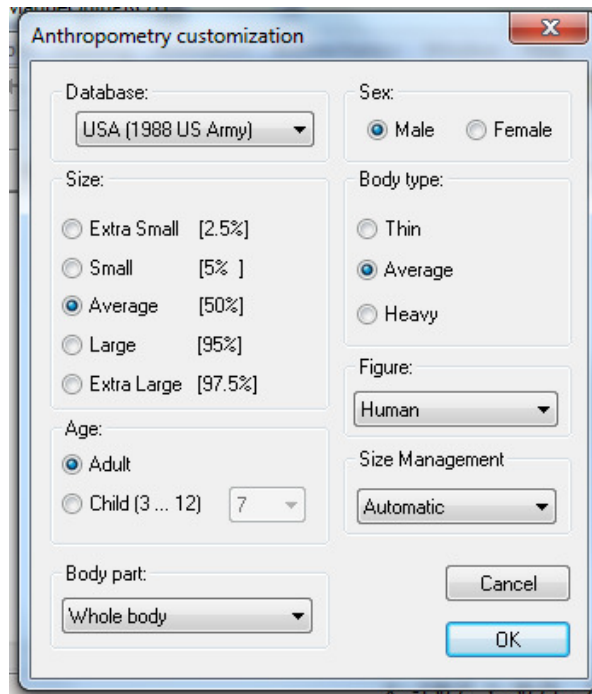


Figure 4. Anthropometric Customization Dialog Box.

- Database: this option is to select the applicable population for the asses. The population databases included in this software are: USA(1988 US Army), Britain, Germany, France, Sweden, Poland, Honk Kong, India, Switzerland, Japan, South China, North Europe, and NASA STD-3000.
- Sex: select Male or Female.
- Size: the statistical percentile for the mannequin that has the appropriate fit for the analysis is in this point.
- Body Type: Thin, Average and Heavy are the options.
- Age: this option indicates the selection of adult or child is made. If the child option is selected, is necessary to choose the child's age from 3 to 12 years.
- Figure: Human, Robot, Stick Figure, Skeleton or Human Form are mannequin models that are available.

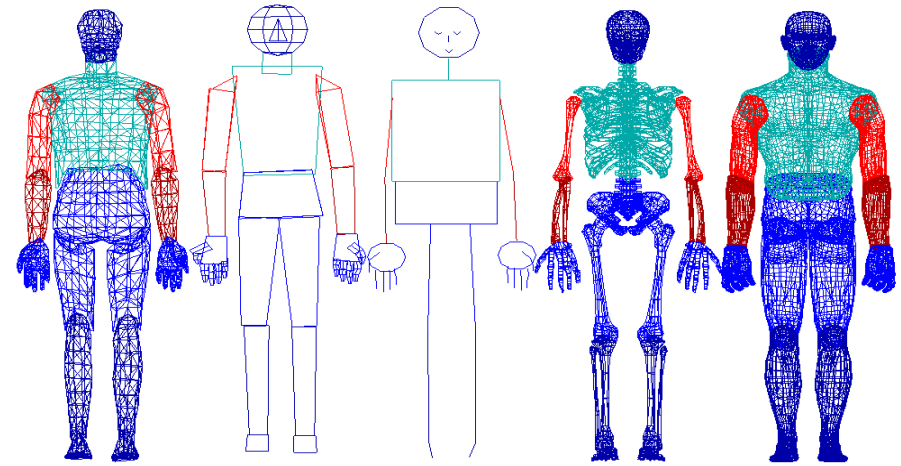


Figure 5. The five Mannequin Models Available

- Size Management: this option allows to create a new mannequin with the specifications that the assess needs.
    - Automatic: creates the mannequin automatically.
    - Semi-Automatic: creates the mannequin based on height and weight.
    - Manual: creates the mannequin with the anthropometric data for each part of the body.
3. When the anthropometric customization has been completed, the next step is to select the body posture that the analysis requires.

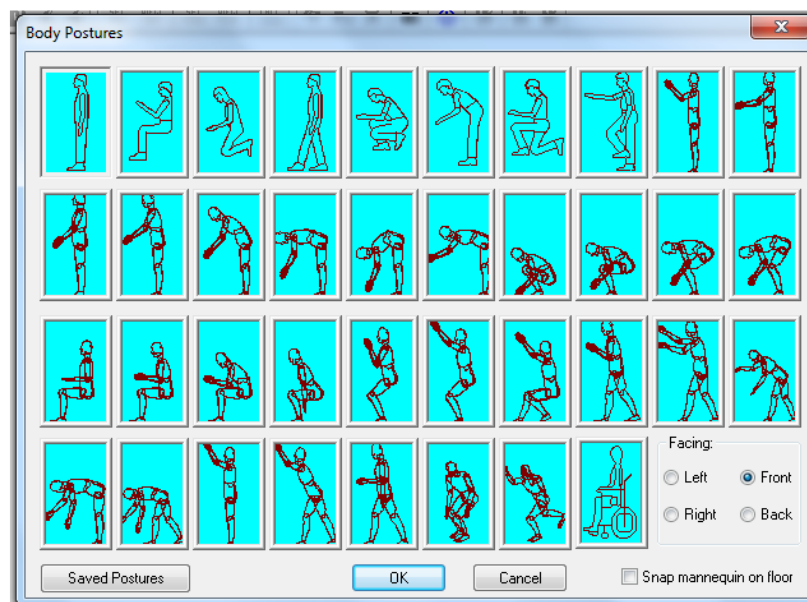


Figure 6. Body Postures Dialog Box.

### 3.2.3 Changing mannequin's posture

MannequinPro™ gives the opportunity to change the mannequin's posture. This is done by going into the People menu and selecting the New Posture option.



In addition, the selection of a new hand posture is possible. This option is located below the New Posture option and by click on it; the Hand Postures dialog box appears.

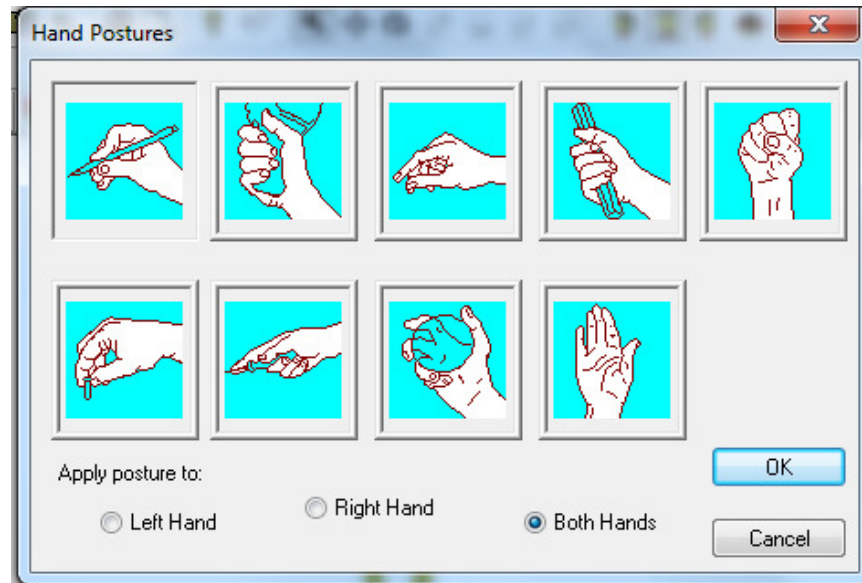


Figure 7. Hand Postures Dialog Box.

### 3.2.4 Presenting mannequin's field of view and view through the mannequin's eyes

This software presents the mannequin's field of view and the objects that are covered underneath that field in order to analyze interaction of mannequin in its environment. This option is selected by click on View Cone from People menu.

The View Cone option allows choosing from two alternatives. The first is the Optimum View Cone which is shown in magenta rays and the second is the Maximum Viewing Cone that is represented by the green rays.

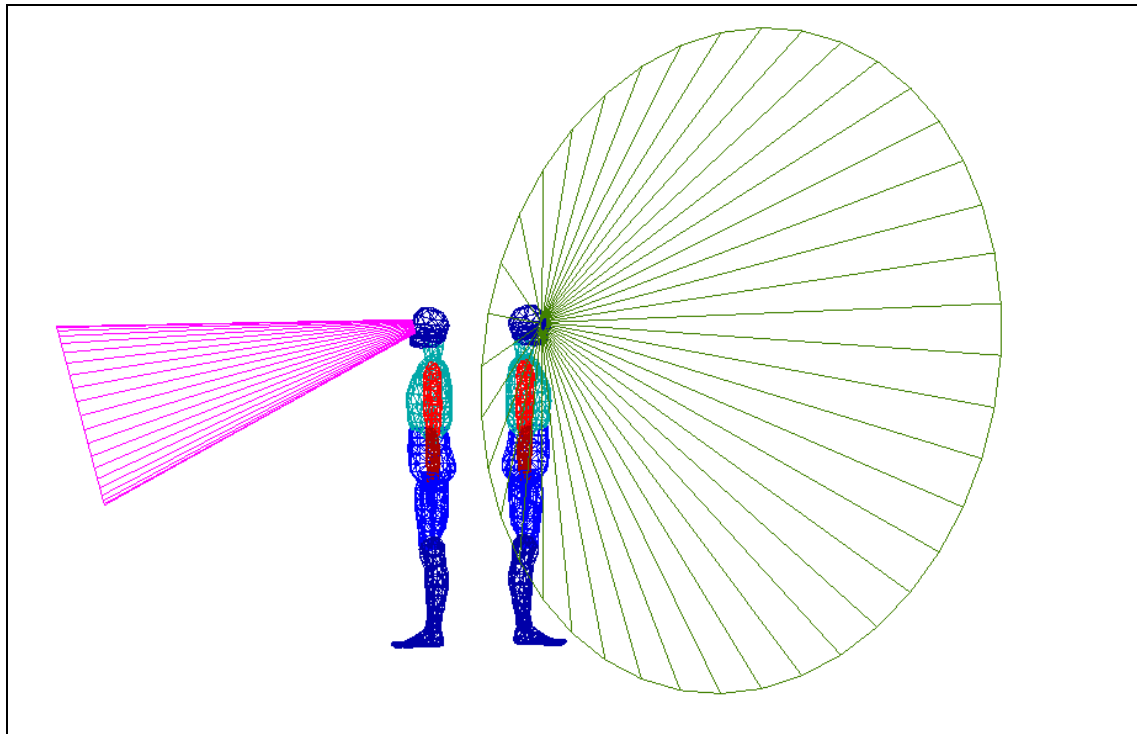


Figure 8. Optimum View Cone and Maximum Viewing Cone Example.

View through mannequin's eyes helps to determine if the mannequin is seeing every object of the workspace that needs to be seen. This option is accessed by choosing Eye View from the Viewpoint submenu under the View menu; also another way to access this option is by clicking on the Eye view icon.

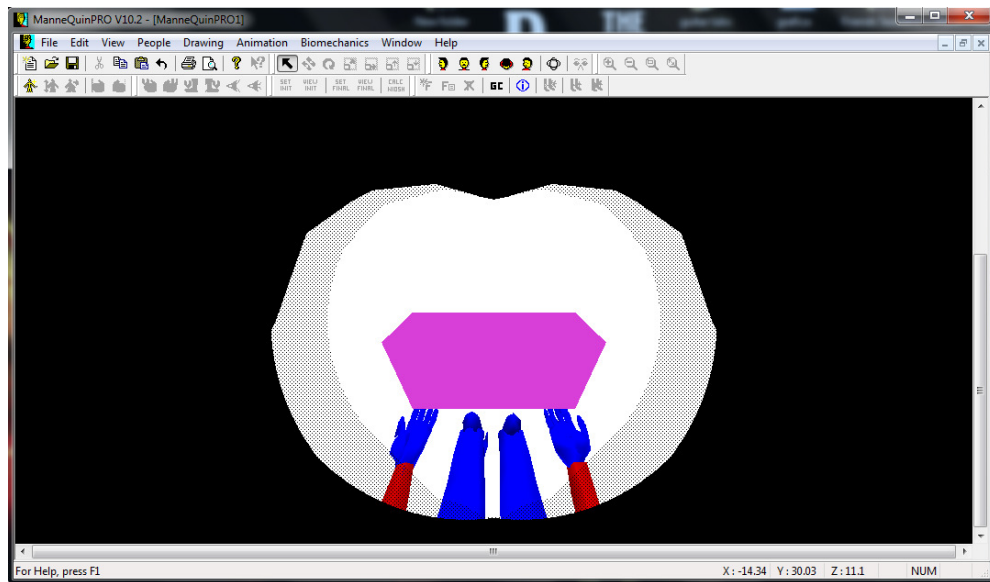


Figure 9. Eye View Example.

### 3.2.5 Mannequin's reach zones

Other feature of this human modeling software is the option that allows observing the functional reach zone capabilities of the mannequin's hands and feet. This helps to determine whether an object or workspaces is within the mannequin's reach. This command can be accessed by selecting the Range Volume option from the People menu.

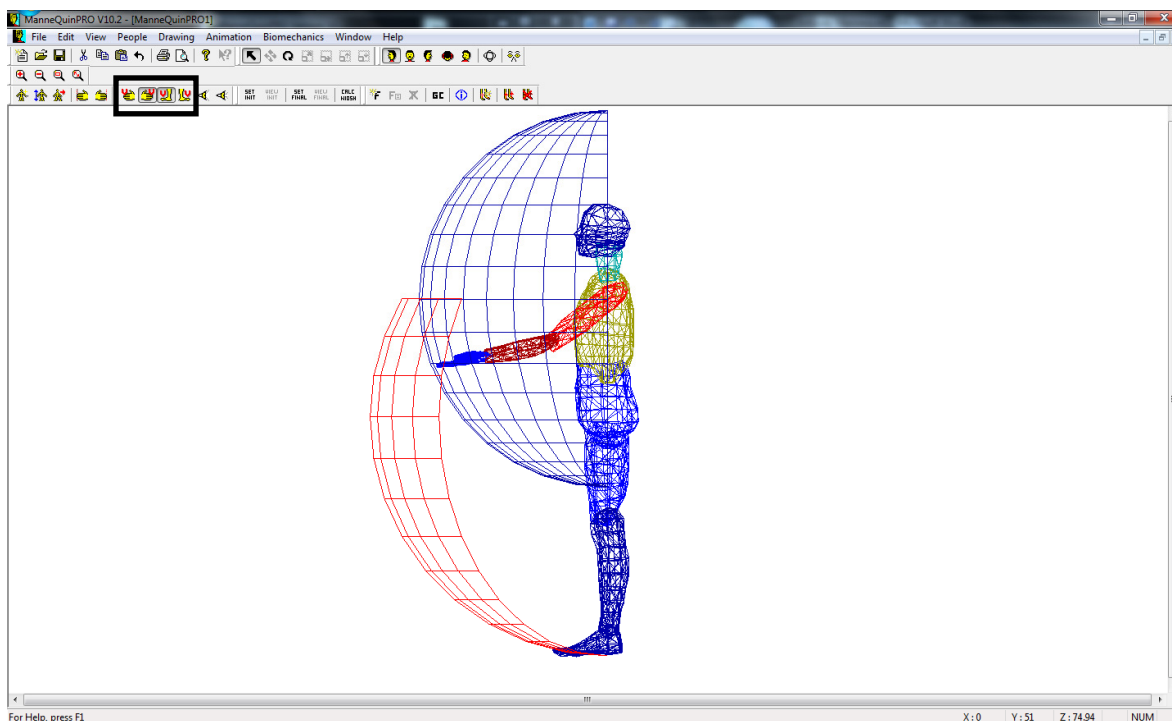


Figure 10. Mannequin's Reach Zones Example.

### 3.2.6 NIOSH lifting task

This command allows the calculation of the Recommended Weight Limit (RWL) as determined by the NIOSH 1991 lifting equation. Three steps are necessary to perform this task.

1. Adjust the mannequin to the initial posture of the lifting task and click on the Set Initial button.
2. Change the mannequin to the final posture and select the Set Final button.
3. From the Biomechanics menu, select Compute NIOSH and the NIOSH Revised Lifting Equation dialog box appears. It is required to introduce the weight, frequency, duration and the hand to object coupling data and click on recompute. Results will appear instantly.

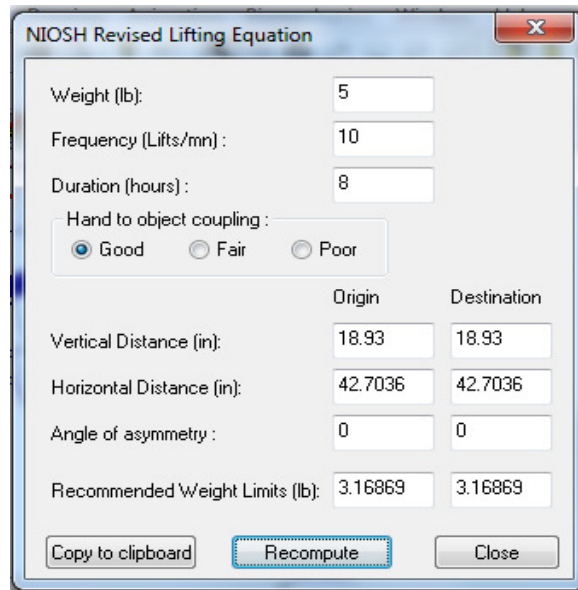


Figure 11. NIOSH Revised Lifting Equation Dialog Box.

### 3.2.7 Biomechanical summary

Two methods to view the biomechanics are shown in MannequinPro™. One method displays the individual body segment properties by selecting a particular body part, followed by clicking on the Segment Properties Floating Panel located in the toolbar. The other one displays a summary of the rotations, forces and moments of all joints by highlighting the entire body and selecting Summary from the Biomechanics menu.

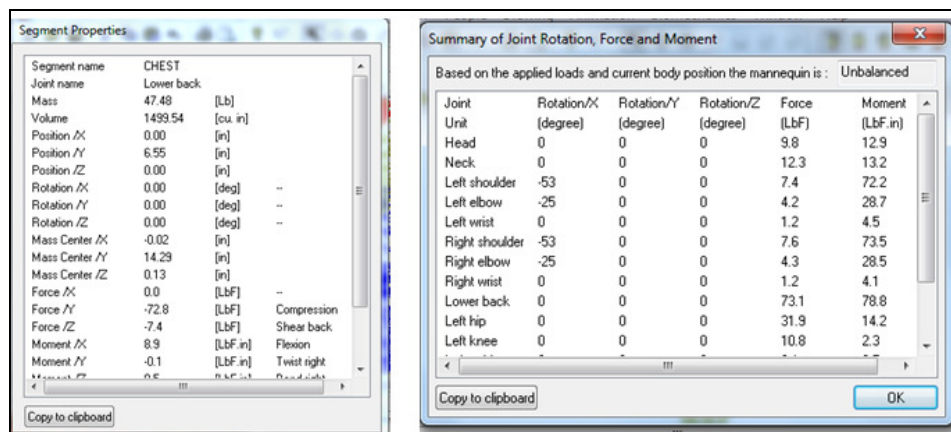


Figure 12. Segment Properties and Summary of Joint Rotation, Force and Movement Dialog Boxes.

### 3.2.8 External forces

Adding an external force to a mannequin's body part is easy with MannequinPro™. The utilization of the features Add External Force and Edit External Force in order to add, edit or delete any external forces.

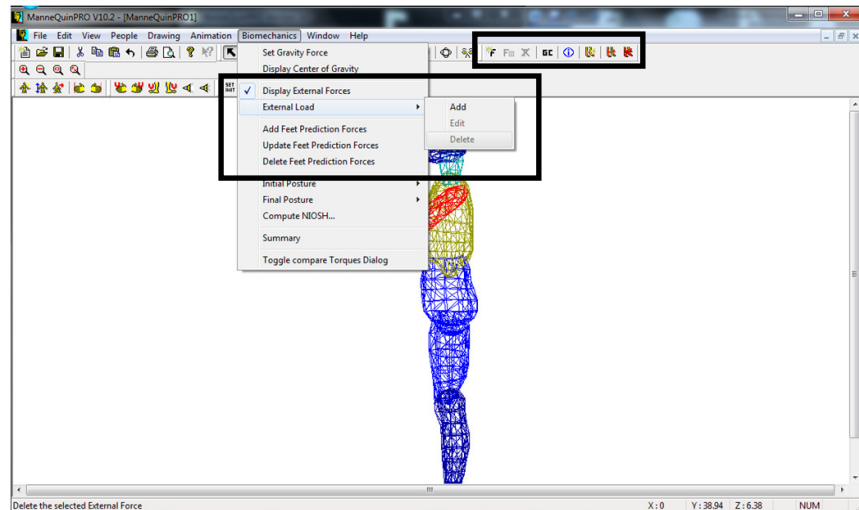


Figure 13. Biomechanics menu, submenus and icons.

#### 4. DISCUSSION

Some previous studies mentioned that MannequinPro™ software has been one of the most successful human modeling programs because of its ergonomically human figures based in very specific anthropometric databases, functions that are simple to control like reaching, walking, and posing and the simulation of lifting, pushing and pulling by adding forces on any part of the body in any possible direction. Furthermore, other advantages are that mannequin's joints have convincing ranges of motion. Likewise, provides a needed and effective assessment tools for a modest price and offers a good performances ratio with moderate graphics requiring only a single computer to run.

On the other hand, some disadvantages have been also mentioned in relation with the limitations and problems of the software. The limited formats of CAD files that support the difficulty to import files correctly, the correct positioning of the mannequin on the work area and the interpretation of some of the task results are mentioned as the most common problems. Additionally, other software like JACK™ and RAMSIS™ are considered as more efficient and specialized due to their extended number of tools and features.

#### 5. CONCLUSIONS

This paper showed that the characteristics and tools of the MannequinPro™ software are easy to understand and use in basic ergonomic assess. Also gives an extensive background and introduction of the software that facilitates the knowledge of the software capabilities, so it is concluded that MannequinPro™ is flexible and usable software which have components and tools that are friendly and can be used during any phase of a design process.

This investigation presented some of the modern Human Modeling Tools and its characteristics. On the other hand, it was showed two case studies where risk factors were founded thanks to modeling in MannequinPro™, so it is concluded the importance of this software while design or redesign a work area.

Also, it was presented an overview of the software where it was briefly explained some menus, features and tasks to understand the functions.

Therefore, students are able to use this Human Modeling software in order to increase their ergonomic evaluation into educational activities and to enhance their projects and papers.

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