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Development of a 3D Neck Model for Chinese Male Professionals

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In recent years, more and more people are using computers with poor head posture or looking at their mobile phones with their heads tilted downwards (Kenneth K., 2014). This type of posture goes against the normal cervical shape, thus causing neck morphological changes. Research on ergonomic design is not new. However, research on neck modelling is relatively limited. Previous studies usually focused on 2D models around the girth section of the neck (Wu, et al., 2011). But, the analysis of a single section can't provide comprehensive information on the state of the neck. Three-dimensional models are mostly used in studies involving the torso, limbs and other body parts (Lin, et al, 2011). The development of 3D models of the neck has not been established systematically. Additionally, previous research on neck modelling was based on general population. Neck studies for certain target population are inadequate. This study, using 3D measurements, aims to develop a neck model for a particular market segment in China- male professionals age 25-30, whose work and lifestyles make them vulnerable to neck morphological tensions and changes (Fox news., 2014). Therefore, there are two objectives for this study: 1) to investigate the characterization of Chinese male professionals' neck by using 3D neck measurements; and 2) to build a 3D neck model that can provide a theoretical reference for an optimal neckline design from an ergonomic point of view.

A total of 200 subjects meeting the sampling criteria were recruited for this study. Neck information from each subject was collected using the Vitus Smart non-contact laser 3D body scanner. According to the anthropometric base parameters for basic human body measurement for technological design (GB/T 5703-2010), 12 direct measurements were obtained from a 3D scan to characterize a male neck, such as anterior neck length(ANL), posterior neck length (PNL), etc. From these 12 raw measurements, six parameters can be derived, such as Ratio of ANL to PNL (RNL). Together, these 18 parameters were used to describe the neck characteristics.

To reduce the dimension of these 18 parameters, a principal component analysis (PCA) was conducted. The PCA results suggest three main groups of neck parameters: neck length, neck girth, and neck inclination. Using these three main groups of neck parameters, a Q-type cluster analysis was conducted to classify the 200 subjects into different groups. The results suggest four different types of neck shapes and neck characteristics for the male professionals in China.

Twenty subjects from the largest group were scanned using the 3D body scanner to obtain the cross-section point cloud figures. Forty cross-section point figures were obtained for each subject. The reading point on the cross-section point cloud figure was identified every 5° by MATLAB. The 3D coordinates of the neck section were then obtained, and entered into SolidWorks to output the neck skin layer 3D model. Using similar method, a skeletal layer model was obtained from a standard male neck skeleton. Adopting the average skin thickness of 1.8mm (Li, et.al, 2008), a soft tissue layer 3D model was established from the skin layer model. The final 3D model includes these three models (skin layer, soft tissue layer, and skeletal layer) together provides a comprehensive representation of the neck.

To test the accuracy of this 3-layer 3D model, a wearing pressure test was conducted to obtain the pressure that the neck receives when a clothing item was worn by the subjects. The pressure value was obtained from nine different locations on the neck. Then on the 3D model, the surface curvature was obtained from these same nine locations. The results of correlation analysis between these two variables conformed to the property of the positive correlation between clothing pressure and surface curvature, indicating that the established 3D model reflected the actual neck composition pretty well.

In summary, this study identified three major groups of neck parameters (neck length, neck girth, and neck inclination), which led to the successful classification of the four neck types for the male Chinese professionals age 25-30. A 3-layer 3D neck model was established for the largest neck type and was validated by the wearing pressure and surface curvature relationship. The results of this study can provide a great foundation for the ergonomic apparel (collar) design for male professionals in China.

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