Posture Analysis and Evaluation for Modeling in Elderly Adults

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Abstract. In this study, from the viewpoints of enhancing communication of elderly people, we suggest a model to estimate the distortion value of the human body caused by aging as a new index of aging, which is “distortion age,” measured using the robotic “DOCTOR’S EYE”, which is equipped with Kinect. As a result, we found a more significant difference of the distortion in the front–back direction of elderly participants between standing and walking than in the distortion of young participants. We also determined the necessity of measuring the difference for a precise evaluation of the distortion and the effectiveness of the easy measurement method of distortion during walking, such as Kinect. In addition, as the results of the analysis of the relationship between the aging and the distortion, we found the two kinds of positive correlations between age of the elderly participants and the horizontal distance between the positions of the head and shoulder, and between age and the value of differences between the horizontal distances of standing and walking. Finally, based on these two correlations, we proposed the model to estimate the distortion age of elderly people for engineering applications, such as installment of the DOCTOR’S EYE.

Keywords: Aging · Gait motion · Posture · Kinect · Elderly

1 Introduction

Body distortion caused by aging is generally known to worsen an individual’s posture, as well as cause headache, organ disease, and traffic accidents. In particular, falls in elderly adults cause bone fractures and brain disorders, and falls have been indicated to pose a risk of an individual becoming bedridden [1]. It is one of the major social issues that need to be resolved, from the viewpoints of preventing their social isolation and enhancing their communication.

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Conventionally, measurement methods used to evaluate body distortion include methods that use motion capture equipment. For example, optical motion capture is highly accurate and reliable; hence, it is widely used to measure various body movements. However, the disadvantages of this method include the necessity of placing markers on the body, creating a substantial burden on the subject, and the high cost involved in introducing this method. Conversely, Kinect (Microsoft Corporation, USA) is non-contact, low cost, and easy-to handle interface. However, there are concerns regarding the accuracy of Kinect measurements; hence, a number of research and clinical facilities in Japan have avoided using Kinect.

Recently, in basic research aiming for clinical application overseas, adequately accurate measurements have been reported to be assured by limiting the measurement methods and targets. For example, when Kinect and optical motion capture were compared when measuring a healthy individual's gait, the report showed that the accuracy of Kinect was slightly lower for the leg swing time and step time, but the accuracy could be sufficiently assured for walking speed, stride, and step distance [2]. In addition, when comparisons were made using a pressure sensor mat, the report indicated that walking speed, stance, step length, and step time could be measured with an equivalent degree of accuracy [3]. A higher degree of accuracy has been reported to be assured by walking slowly and obtaining the measurements from the front, facing the Kinect [3]. Furthermore, based on the advantage that the Kinect can obtain measurements without coming into contact with the patient, other reports [4] have already demonstrated improved effect by using this device in the rehabilitation of patients with stroke-induced hemiplegia [4] and Parkinson disease [5].

Based on the above information, this research focused on the possibility that the user-friendly Kinect may be useful for maintaining the health of elderly people by devising measurement targets and methods. We will also measure and analyze body distortion caused by aging, using the robot DOCTOR'S EYE equipped with Kinect, with the aim of building interface technology to quantitatively evaluate body distortion to maintain the health of elderly people. The posture of elderly adults and younger adults will be particularly measured when they are upright and stationary, while walking, and while walking after standing up from a chair, and parameters for evaluating body distortion will be extracted from coordinate information of the head, shoulders, and hips in relation to the spine. Based on these results, the relationship between the amount of body distortion and the age of the elderly adult will be analyzed, and we will propose a new model to estimate the age index (distortion age) based on body distortion.

2 Method

2.1 Participants

There were a total of 36 participants. The 20 elderly adults were aged 70 to 83 years (mean, 75.55 years), and consisted of 10 men and 10 women. The younger adults were 16 university students aged 19 to 21 years (mean, 20.8 years) (12 men and 4 women). The participants joined the study after receiving sufficient explanation and providing informed consent.

2.2 DOCTOR'S EYE

The robot "DOCTOR'S EYE" ((Inc.) TeleBusiness) used in this experiment is shown in Fig. 1. Kinect V2 for Windows (Microsoft) was loaded into the camera of this robot, whereas a tablet PC (Surface Pro 3, Microsoft) equipped with software to measure posture developed by TeleBusiness was loaded into the monitor. In addition, the Kinect sensor installed in the DOCTOR'S EYE simultaneously collects and records the three-dimensional space coordinates for 25 joints using the same software, and enables reproduction of the imaging information from the front, left, and right sides, and from above. Research in the development of this system and use of the technology in rehabilitation practice have been reported [6–9]. Also former studies reports that the Kinect V2 is accurate enough to measure these clinical parameters in healthy subjects [10, 11]. In this study, we conducted the experiment with the robot in a fixed location, but movement is also possible when controlled by an application developed by TeleBusiness, with a mobile robot (Roomba 500 series, Research and Development Kit, iRobot Corporation, USA) mounted at the bottom of the DOCTOR'S EYE.

Fig. 1. DOCTOR'S EYE

2.3 Experiment Procedures

To measure the posture of the experiment participants, the DOCTOR'S EYE was set up in a fixed position facing the participant at a distance of 4 m to enable sufficient measurement accuracy. The experiment was conducted under two conditions: walking upright (condition 1), and walking immediately after sitting (condition 2). In condition 1, the participants were required to walk straight toward the robot from an upright and stationary position 4 m from the robot. This was repeated thrice by each participant. Conversely, in condition 2, the participant was required to sit on a chair located 4 m away from the robot, and then to stand and walk straight towards the robot, similar to condition 1. This was repeated twice by each participant. The participants were requested in advance to walk naturally and at their own pace (at their normal speed) while walking for each condition.

2.4 Analysis

The data obtained from the Kinect sensor was collected at a 30-Hz sampling rate as the time-series data for 25 joint (Fig. 2) position coordinates (*x, y,* and *z*). In this study from these 25 joints, we focused on joints relating to the head, shoulders, and hips, and the relationship of these joints with the spine, to evaluate posture. The *z* coordinates of these joints were used for analysis. Each *z* coordinate shows the horizontal distance between the Kinect and each of the participant's joints. For example, the head *z* coordinate shows the horizontal distance between the participant's head and Kinect; the right shoulder {Shoulder(R)} *z* coordinate shows the horizontal distance between the Kinect and center of the participant's shoulder (Fig. 3); and the hip center {Hip(C)} shows the horizontal distance between the Kinect and center of the participant's hip. Furthermore, the difference between the hip and head *z* coordinates {Hip(C) - Head} and the difference between the shoulder head *z* coordinates {Shoulder(R) - Head} were calculated to evaluate the distortion of the shoulders and hips using the head position (*z* coordinate) as the criteria. Adopting this method enables quantitative determination of how much horizontal distance is kept in position by the head, shoulders, and hips against the plane of the vertical direction, with the *z* axis as the normal plane. In other words, provisionally, this would mean that if {Hip(C) - Head} = {Shoulder(R) - Head} = 0, then the head, shoulders, and hips are all positioned in one plane of the vertical direction, with the *z* axis as the normal plane. In addition, when {Hip(C) - Head} > 0 and {Shoulder(R) - Head} > 0, the head would be projecting ahead of the hips and shoulders, hence, in other words, quantitatively demonstrating that the participant was stooping would be possible.

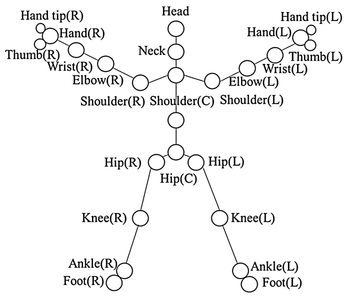

Fig. 2. Skelton model with 25 joints by Kinect

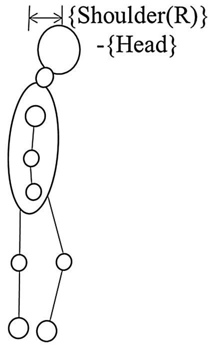

Fig. 3. {Shoulder(R)-Head}

3 Results

3.1 Posture When Upright and Stationary

Comparison of younger and elderly adults. We compared the posture in an upright and stationary position before starting to walk in younger and elderly adults based on data obtained in condition 1. Figure 4 shows the relationship between two types of posture distortions when they were upright and stationary for the 36 participants for three trials. The vertical axis is the difference between the Kinect and right shoulder horizontal distance, and the difference between the Kinect and head horizontal distance. In other words, it shows the horizontal distance between the right shoulder and head {Shoulder(R) - Head} (Fig. 3). The horizontal axis similarly shows the horizontal distance between the hips and head {Hip(C) - Head}.

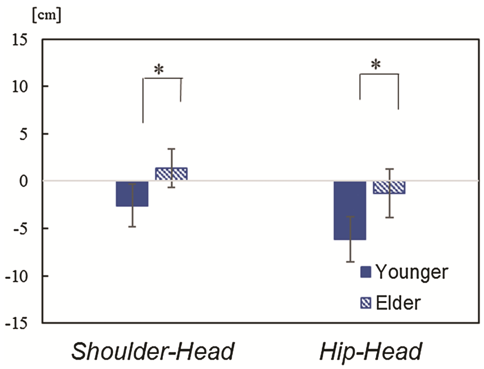

Fig. 4. Comparison between younger and elderly participants in standing condition 4

The mean values for the elderly adults were {Hip(C) - Head} = 1.29 cm (SD = 2.61) and {Shoulder(R) - Head} = 1.35 cm (SD = 2.07), whereas the mean values for the younger adults were {Hip(C) - Head} = −6.16 cm (SD = 2.40) and {Shoulder(R)-Head} = −2.57 cm (SD = 2.26). Furthermore, the younger adults' mean value $\mu \pm 2\sigma$ range is shown in the green frame in the figure, and 95% of the younger adult data are contained within this green frame. From this figure, the comparatively younger adults are determined to be distributed densely around the center of the third quadrant, whereas the elderly adults are more widely distributed mainly in the first and second quadrants. From this information, we determined that the elderly adults showed a positive value in the horizontal distance between the shoulders and head compared with that of the younger adults, and the position of the head had the tendency to project in front of the shoulder position. Furthermore, based on the results of comparing the mean value of elderly adults and younger adults when standing upright and stationary, we determined that a significant difference was found between the elderly and younger adults for the horizontal distance between the shoulders and head and the horizontal distance between the hips and head (Welch t test, $t = -20.60$, $p < 0.001$).

In contrast, when we examined the elderly adult data in detail, we noticed that 25.4% of the elderly adults who participated in this experiment were within the green frame in Fig. 5 (younger adult mean value $\mu \pm 2\sigma$ range). In addition, all the elderly adults who fell within this range were 74 years or younger. These data mean that approximately 25% of the elderly adults aged 74 or younger were able to maintain almost the same posture as the younger adults.

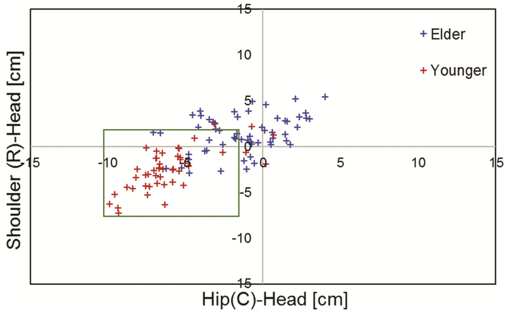

Fig. 5. Scatter plot showing the relationship between each participant's posture in standing condition

Changes in posture with aging. We analyzed the relationship between the age of each participant and the horizontal distance between the right shoulder and the head {Shoulder(R) - Head}, and the horizontal distance between the hips and the head {Hip(C) - Head} when the elderly adult participants were standing upright and stationary, to investigate the changes in posture associated with aging. Figure 6 shows the relationship between the age of the elderly adult and the horizontal distance between the right shoulder and head {Shoulder(R) - Head}. Figure 7 shows the relationship between the age of the elderly adult and horizontal distance between the hips and head {Hip(C) - Head}.

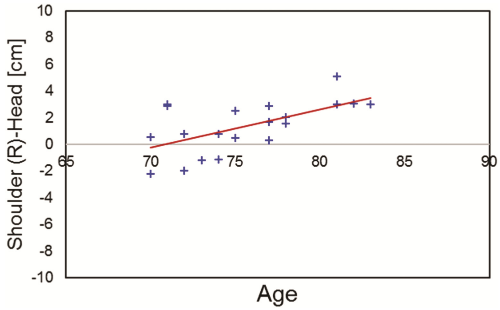

Fig. 6. Relationship between age and {Shoulder(R) - Head} in standing condition

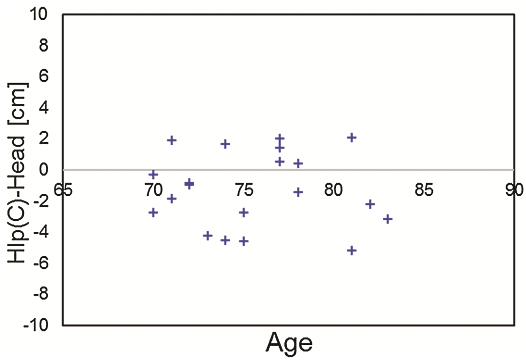

Fig. 7. Relationship between age and {Hip(C) - Head}in standing condition

The results of Investigation of the correlation coefficient for each scatter plot shows that a positive correlation value of $r = 0.64$ between the age of the elderly adult and horizontal distance between the right shoulder and head {Shoulder(R) - Head} when the person was upright and stationary. However, almost no correlation was seen between the age of the elderly adult and horizontal distance between the hips and head {Hip(C) - Head} ($r = -0.18$). Based on these results, we determined that the horizontal distance between the right shoulder and head when the elderly adult was upright and stationary increased with advanced age, and a tendency for body distortion presents in the form where the head projects ahead of the shoulder position.

3.2 Posture When Walking Upright

Comparison of younger and elderly adults. In condition 1, the horizontal distance between the hips and head {Hip(C) - Head} is shown in Fig. 8 to compare the posture in younger and elderly adults. The mean value of younger adults was −5.80 cm (SD = 5.83 cm), whereas the mean value for elderly adults was 2.90 cm (SD = 2.98 cm); hence, a significant difference was found between elderly and younger adults *(Welch t test,* $t = -10.07$, $p < 0.001$). Based on these results, the horizontal distance between the hips and head {Hip(C) - Head} in elderly adults was a positive value, whereas this was a negative value in younger adults. These data indicate that the elderly adult head position was in a more forward position than the hips, whereas the younger adult head position was positioned further back than the hip position. In addition, accurately measuring the horizontal distance between the right shoulder and head {Shoulder(R) - Head} is considered to be difficult, while the participants were walking, due to the movement of the feet and coordinated movement of the arms, despite using this measurement as an index for evaluating posture when the participants were upright and stationary. Hence, for this reason, we conducted an analysis focusing on the hip position only during walking upright based on this measurement method.

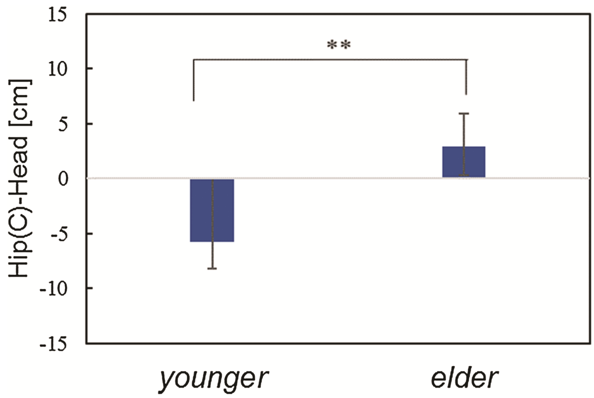

Fig. 8. Comparison between younger and elderly posture in walking condition

Changes in posture with aging. We analyzed the relationship between the age of the elderly adult participant and horizontal distance between the hips and head {Hip(C) - Head} when walking upright to investigate changes in posture with aging (Fig. 9). As a result of investigating the correlation coefficient for both, we obtained a low positive correlation of $r = 0.38$.

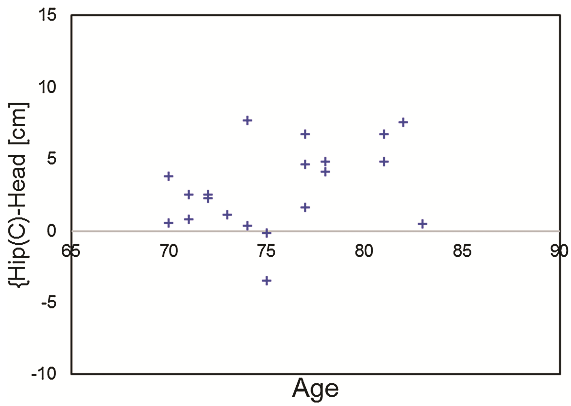

Fig. 9. Relationship between age and {Hip(C) - Head} in walking condition

3.3 Comparison of Posture When Upright and Stationary and When Walking Upright

Comparison of younger and elderly adults. The results of comparing the horizontal distance between the hips and head {Hip(C)} - {Head} when upright and stationary and when walking upright in younger and elderly adults are shown in Fig. 10. No significant difference was found in younger adults between when they were upright and stationary and when they were walking upright ($p = 0.35$), but a significant difference was found in elderly adults (Welch's t test, $t = 2.63, p < 0.01$). Furthermore, the horizontal distance between the hips and head {Hip(C) - Head} showed a positive value in elderly adults when walking upright, and they have a tendency to have a more forward leaning posture than when they were upright and stationary. Based on these results, the characteristics of elderly adults were a prominent change in the posture between when they were upright and stationary and when they were walking upright. The elderly adults tended to have a more notable forward leaning posture when they walked upright. Conversely, these changes were not observed in younger adults; thus, this tendency was absent in younger adults.

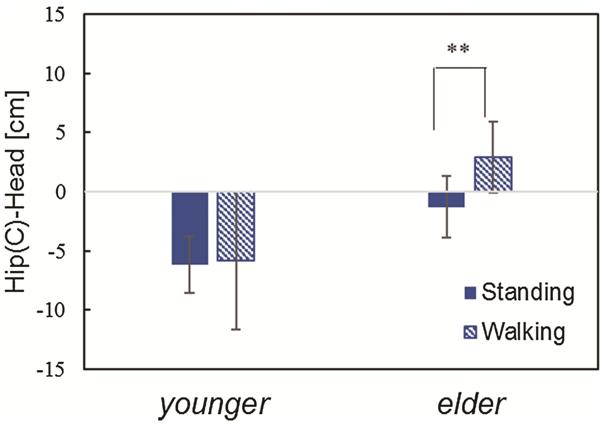

Fig. 10. Comparison between postures during standing and walking

Changes in posture with aging. Based on the results described in Section (Comparison of younger and elderly adults), we calculated the difference (amount of change) in the horizontal distance between the hips and head {Hip(C) - Head} when the elderly adult

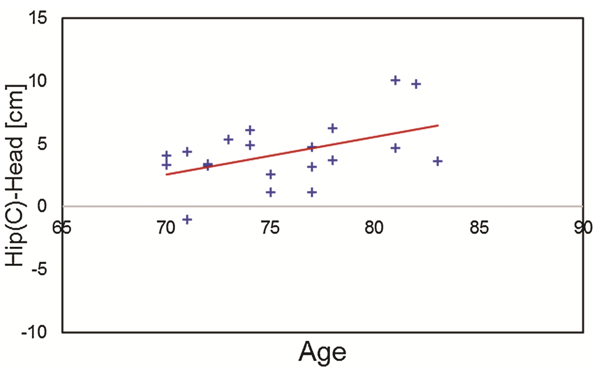

Fig. 11. Relationship between age and {Hip(C) - Head} difference in standing and walking conditions

was walking upright, and the horizontal distance between the hips and head {Hip(C) - Head} when standing upright and stationary. The relationship between the values and ages of the participants is shown in Fig. 11. Furthermore, we detected a significant positive correlation of $r = 0.48$ when we analyzed the correlation coefficient. This was even larger than the value found in Section (Changes in posture with aging) for standing upright and stationary ($r = -0.18$), and the correlation value obtained for walking upright ($r = 0.38$) as a result of the investigation in Section (Changes in posture with aging). Based on this result, we found a higher correlation between the age of the elderly adult and the difference (amount of change) between walking upright and standing upright and stationary in relation to the horizontal distance between the hips and head than the difference between standing upright and stationary and walking upright.

3.4 Posture When Walking Immediately After Sitting

Comparison of younger and elderly adults. The results of comparing the horizontal distance between the hips and head {Hip(C) - Head} in younger and elderly adults when walking immediately after sitting (condition 2) are shown in Fig. 12. The mean value of younger and elderly adults was −3.38 cm (SD = 2.53 cm) and 4.21 cm (SD = 4.11 cm), respectively, indicating that a significant difference was also found between elderly and younger adults in condition 2 (Welch t test, $t = -4.30$, $p < 0.001$).

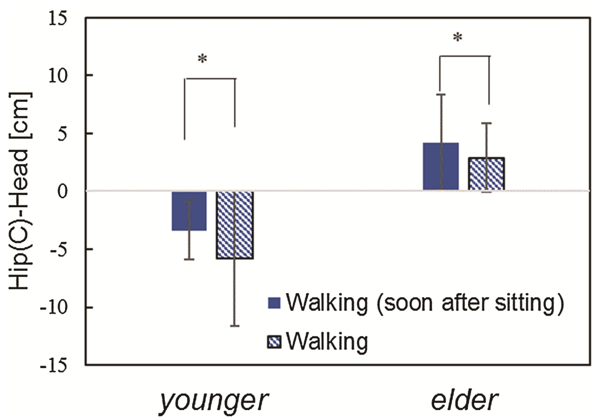

Fig. 12. Comparison between postures during walking immediately after sitting and just walking conditions

Comparison of walking immediately after sitting and walking upright. The results of comparing the horizontal distance between the hips and head {Hip(C) - Head} when walking upright (condition 1) and when walking immediately after sitting (condition 2) are shown in Fig. 13. These results show a significant difference between the horizontal distance between the hips and head {Hip(C) - Head} in both younger and elderly adults when walking upright and walking immediately after sitting (Welch t test, younger adult: $t = -2.50$, $p < 0.05$; elderly adult: $t = -1.73$, $p < 0.05$). Based on these data, both younger and elderly adults have a tendency to adopt a more forward-leaning posture when walking immediately after sitting compared with walking upright; hence, we cannot conclude this to be a tendency peculiar to elderly adults.

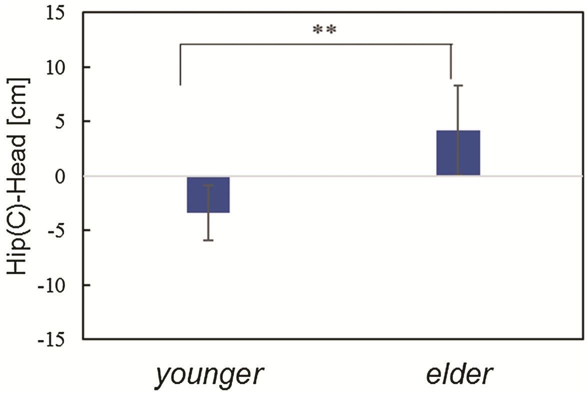

Fig. 13. Comparison between younger and elderly posture in walking immediately after sitting condition

4 Proposal of an Elderly Adult Body Distortion Age Estimation Model

Based on the above results, we proposed in this study body distortion age as a new age index based on elderly adult body distortion, and we are proposing a model to estimate that age.

First, we observed a significant positive correlation of $r = 0.64$ between the age of the elderly adult and horizontal distance between the right shoulder and head {Shoulder(R) - Head} when standing upright and stationary based on the analysis of the relationship between body distortion and age of the elderly adult. However, we did not observe an adequate correlation between the horizontal distance between the hips and head {Hip(C) - Head} ($r = -0.18$).

Although a low positive correlation of $r = 0.38$ was found in the correlation between the age of the elderly adult and horizontal distance between the hips and head {Hip(C) - Head} when walking upright, we detected a more positive correlation of $r = 0.48$ between the age of the elderly adult and change in the horizontal distance between the hips and head {Hip(C) - Head} when walking upright and when standing upright and stationary. Based on these results, we conducted a multiple regression analysis to estimate the age of elderly adult body distortion, setting x_1 as the index relating to the shoulder for the horizontal distance between the right shoulder and head {Shoulder(R) - Head} when standing upright and stationary, and x_2 as the index relating to the hips in the amount of change in the horizontal distance between the hips and head {Hip(C) - Head} when walking upright and the horizontal distance between the hips and head {Hip(C) - Head} when standing upright and stationary, and these were set as objective variables. The proposed model formula is shown in Eq. (1). In addition, x_1 and x_2 are both uncorrelated ($r = 0.03$), and no multicollinearity was observed.

$$y = 1.069x_1 + 0.583x_2 + 71.69 \tag{1}$$

The multiple regression Eq. (1) coefficient of determination was $R^2 = 0.49$. The p value was 1% or less than the significance level, and x_1 and x_2 showed that these variables had a high explanatory power level.

5 Discussion

5.1 Characteristics of Elderly Adult Posture Distortion

The results of comparing younger and elderly adult posture showed prominent differences in body distortion in younger and elderly adults under all the conditions of standing upright and stationary, walking upright, and walking immediately after sitting. The elderly adults particularly tended to have a slouching stooped posture given that the position of the elderly adult head was further forward in the direction of travel than the shoulders and hips.

However, as mentioned in Section (Comparison of younger and elderly adults), we found that 25.4% of the elderly adults who participated in the study maintained almost the same posture as the younger adults when standing upright and stationary. This suggested that factors other than age may be involved in the extent of posture distortion. These 25.4% of the elderly adults were all 74 years old or younger, and this group did not include any participants aged 75 years or older. Therefore, these results suggest that quantitatively demonstrating the extent of body distortion may be beneficial for maintaining the health of elderly adults in line with their age.

In addition, the slouching posture observed in elderly adults may visually narrow the range of attention due to the downward-facing position of the head, which in turn lowers the line of sight, and this is known to increase the risk of falls [12]. Based on this information, quantifying the extent of the forward-leaning posture would be effective in estimating the risk of falls based on the forward-leaning posture of elderly adults.

5.2 Amount of Change in Body Distortion When Walking Upright and Standing Upright and Stationary

Conventionally, assessment of body distortion generally targets the upright and stationary position. However, as a result of comparing postures when upright and stationary and when walking upright, no significant difference was seen between the two in younger adults, but a significant difference was seen in elderly adults. Based on this information, the characteristic of elderly adult body distortion is speculated to be related to the amount of change in posture distortion when walking upright and when standing upright and stationary. Hence, when we observed postures both when standing upright and stationary and when walking upright, we feel that a method to quantitatively evaluate the difference in posture distortion at these times would be effective. However, determining the posture distortion when walking upright and when standing upright and stationary is difficult with qualitative visual evaluation only; hence, using a device able to measure the posture during walking with sufficient accuracy is essential, such as the device used in this study, to evaluate elderly adult body distortion.

5.3 Body Distortion When Walking Immediately After Sitting

The results of comparing body distortion when walking upright and when walking immediately after sitting showed a significant difference in both younger and elderly adults, and we determined that both groups walked with a forward slouch when walking immediately after sitting. We presumed that this was because a forward-leaning posture was adopted to maintain the body balance when standing up after sitting. In other words, these were considered to be changes in posture common to both younger and elderly adults.

5.4 Technological Application of the Elderly Adult Body Distortion Age Estimation Model

The results of investigating the correlation between the age of the elderly adult and body distortion showed a significant positive correlation in the age of the elderly adult and the horizontal distance between the right shoulder and head {Shoulder(R)-Head} when standing upright and stationary, and the amount of change in the horizontal distance between the hips and head {Hip(C) - Head} when walking upright and when standing upright and stationary.

Based on these results, we proposed a model to estimate the age of elderly adult body distortion using multiple regression analysis (Eq. (1)), with x_1 as the index relating to the shoulder for the horizontal distance between the right shoulder and head {Shoulder(R) - Head} when standing upright and stationary, and x_2 as the index relating to the hips for the amount of change in the horizontal distance between the hips and head {Hip(C) - Head} when walking upright and the horizontal distance between the hips and head {Hip(C) - Head} when standing upright and stationary, and these were used as objective variables.

The characteristic of this model formula is that the coefficient of x_1, which is the objective variable in this model formula, is 1.069, whereas the x_2 coefficient is 0.583, hence, the influence of the x_1 value is stronger. In other words, this formula shows that when estimating body distortion age, the influence of the value of x_1 relating to the shoulder position when standing upright and stationary is approximately 1.83 times stronger than x_2 relating to the hip position.

Generally, in measurements of joint positions with Kinect, measurement errors are considered to be generated relating to locations where clothing tends to bulge, such as the hips and chest, and joint locations associated with large movements, such as the upper arm joints, where tracking tends to be lost. In fact, in this study, completely ruling out the effect of the participant's clothing as a reason for the low correlation is impossible ($r = -0.18$) between the age of the elderly adult and the horizontal distance between the hips and head {Hip(C) - Head} when standing upright and stationary. In addition, this may be similarly applicable to the correlation between the age of the elderly adult and the horizontal distance between the hips and head {Hip(C) - Head} when walking upright.

However, the calculations of x_1 relating to the head and shoulder are not easily influenced by bulging of clothing, and these are locations that do not generate comparatively large movements; hence, these errors would be relatively small for these locations. Therefore, the objective variable x_1 could be used even on the premise that Kinect was used for the measurements.

In addition, data on hip coordinates were used to calculate the objective variable x_2, but the value offsets the displacement caused by clothing when standing upright and stationary and when walking upright; hence, it is calculated as the difference between the horizontal distance between the hips and head {Hip(C) - Head} when walking upright and the horizontal distance between the hips and head {Hip(C) - Head} when standing upright and stationary. Therefore, clothing has little influence on the values, and similar to the objective variable x_1, objective variable x_2 could be used even on the premise that Kinect was used for the measurements.

Based on these points, the proposed model for estimating the age of elderly adult body distortion is suitable for measurements using Kinect, which suggests that it would be possible to mount this in the DOCTOR'S EYE, and operate it as a system to estimate the age of elderly adult body distortion.

6 Conclusion

In this study, we quantitatively analyzed body distortion caused by aging using Kinect mounted on DOCTOR'S EYE, and bearing in mind engineering applications, we proposed a model that estimates a new age index (distortion age) based on body distortion.

Specifically, profound differences were found in the size of body distortion in elderly adults when standing upright and stationary and when walking upright compared with that of younger adults. The results demonstrated focusing on these differences is essential when evaluating body distortion. In addition, evaluation of these differences need not be determined visually as is generally the case, or conducted using measurement methods that are a burden for elderly adults, including optical motion capture, rather, significant advantages in achieving these measurements are observed by using routine measurement methods that are inexpensive and have no physical burden. Therefore, evaluation using methods that utilize equipment that can easily measure posture during movement, such as walking, such as the method used in this study, is considered to be more effective for estimating distortion age.

In addition, as a result of investigating the relationship between aging and body distortion, we determined that a significant positive correlation was found in the age of the elderly adult and the horizontal distance between the right shoulder and head when standing upright and stationary, and the difference between horizontal distance between the hips and head when walking upright and when standing upright and stationary. These results are also considered beneficial from the perspective of research relating to decreased exercise capacity associated with aging in the elderly adult. Furthermore, we proposed a model for estimating elderly adult body distortion age based on these two correlations. This model is designed taking into consideration the reliability of Kinect, and we anticipate technological applications, including mounting it on the DOCTOR’S EYE.

To date, there has generally a low expectation of the reliability for the accuracy of Kinect, and while this device is able to measure human body movement easily and at low cost, clinicians in Japan in the fields of medicine and health maintenance has been previously reported to avoid using this device. However, Kinect will be expected to be used in the future as an interface technology that can be used in rehabilitation and to support maintaining health in elderly adults by proactively sharing knowledge on the accuracy of Kinect and by devising methods to the use of the device.

In addition, through technological application of the elderly adult body distortion age estimation model proposed in this study, directly communicating to elderly adults that their posture has become slouched may be possible. Forward-leaning posture narrows the field of vision, which is generally known to increase the risk of falls [12]. Based on this information, the proposed model may be used as a device to prevent falls by directly communicating the risk of falls caused by a forward-leaning posture in an easy-to-understand manner to elderly adults.

Previous measures to prevent falls include local activities aiming to improve motor function through exercise [13] Step+ [15], which was developed based on the effect of cognitive function (dual task ability [14])), and MTST (Multi-Target Step test) [16], however, thus far no one has proposed interface technology from the perspective of evaluating elderly adult posture in everyday life from a scientific perspective to encourage people to improve their posture. In addition, falls in elderly adults are listed as risk factors for a person becoming bedridden; thus, fall prevention is known to be extremely important for maintaining the health of elderly adults. Thus, we hope that it will be possible to enable more effective fall prevention measures by combining the proposed method with conventional fall prevention measures.

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