INFLUENCE OF HUMAN FACTORS ON MESH QUALITY FOR DIGITAL ANTHROPOMETRY: TIME, POSTURE AND COMFORT

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1. Context

In performing large-scale digital anthropometric studies, using 3D scanning, besides the choices of equipment (KOUCHI, 2012) and accompanying software, the researchers must consider the user participation (SCHWARZ-MUELLER; MARSHALL; SUMMERSKILL, 2018) and also their own post-processing work (HEYMSFIELD et al., 2018). So, we can consider that in the scanning process the participants influence directly the quality of the mesh obtained and that the quality of the mesh accounts for most of the post-processing time and quality of the measurements taken.

This is more concerning when considering the use of low-cost hardware such as Kinect, because of its scanning time between 30 seconds to three minutes (BRAGANÇA et al., 2017; BRENDLER et al., 2016), and quality limitations (GUIDI; GONIZZI; MICOLI, 2016). Some of these might be mitigated when using more than one Kinect at a time (PARK; REED, 2014).

Nevertheless, when adding more Kinects to the study, other concerns arise such as the calibration of the equipment (HEYMSFIELD et al., 2018; KOUCHI, 2012) and structural support (SCHWARZ-MUELLER; MARSHALL; SUMMERSKILL, 2018) to hold all the equipment in fixed positions or moving together.

The other variable in this study is the subject's capability of holding the posture for the necessary fixed time (SCHWARZ-MUELLER; MARSHALL; SUMMERSKILL, 2018). Even for young adults with full-body capabilities, holding a posture for more than 3 minutes is painful and uncomfortable (KEE; KARWOWSKI, 2001). Another point regarding time is that there might be a relation between scanning time and the quality of the mesh. Shorter scanning times tend to leave holes and blank spaces that add to the post-processing time of the digital model (HEYMSFIELD et al., 2018). The ideal time is such that the participants are comfortable enough that they can hold the posture for the determined time and that the scan is as complete as possible.

Considering this context, we hypothesized that in using low-cost scanners, the principal influences on the quality of the mesh are the comfort and difficulty of attaining the postures adopted by the participants and the scanning time which affects their capability of holding the posture. The final objective was to improve large-scale anthropometric studies.

2. Method

This experiment was devised to evaluate different postures taken from the various norms and large-scale studies in terms of the capability of holding the posture by the participants in the required period, comfort rating after the posture was adopted and quality of the mesh obtained.

The experiment was the following, first, the participants were presented the tasks and were asked to sign consent agreements. After they signed, they were scanned three times, one in each posture (Figure 1) in random order. The participant stood on the platform and the scanners were turned around them manually. The order of postures and number of turns was randomized to avoid biases such as tiredness and learning. After each scan, the participants were asked to answer a comfort scale level (SHACKEL; CHIDSEY; SHIPLEY, 1969).

Figure 1: Postures.

1.  2.  3. 

Font: The authors (2019).

At the end of the experiment we graded each scan using the MAP protocol that quantifies the quality of the mesh obtained and tabulated the times and comfort scales (SHACKEL; CHIDSEY; SHIPLEY, 1969). At the same time, we also did the REBA (HIGNETT; MCATAMNEY, 1997) and RULA (MCATAMNEY; CORLETT, 1993) analysis of the postures.

The scanning platform used works with 3 Kinects 360 (MICROSOFT, 2019). The platform is constructed in metal bars and wood surfaces with 3D printed holders for the Kinects that can be height adjusted manually. The platform radius is one meter. The scanning software used was RecFusion (RECFUSION, 2019) and the mesh cleaner was Meshmixer (AUTODESK, 2019).

The sample was composed of sixteen participants (6 females and 10 males) from a convenience sample. They all signed consent agreements to participate. Their ages varied from 24 to 60 and were all able-bodied with no medical constraints that hindered their ability to hold the postures asked. In total, we took 48 scans (three for each participant).

3. Results and discussion

There seems to be a greater influence of the posture on the mesh quality than time in mesh quality. Even though the time with two turns of the platform was 40% greater, the increase in mesh quality did not justify the extended period, improving only 2.5 points. This leads us to believe that the mesh problems were related to the limitations of the equipment and the posture selected other than the time the participant held the posture.

The first posture gave the best mesh quality, firstly because it was not touching the body and did not weld the area and secondly because it is an easier posture to hold. The worst posture, the second, gave the worst mesh quality, because of the difficulty of holding the arm extended in the front of the body, making it sway, and hindering the closing of the mesh. Also, for people with arm length greater than the maximum size of the platform, part of the arms and the head, were not scanned.

The other problem with the mesh quality was the calibration which hindered the quality of some scans. This could have been corrected at the time but we opted not to do so to demonstrate that this can occur. For actual anthropometric studies, this problem can be avoided, or corrected, with the recalibration of the scanners every so often. The MAP score can be used to determine whether the scan should be remade or not.

The participant's comfort, as predicted, was influential on the quality of the scans. Some, even with reporting of having no preconditions that could deter them from holding the position had difficulty and reported great levels of discomfort. This was not related to age and was probably a cause of some musculoskeletal distress from before the scans or overall lower pain threshold.

All postures were considered to be of medium risk, the scores are related to the time of static maintenance of the posture and extension of unsupported limbs which caused that, despite the lack of vibrations and weights, the neutral position of the legs and the upright posture of the trunk, the postures were still considered medium risk. The main ergonomic concern is the position of the arms extended in front and on the side of the body.

Most of the problems encountered can be corrected with the use of appropriate clothing, changes to the scanning platform such as variable lengths and heights and changes to the protocol, especially for the calibration of the scanners. To expedite the process for a greater number of participants, they could be divided into height percentiles before the scanning and scanned into groups with appropriate platform lengths for the size of the participants.

Finally, we were able to choose the best posture (Posture 1) which was the one that gave the best mesh quality and that was also the most comfortable for the participants so they could hold it longer.

4. Conclusion

With this experiment, we discovered that the postures adopted had more influence on the quality of the mesh, then the time and the number of turns to do the scanning. This proved that our hypothesis was correct especially for the effect the posture had on the quality of the mesh.

Comfort, although being a subjective matter, was useful for discussing and choosing between the postures. Even for the small sample, there were conflicting results that would probably be verified with greater samples. The other measures such as quality, ergonomic assessment and time were also effective in analyzing the data and easily collected.

Because of the variability added when dealing with different people, and because of the influence these people might be for the quality of the overall study they should always be carefully considered. Also, participant safety and well-being must be one of the first considerations when devising an experiment.

Finally, this work, while answering our questions about experiment conditions can also be a guideline for the preparation and verification of other experimental configurations regarding subject participation.

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