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Analysing Contact and Non-Contact Methods of Anthropometric Data Collecting in Estonian Rescue Board

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ABSTRACT

This study investigates different non-contact and contact methods to find a suitable measuring approach for taking body measurements from rescue workers. In the public sector, when ordering a uniform, every employee has to provide the body measurements themselves. This is a difficult task for ordinary consumer. Therefore, most employees give old uniform sizes. However, in the case of changes in industrial patterns of sewed items, it is necessary to know the actual body dimensions. In this article, three methods have been studied: measuring with a measuring tape from the human body, measuring with a body scanner Human Solution 3D and measuring with two different smartphone applications - apps. Forty seven employees of the Rescue Board were measured within a period of two weeks using different methods. After the analysis, the correct measurement instructions were prepared for the employees. The measurement instructions involved a combination of two approaches – tape measuring method and selected mobile app method. Collecting the right anthropometric data helps to produce work clothing of the right size and better fit, optimise the need for stocks and is the basis for creating an online order system for uniforms.

Keywords: Human Solution 3D scanner, tape measuring, smartphone application - app measuring.

1. INTRODUCTION

For work uniforms, finding the right size is just as important as finding the right fit. Clothing manufacturers use different systems for clothing design, as well as different size charts [1]. Therefore, in order to determine if the garments fit, it is necessary to have the correct body measurements, which can later be compared with the body measurements used by the manufacturer or with the measurements of the finished garment to find the right size.

This research has been carried out in the context of a practical demand. The uniforms for the Estonian Rescue Board are produced on the basis of a pre-agreed size chart. Each employee has to order their own uniform, which in turn often creates a situation where people order a wrong-sized uniform due to a lack of knowledge on the part of the staff on how to take the correct body measurements.

A proposal was made to the Estonian Rescue Board that a research project would be carried out, in the course of which different measurement methodologies would be analysed, as a result of which a measurement manual for internal use would be drawn up that would be as simple as possible.

2. METHODS

In order to carry out the research work, rescuers from two Estonian Rescue Board's stations and office specialists were measured. Measurements were carried out in three ways: manual measurement, measurement with two different mobile apps, and using a 3D body scanner. The total number of people measured was 47. A total of 34 people were measured with all three methods, and 13 people were measured manually and with apps only. Measurements were carried out at the stations on site and in the anthropometry laboratory of TTK University of Applied Sciences.

The measuring tools were two different measuring tapes for anthropometric measurements, a metal tape measure for height measurements and a triangular ruler for accurate height and foot measurements. The accuracy of the soft measuring tapes was checked at the beginning of each measurement and in-between with a metal ruler to check that the tape had not de-formed during the measurements.

Prior to the measurement procedure, a suitable time was arranged and the employees were informed of the measurement conditions. At TTK University of Applied Sciences, 30 minutes were allotted per person to measure using all three methods, and for the rescuers, who came together as a team of four to measure in the 3D body scanner, a total of 60 minutes. On-site manual and app measurements were taken at the stations on a live queue basis, once one was measured, the next was called in. At the time of the measurement, the subject had to have their hair tied up if they had long hair, preferably wear light-coloured underwear and a casual daily bra for women.

The measurement methodology was the same for all subjects, but the measurement location was different. On-site contact measurements of rescuers and mobile app measurements were carried out at the stations. Measurements with the body scanner were performed at TTK University of Applied Sciences – transporting a 3D body scanner was not practical due to the small number of people to be measured, time-consuming packing and unpacking of the scanner, and costly transport. As the distance between the Rescue Board station and TTK University of Applied Sciences is small, we agreed that the rescue squad will go to the university in a team of four and fully equipped (in case of an emergency call during the measurement). The collection of measurements from the professionals of the Rescue Board using both contact and non-contact methods took place at TTK University of Applied Sciences.

Each person was measured twice with the measuring tape. There were two measurers, each taking agreed measurements from the subject. This was done in order to compare how big the difference can be when measurements are taken by different people. Measurements were taken from the worker's body in their underwear to make the measurements as accurate as possible. The very first step was to measure height – the subject stood, maintaining a natural posture, close to the wall, with the most protruding part of the body against the wall (shoulder blades or buttocks touching the wall, depending on body shape). Their waistline was then determined with a standard soft tape to help take the right measurements. A total of 23 manual measurements were taken: height, head circumference, midneck girth, neck at base girth, cross shoulder, shoulder length, arm length, arm circumference, palm length, arm length, palm girth, palm circumference, Bust/chest girth horizontal, across front width armpits level, waist girth, waist band, neck front to waist, buttock girth, across back width armpit level, neck to waist centre back, inseam, right thigh girth, foot length and foot width. The dimensions were chosen based on the measurement areas provided by the apps and the requirements set by the Rescue Board.

The app measurements were taken with two different phones, each with both apps downloaded. The apps were Abody.ai [2] and TailorGuide [3], and the phones were android and iPhone. In order to carry out the measurements with the apps, it was necessary to look for an area with a sufficiently white and neutral background.

The Abody.ai app wanted to know the person's height before starting the measurement process (Figure 1). After that, the person had to stand at a certain distance, initially facing the phone. The phone had to be held at a 90-degree angle to the floor. In order for the app to read the measurements as accurately as possible, the measured person had to be instructed on the correct posture. The second picture was taken from the side, requiring the person being measured to turn their left side forward and stand as instructed. After the pictures, the measurements of the subject appeared on the screen (Figure 2).

Because of the phones' differences, they took measurements from different distances. In the case of the Abody.ai app, the subject had to stand 3 metres away from the phone. When measured with the TailorGuide app, the person had to stand about 2.5 metres away for An-droid and 1.5 metres for iPhone.

Figure 1. Abody.ai app [2]

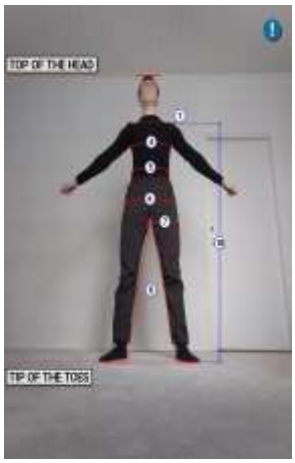

Figure 2. TailorGuide app [3]

The Human Solution 3D body scanner measurements were taken at TTK University of Ap-plied Sciences. The body scanner replaces manual measurement by analysing measurements from 3D body scans. Measurements are done using laser technology: the scanner projects a laser light beam around the body. The scanners in the scan heads move vertically along the scan path and form a digital image of the object. Data is stored on a computer where it can be further processed [4]. Anthroscan is a software for the visualization, processing and evaluation of 3D scan data, in general delivered by the VITUS 3D whole body scanner.

The measurement process was as follows: the subject undressed in the changing room, the measurements were taken in their underwear. The subject then stepped into the body scanner at the marked position and assumed the pre-agreed posture: back straight and arms slightly away from the body so that the beam could reach the surface of the body without any obstacles in the measured area. During the scan, the subject had to stay still. Their jewellery had to be taken off and long hair tied at the lower part of the occiput. [5]

Body scans were done three times in case any of them failed.

The measurement process with all three methods took 20 to 25 minutes per person, including dressing. The manual measurements took 10 to 15 minutes. Measuring with the apps took 4 to 5 minutes in total and with the 3D body scanner 5 to 7 minutes.

3. ANALYSIS AND RESULTS

For the analysis, all the data collected for each person measured was added to one table and sorted (Figure 3). The measurements taken with a measuring tape were used as the basis for all measurements. In the case of manual, soft-tape measurements, the average of the two measurements was selected for each measurement if the difference between the measurements was 0.5-1 cm. If the difference was greater, the closest was chosen compared to the other measurement methods. The same was done with the apps, and very large differences were highlighted for later analysis. On the basis of the three body scanner measurements, the average or most likely was also selected and inaccuracies in the scan were ignored. All figures were rounded to decimal places.

		Measured manually			Measured with the phone applications						Measured with a 3d body scanner			
		Manual 1	Manual 2	AVERAGE	Abody.ai		AVERAGE	TailorGuide		AVERAGE	SCAN 1	SCAN 2	SCAN 3	AVERAGE
					iPhone	android		iPhone	android					
1	Height	198	198	**198**							197.2	197.2	197.9	**197.4**
2	Head circumference	57	57	**57**							59.8	59.7	59.5	**59.7**
3	Mid neck girth	40.5	40.5	**40.5**	45	43.5	**44.3**				41.3	40.6	40.7	**40.9**
4	Neck at base girth	50	51	**50.5**							48.9	48.4	49.9	**49.4**
5	Cross shoulder	52	52.5	**52.3**	49.2	48.8	**49**	52.4	52.5	**52.5**	51.9	50.7	50.9	**51.2**
6	Shoulder lenght	15	15.5	**15.3**							15.4	15.4	16	**15.6**
7	Arm lenght	71	72	**71.5**	72.6	69.2	**72.6**	70.5	62.4	**70.5**	72.1	72.4	72.9	**72.5**
8	Arm circumference	36.5	36	**36.3**	37.9	37	**37.5**				36.6	35.3	35.4	**35.8**
9	Palm lenght	23	23	**23**										
10	Palm girth	30.5	30.5	**30.5**										
11	Bust/chest girth horizonatal	107	106.5	**106.8**	106.2	104.7	**105.5**	98	107	**107**	110.2	111.7	110.6	**110.8**
12	Across front width armpits level	43	43.5	**43.3**							47.9	50.1	49.8	**49.95**
13	Waist girth	95	96	**95.5**	96.4	96.2	**96.3**	89.2	90.7	**90**	100.5	98.6	97.6	**98.1**
14	Neck front to waist	30	30.5	**30.3**							39	38.8	39.2	**39**
15	Waist band	99.5	100.5	**100**	100	98	**99**	115.9	133.3	**115.9**	99	99.1	99.1	**99.1**
16	Buttock girth	107	107.5	**107.3**	108.8	108.5	**108.7**	101	100.9	**101**	108.2	108	108.4	**108.2**
17	Across back width armpit level	43.5	43	**43.3**							42.7	42.9	42.1	**42.6**
18	Neck to waist center back	47	48	**47.5**				51.8	51.1	**51.5**	49	48.5	49.1	**48.9**
19	Inseam	96.5	97	**96.8**	83.6	85.6	**84.6**	87.2	89.4	**88.3**	90.2	89.2	89.6	**89.7**
20	Tigh girth	61	60.5	**60.8**	64.5	65	**64.8**	55.6	57.1	**56.4**	61.3	60.7	60.9	**61**
21	Foot length	31.6	31.6	**31.6**										
22	Foot width	11	11	**11**										

Figure 3. Measurement data.

For analysis, the measurements taken with the measuring tape were compared with the results from both apps and the 3D body scanner. The differences between the app and scanner measurements compared to manual measurements were identified, and the percentage difference between the two was compared to find the best method. The smaller the difference, the more accurate the results achieved by this method compared to manual measurements. Figure 4 shows that the 3D body scanner proved to be the most accurate measurement meth-od, with measurements differing from manual measurements by an average of 2.29%. Of the apps, Abody.ai gave the most accurate results, with a difference of 3.08%. The same indica-tor was 4.02% for the TailorGuide app.

Figure 4. Results of the apps and body scanner compared to manual measurements

Apps are more sensitive to the measured clothing and shadows. The analysis showed that the apps were not very reliable. Figure 5 shows in red a big gap between the same app and a different phone, and in red a big gap between the size measured by the app and the tape measure. There are not always clear reasons for inaccurate measurements. It is also not known how different measurement locations and different phones will affect measurements.

		Measured manually			Measured with the phone applications					
		Manual 1	Manual 2	AVERAGE	Abody.ai		AVERAGE	TailorGuide		AVERAGE
					iPhone	android		iPhone	android	
1	Height	188	188	**188**						
2	Head circumference	58.5	58.5	**58.5**						
3	Mid neck girth	48.5	47.5	**48**	47.9	49.7	**48.8**			
4	Neck at base girth	55	55	**55**						
5	Cross shoulder	55	55	**55**	46	48.6	**47.3**	49	50.6	**49.8**
6	Shoulder lenght	15	15	**15**						
7	Arm lenght	67.5	67	**67.3**	65	65	**65**	62.3	67.2	**67.2**
8	Arm circumference	41	39.5	**41**	40.2	42.4	**40.2**			
9	Palm lenght	20	19	**19.5**						
10	Palm girth	28	28	**28**						
11	Bust/chest girth horizonatal	125	125.5	**125.3**	117.6	123.8	**123.8**	118.3	122.6	**122.6**
12	Across front width armpits level	44.5	45	**44.8**						
13	Waist girth	117	118	**117.5**	114.6	121.3	**114.6**	116.4	111	**116.4**
14	Neck front to waist	40	41	**40.5**						
15	Waist band	120	121	**120.5**	116.2	122	**122**	107.9	108.8	**108.4**
16	Buttock girth	117.5	117	**117.3**	114	119.3	**119.3**	113.8	114.9	**114.4**
17	Across back width armpit level	48	48	**48**						
18	Neck to waist center back	48.5	50	**49.3**				49	51.7	**50.4**
19	Inseam	87	87.5	**87.3**	72.4	78.6	**78.6**	84.3	80.8	**84.3**
20	Tigh girth	57	58	**57.5**	62	66.8	**62**	48.2	53.3	**53.3**
21	Foot length	29	29	**29**						
22	Foot width	11.1	11.1	**11.1**						

Figure 5. Large differences in the measurement results

4. CONCLUSION

The reasons for measurement errors and differences in measurement methods are set out be-low, together with a summary of the results of the analysis. Some future measurement proposals are also presented.

Causes of differences in contact measurement:

- different posture: if the person being measured moves too much during the measurements, this can affect posture;
- the measuring tape is held too loosely by the measurer;
- inhalations and exhalations affect the measurement;
- the subject affects the measurements: for example, retraction of the stomach was observed.

The differences between the measurements taken with a measuring tape were not large enough to affect the size number.

Overall, the differences between contact and non-contact measurement methods were only for certain dimensions and this was due to the location of the measuring site on the body. The advantage of the 3D body scanner is that you can review the measurements after the measuring and, if necessary, correct the positioning of the measurement locations on the body, or rescan the body if the required measurements were missed. The body scanner al-lows nearly 150 different measurements. Not all dimensions were analysed in this study, but exceptions were considered. For example:

Reasons for differences between contact and non-contact measurement methods:

- different posture – often tense in the scanner,
- different body position: in manual measurement hands relaxed next to / below the body, but in the scanner hands raised away from the body;
- some measurements are taken differently: for example, the measurement of inseam length in the scanner for fuller thighs starts lower than when measured manually be-cause the laser beam cannot reach between the legs.
- different measurement timing: inhalations and exhalations can affect the measurement by a few centimeters;
- the body scanner scans lighter surfaces better, darker surfaces do not reflect the rays back and therefore do not get the right measurement: for example, in the case of dark hair, the head circumference was not measured;
- sometimes the body scanner used the wrong point as a basis: for example, the height measurement was taken from the topknot higher than the top of the head, or the body scanner itself created an anomaly that was included in the measurement.

Cons of the Abody.ai app:

- you cannot see precisely where the measurements are taken;
- on a couple of occasions, the app did not work, saying there was no one in the picture or the body position was wrong;
- some major differences compared to manual measurements;
- there are also differences between two different phones, and some are very significant.

Cons of the TailorGuide app:

- the picture has to be taken from too low, which may distort some dimensions;
- with android, the pictures turned out blurry;
- sometimes puts the measuring points in the wrong place: on the shade, for example, or at the bottom of boxers;
- it is inconvenient to place the measurement points, and the app user may not know exactly where to place them to get the measurements at the right place;
- some major differences compared to manual measurements;
- there are also differences between two different phones, and some are very significant.

Manual measurement and the 3D body scanner proved to be the best measurement methods. The analysis showed that their outcomes are closest to each other and give the most reliable results. Based on the research, a guide to body measurement for men and women was created.

Suggestions:

- to create a user-friendly interactive environment for inserting measurements: each measurement, the description of how to take the measurement and how to insert your own measurement are on a separate page, and so you move on to the next

pages until you reach the end, where the page gives you the corresponding size number;
- to collaborate with TTK University of Applied Sciences for 3D body scanner measurements of the Rescue Board staff.

CONFLICT OF INTERESTS

The authors would like to confirm that there is no conflict of interests associated with this publication and there is no financial fund for this work that can affect the research outcomes.

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