Novel Physiotherapies

Okada et al., J Nov Physiother 2014, 4:5
http://dx.doi.org/10.4172/2165-7025.1000232

Research Article | Open Access

In-Home Posture Evaluation and Visual Feedback Training to Improve Posture with a Kinect-Based System in Parkinson's Disease

Yohei Okada[1,2]*, Tomohiro Shibata[3,4], Tomoya Tamei[4], Yasuyuki Orito[4], Hiroyuki Funaya[3], Chihiro Obayashi[4], Kazushi Ikeda[4], Makoto Hiyamizu[1,2] and Shu Morioka[1,2]

[1]*Graduate School of Health Science, Kio University, Nara, Japan*
[2]*Neurorehabilitation Research Center of Kio University, Nara, Japan*
[3]*Graduate School of Life Science and Systems Engineering Human and Social Intelligence Systems Lab, Kyusyu Institute of Technology, Fukuoka, Japan*
[4]*Graduate School of Information Science, Nara Institute of Science and Technology, Nara, Japan*

Abstract

Purpose: We tested a Kinect-based system for in-home posture evaluation and visual feedback training in an individual with Parkinson's disease with moderate postural abnormality and evaluated the test-retest reliability of the anterior and lateral bending angles during standing in healthy subjects.

Methods: Eleven healthy subjects performed two sets of measurements of average anterior and lateral bending angles with the Kinect-based system, and we calculated the test-retest reliability of the anterior and lateral bending angles with the intraclass correlation coefficient and standard error of measurement. An individual with Parkinson's disease with moderate thoracolumbar flexion participated to test the Kinect-based system. The study lasted 3 weeks. During the 1st and 3rd weeks, the participant performed only in-home posture evaluations. During the 2nd week he executed both visual feedback training and posture evaluations.

Results: The anterior bending angle showed good reliability (intraclass correlation coefficient ≥ 0.88). The lateral bending angle during standing showed fair to poor reliability (intraclass correlation coefficient=0.46-0.78). Standard error of measurement values for the anterior and lateral bending angles were low (0.35-0.63). The individual with Parkinson's disease completed almost all sessions of in-home posture evaluation and visual feedback training without any adverse effects. His anterior bending angle was significantly improved immediately after the visual feedback training, and significant short-term improvement was observed during the second week.

Conclusion: Posture evaluation with the Kinect-based system was more relatively reliable in the sagittal plane than in the frontal plane and absolutely reliable in both planes in the healthy subjects. In the individual with Parkinson's disease with moderate postural abnormality, the in-home posture evaluation and visual feedback training with the Kinect-based system was feasible, and the visual feedback training improved the anterior bending angle immediately and in the short term in an individual with Parkinson's disease with moderate postural abnormality.

Keywords: Parkinson's disease; Postural abnormality; Kinect

Introduction

Posture is often affected in individuals with Parkinson's disease (PD) [1]. Abnormal postures include anterior trunk bending, lateral trunk bending, and neck flexion. Mechanisms underlying the development of the postural abnormalities in PD are not well understood, but a number of possible mechanisms, such as dystonia, rigidity, drugs, myopathy, skeletal and soft tissue changes, and proprioceptive disintegration have been proposed [1]. There is insufficient evidence to support the effectiveness of the adjustment of antiparkinson medications [2,3], deep brain stimulation [4-6], botulinum toxin or Lidocaine injections [7,8], and orthosis and physiotherapy [9-12].

Posture evaluation in individuals with PD is important for healthcare professionals (such as neurologists and physical therapists) in decision-making regarding medical treatment and in assessments of treatment effects. There are several problems concerning the current status of posture evaluation in individuals with PD living at home. One is the limited frequency of posture evaluation. Posture is commonly assessed only at the time of medical care in a medical facility (e.g., hospital, clinic) or at home. Individuals with PD have a tendency to stand more erect in front of healthcare professionals and then stand comfortably in the absence of healthcare professionals. Therefore, in-home posture evaluation by oneself could provide critical information about individuals with PD. A third problem is that the posture evaluation systems that are commonly used in clinical settings (e.g., with a digital camera) may not be objective compared to a motion-capture system. However, motion-capture systems are not suited to in-home posture evaluations since they are quite expensive and time-consuming.

In-home rehabilitation is important to improve abnormal posture in individuals with PD. There are still many barriers that prevent individuals with PD from obtaining sufficient quantity of rehabilitation: high medical expenses and the limited number of medical facilities that accept outpatients are two such barriers. It is thus desirable to design and offer low-cost systems for the assessment of daily natural posture and for daily rehabilitation to improve abnormal posture in individuals with PD. These systems should be easy to install and easy for the individual to use by him- or herself at home. Several trials using game devices such as Kinect (Microsoft Corp.) for the assessment

***Corresponding author:** Dr. Yohei Okada, Faculty of Health Science, Department of Physical Therapy, Kio University, 4-2-2 Umami-naka, Koryo-cho, Kitakatsuragi-gun, Nara, 635-0832, Japan, Tel: 81-745-54-1601; E-mail: y.okada@kio.ac.jp

Received August 23, 2014; **Accepted** November 10, 2014; **Published** November 17, 2014

Citation: Okada Y, Shibata T, Tamei T, Orito Y, Funaya H, et al. (2014) In-Home Posture Evaluation and Visual Feedback Training to Improve Posture with a Kinect-Based System in Parkinson's Disease. J Nov Physiother 4: 232 doi:10.4172/2165-7025.1000232

of postural control and dynamic movement and rehabilitation for improving postural control have been reported [13-18]. Recently, accuracy of Kinect to measure posture in Parkinson's disease was confirmed by simultaneously recording standing postures with Kinect and the motion capture system and comparing these results in the experimental setting [16]. However, it has not been tested whether individuals with Parkinson's disease could measure their posture with Kinect by oneself at home.

Misperception of the vertical position due to disintegration of proprioceptive, somatosensory and vestibular information has been suggested to be associated with the postural abnormalities such as anterior bending posture and lateral bending posture in individuals with PD [1]. A misperception of the vertical position might thus contribute to the difficulty that some PD patients with postural abnormalities have in making their posture erect. In such individuals, training with some additional feedback about posture might improve the abnormal posture.

In individuals with PD, the performance of postural orientation tasks in the vertical plane with eyes open is better than that with eyes closed, indicating that vertical control during standing with the visual sense is able to-at least partially-compensate for proprioceptive impairment [19,20]. Visual feedback might thus promote correction of the posture in individuals with PD with postural abnormalities. It has also been reported that exercise focusing attention on proprioceptive feedback improved motor symptoms in individuals with PD [21,22]. Therefore, training which consists of correcting posture with visual feedback and maintaining the corrected posture while focusing attention on proprioceptive and somatosensory feedback may correct the misperception of the vertical position and posture in individuals with PD with postural abnormalities. To our knowledge, there have been no reports about the effects of visual feedback training on postural abnormalities in individuals with PD.

Based on the findings and concepts described above, we developed a system using a Kinect sensor (Microsoft Corp.) and information and communications technology that enables users to evaluate their own posture and perform visual feedback training to improve posture by themselves at home, and that healthcare professionals can use to remotely check the implementation status of patients' posture evaluation and visual feedback training and these results via the internet. Our Kinect-based system can detect posture and measure the bending angle in the sagittal and frontal planes without attaching sensors to user's body. Our system could estimate midpoint of the two shoulder joint centers and midpoint of two hip joint centers from depth information of Kinect sensor and calculate angles between line connecting two midpoints and vertical line in the sagittal and frontal plane as anterior-posterior angle and lateral bending angle. The Kinect-based system provides visual feedback in the form of real-time anterior-posterior and lateral bending angles and visual images based on these angles during the visual feedback training [23].

In our previous study, we examined the concurrent validity between the Kinect-based system and a motion capture system as methods for measuring the anterior and lateral bending angles during standing in healthy subjects [24]. We found that the angle data measured by the Kinect-based system and the corresponding data measured by the motion capture system had relatively high correlation coefficients. We examined the accuracy of the body-tracking algorithm of the Microsoft Kinect Software Development Kit (SDK) by simultaneously recording standing postures with Kinect and the motion capture system in healthy subjects, and we compared the results. We observed that the residual error of the body inclination angle measured by the Kinect and the regressed motion capture markers was small (0.6-1.9 degree) during standing, although the residual error was smaller in unbalancing tasks [23]. However, the test-retest reliability of the anterior and lateral bending angles has not been tested. In addition, we have not tested our Kinect-based system for in-home posture evaluations and visual feedback training to improve posture. Accordingly, we evaluated the test-retest reliability of the anterior and lateral bending angles during standing in healthy subjects in Experiment 1, and we tested our Kinect-based system for in-home posture evaluation and visual feedback training to improve posture in an individual with PD with moderate postural abnormality in Experiment 2.

Methods

Experiment 1

Test-retest reliability of the anterior and lateral bending angles with the Kinect-based system

Subjects: Eleven healthy young subjects aged 21–23 years participated (6 males and 5 females; height 1.58-1.77 m). They had no history of neurological or orthopedic disease. All of the subjects gave written informed consent for study participation in accordance with the Helsinki Declaration. The study protocol was approved by the ethical committee of Kio University.

Posture evaluation: All participants performed two sets of measurements of the average anterior and lateral bending angles during comfortable standing with eyes open (eyes-open condition) and with eyes closed (eyes-closed condition) for 30 seconds each using the Kinect-based system, separated by 30 min. The single Kinect sensor was set at the height of 1.2 meters and at 2.5 meters from the subject's standing point in the laboratory. Research staff operated the Kinect-based system for the posture evaluation. The subjects wore close-fitting clothes that we provided.

Data analysis: We calculated the test-retest reliability of the anterior and lateral bending angles in the two sets of measurements with the intraclass correlation coefficient (ICC) and standard error of measurement (SEM). The ICC was characterized as follows: good reproducibility (0.80–1.0), fair reproducibility (0.60-0.79) and poor reproducibility (<0.60) [25]. The SEM is an absolute measurement of reliability and is determined from the square root of within-subject variance. The SEM can be interpreted as 'the smaller the value, the better the reliability.'

Experiment 2

In-home posture evaluation and visual feedback training with the Kinect-based system in an individual with Parkinson's disease

Case presentation: The participant was a 59-year-old man with PD. His weight was 81 kg and his height was 174 cm. He had been diagnosed with PD five years earlier. His Hoehn and Yahr stage was 2. His total Unified Parkinson's Disease Rating Scale (UPDRS) motor subscore was 25: the subscore for rigidity (item 22) was 7, the subscore for akinesia (items 23-26) was 11, the subscore for tremor (items 20, 21) was 3, and the subscore for postural instability (item 30) was 0. He was taking carbidopa-levodopa 100 mg twice a day, selegiline 2.5 mg once a day, and rotigotine 13 mg twice a day. The antiparkinson drugs remained unchanged during the study. He subjectively felt no motor fluctuation. He had not undergone brain surgery such as deep brain stimulation, and he had no history of spinal disease. Written informed consent was obtained from the participant in accordance with the

Citation: Okada Y, Shibata T, Tamei T, Orito Y, Funaya H, et al. (2014) In-Home Posture Evaluation and Visual Feedback Training to Improve Posture with a Kinect-Based System in Parkinson's Disease. J Nov Physiother 4: 232 doi:10.4172/2165-7025.1000232

Helsinki Declaration. The study protocol was approved by ethical committee of Kio University.

The participant exhibited moderate (approximately 20°) thoracolumbar flexion during standing, but the flexion was almost completely resolved in the supine position. He had presented with moderate thoracolumbar flexion since the onset of the disease. The subscore for posture (item 28) was 2. He did not report a sensation of tightening in his abdomen during standing. His thoracolumbar flexion interfered with his mobility and office work; in fact, his chief complaint was the thoracolumbar flexion.

He was identified as a suitable candidate for our developed Kinect-based system for several reasons. One is that the onset of his postural abnormalities was not acute for a reason such as the change of antiparkinson drugs; rather, the abnormalities had progressed chronically. Second, he reported that he had undergone antiparkinson drug treatment and implemented trunk stretching and strengthening exercises supervised by a physical therapist for the prior three months to improve his thoracolumbar flexion, but his thoracolumbar flexion had not changed subjectively. Third, he was able to start our program with the Kinect-based system by clicking an icon on a personal computer. Accordingly, we suspected that his postural abnormality might be partially due to a misperception of vertical position and that he could use our developed Kinect-based system successfully.

In-home posture evaluation and visual feedback training

The study protocol is illustrated in Figure 1. The duration of the study was 3 weeks. During the first week, the participant did only an in-home posture evaluation in the morning and at night every day as far as possible. During the second week he engaged in both visual feedback training at night and posture evaluations in the morning and before and after the training at night every day as far as possible. The third week's protocol was the same as that of the first week. He did the posture evaluations and visual feedback trainings at the almost same hours of the day in each day. Over the 3-week study period, the maximum number of scheduled sessions of posture evaluations was 49, and that of the visual feedback training was seven.

At the beginning of the study, a physical therapist and an information scientist visited the participant's home together to set up the Kinect-based system and to instruct him how to use the system. The single Kinect sensor was set at the height of 1.2 meters and at 2.5 meters from the participant's standing point (Figure 2A). The participant stood at the standing point for both the posture evaluations and visual feedback training. His visibility of the visual feedback information in the monitor from the standing point was checked during the installation of the Kinect-based system. In the posture evaluations, his average

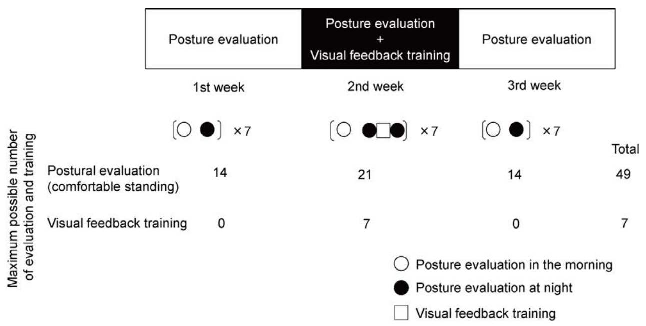

Figure 1: Study protocol and the maximum numbers of sessions of posture evaluation and visual feedback training during the 3-week study period.

Figure 2: A: The participant, a 59-year-old man with PD and moderate thoracolumbar flexion, performing a posture evaluation with the Kinect-based system. **B:** Display of the PC screen during the visual feedback training with the Kinect-based system.

anterior and lateral bending angles during comfortable standing with his eyes open and with eyes closed for 30 seconds each were measured by the Kinect-based system. The duration of one session of postural evaluation was about 2 minutes.

In the visual feedback training sessions, the numeric values of the participant's actual anterior and lateral bending angle data during standing were presented on a personal computer (PC), as were visual images showing these angle data by an animated figure (Figure 2B). At the time when we had visited the participant's home and set the Kinect-based system at the beginning of the study, we had confirmed there were no problems in the visibility of visual feedback information such as numeric value and visual images on a PC monitor for the participant. We set the length of the visual feedback training session at 5 min, in accord with study protocol reported in a previous study [26]. In that study, individuals with PD underwent training to perform a balancing task with the self-controlled use of a physical assistance device. The 5-min practice session consisting of 10 trials, each of which was 30 s long, immediately improved the subjects' performance, and the improvement was sustained on the day following the practice. We also felt that 5 min for the visual feedback training with the Kinect-based system was appropriate to promote adherence.

A positive angle value in the sagittal plane indicates anterior bending, and a positive value in the frontal plane indicates right lateral bending. Since the participant's main problem was his anterior bending posture, he especially tried to correct his anterior bending posture by using the visual feedback and to maintain his corrected posture while focusing his attention on proprioceptive and somatosensory feedback (as instructed by the physical therapist at the beginning of the study).

Data analysis: To assess the influence of conditions including the existence of visual input, we compared the anterior and lateral bending angle data obtained while the participant was standing during the first week between the eyes-open and eyes-closed conditions. We used the Wilcoxon signed rank test to examine the difference in the anterior and lateral bending angles between the eyes-open and eyes-closed conditions. To assess the immediate changes provided by the visual feedback training, we used Friedman's test to examine the differences in the anterior and lateral bending angles among four time points on the basis of the training in the second week: before the training, during the training, and immediately after the training in the second week. Pairwise comparisons were conducted using the Wilcoxon signed rank test.

To assess the short-term changes provided by the visual feedback training, we compared the anterior and lateral bending angles obtained in the morning and at night during the first week, those in the morning and before the training at night during the second week, and those in

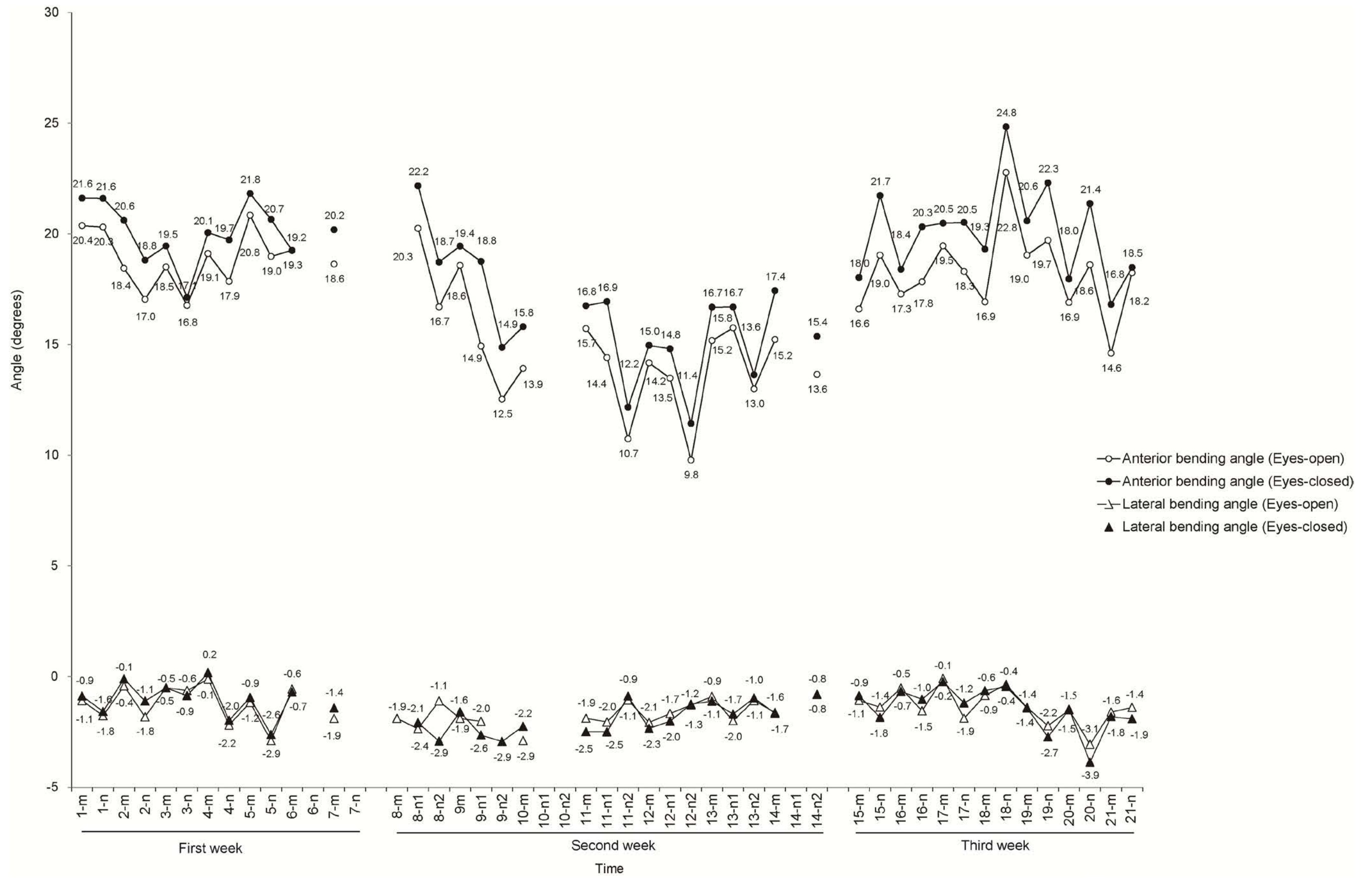

Figure 3: Anterior and lateral bending angles in the eyes-open and eyes-closed conditions in all sessions of posture evaluation. m: a morning session. n: a night session.

Table 1: Mean, SD, ICC, and SEM values for anterior and lateral bending angles in the eyes-open and eyes-closed conditions.

Variable	Test 1		Test 2		ICC	SEM
	Mean	SD	Mean	SD		
Anterior bending angle (eyes-open) (degrees)	−1.9	1.7	−2.1	1.5	0.9	0.48
Anterior bending angle (eyes-closed) (degrees)	−1.6	1.4	−1.8	1.3	0.84	0.53
Lateral bending angle (eyes-open) (degrees)	−0.4	0.7	−0.4	0.8	0.78	0.35
Lateral bending angle (eyes-closed) (degrees)	−0.4	0.8	−0.3	1	0.46	0.63

SD: standard deviation
ICC: intraclass correlation coefficient
SEM: standard error of measurement

the morning and at night during the third week. We used the Kruskal-Wallis test to compare the anterior and lateral bending angles obtained among the first, second and third weeks. Pairwise comparisons were conducted using Steel-Dwass multiple comparison tests. The alpha level was 0.05.

Results

Experiment 1

The anterior bending angle during comfortable standing in the eyes-open and eyes-closed conditions showed good reliability (ICC$\geq$0.84) (Table 1). The lateral bending angle showed fair reliability in the eyes-open condition but poor reliability in the eyes-closed condition. The SEM values for the anterior and lateral bending angles in the eyes-open and eyes-closed condition were low (0.35-0.63).

Experiment 2

The participant completed 47 sessions of posture evaluation and six sessions of visual feedback training. There were two deficit data of posture evaluations and one deficit data of visual feedback training due to an overnight business trip and forgetting. Valid data were acquired for 45 posture evaluations, and the ratio of the number of valid data to the number of total sessions of postural evaluation was 0.96. There were no adverse effects such as falls associated with the postural evaluation or visual feedback training using the Kinect-based system. We were able to remotely check the participant's implementation status of the posture evaluations and visual feedback training and the results via the internet during the entire study period.

His average anterior and lateral bending angles in each condition during the first week are given in Table 2. The anterior bending angle in the eyes-closed condition was significantly larger than that in the eyes-open condition in the morning and at night in the first week (Wilcoxon signed rank test, $p<0.05$). There was no significant difference in the lateral bending angle between the eyes-open and eyes closed conditions. All of the participant's anterior and lateral bending angle data during the study period are plotted in Figure 3.

The anterior bending angle in the eyes-closed condition was

Table 2: Anterior and lateral bending angles during each condition during the first week.

Item	Morning/Night	Eyes-open	Eyes-closed
Anterior bending angle (degrees)	Morning	19.3 (0.4)	20.4 (0.4)*
	Night	18.2 (0.7)	19.6 (0.8)*
Lateral bending angles (degrees)	Morning	−0.8 (0.2)	−0.6 (0.2)
	Night	−1.9 (0.4)	−1.6 (0.3)

Data are as means (standard error of the mean).
Asterisks indicate significant difference between the eyes-open and eyes-closed conditions.

Table 3: Immediate and carryover effects of visual feedback training.

		Before training	During training	After training
Anterior bending angle (degree)	Eyes open	15.8 (1.2)	9.5 (0.9)*†	12.6 (1.2)‡
	Eyes closed	17.9 (1.3)	-	14.2 (1.3)‡
Lateral bending angle (degree)	Eyes open	-1.9 (0.1)	-2.0 (0.6)	-1.5 (0.3)
	Eyes closed	-2.2 (0.2)	-	-1.8 (0.6)

Data indicates as mean (standard error of the mean).
*p<0.05, Before training vs. During training.
†p<0.05, During training vs. After training.
‡p<0.05, Before training vs. After training.

Table 4: Short-term effects of visual feedback training.

	Eyes open/Eyes closed	1st week	2nd week	3rd week
Anterior bending angle (degree)	Eyes open	18.8 (0.4)	15.6 (0.6)*†	18.3 (0.5)
	Eyes closed	20.1 (0.4)	17.3 (0.6)*†	20.1 (0.6)
Lateral bending angle (degree)	Eyes open	-1.3 (0.3)	-1.9 (0.2)†	-1.4(0.2)
	Eyes closed	-1.0 (0.2)	-2.0 (0.2)*	-1.4 (0.2)

Data indicates as mean (standard error of the mean).
*p<0.05, 1st week vs. 2nd week.
†p<0.05, 2nd week vs. 3rd week.

consistently larger than that in the eyes-open condition over the 3-week period, although the difference was small.

During the second week, the anterior bending angle in the eyes-open and eyes-closed conditions varied significantly across the time points on the basis of the training; before the training, during the training, and immediately after the training. The participant's average anterior bending angle during the visual feedback training was significantly smaller than the angle in the eyes-open condition before the training and immediately after the training. The anterior bending angle in both the eyes-open and eyes-closed conditions immediately after the training was significantly smaller than that before the training. The lateral bending angle in the eyes-open and eyes-closed conditions did not vary significantly across the time points on the basis of training during the second week (Table 3).

The participant's anterior and lateral bending angles in the eyes-open condition and the eyes-closed condition varied significantly across the weeks. The anterior bending angle in both the eyes-open and eyes-closed conditions during the second week was significantly smaller than that in the first and third weeks. No significant difference was observed in the comparison between the anterior bending angle in the eyes-open condition and the eyes-closed condition in the first week and that in the second week. The lateral bending angle in the eyes-open condition in the second week was significantly larger than that in the third week (Steel-Dwass multiple comparison, p<0.05), and the lateral bending angle in the eyes-closed condition in the second week was significantly larger than that in the first week (Steel-Dwass multiple comparison, p<0.05), although the difference was small (Table 4).

Discussion

In the healthy young subjects, the test-retest ICCs of the anterior bending angle in the eyes-open and eyes-closed conditions were high compared to those of the lateral bending angle in the eyes-open and eyes-closed conditions. These results indicated that the posture evaluation in the sagittal plane with the Kinect-based system is more relatively reliable than that in the frontal plane in healthy young subjects. Posture evaluation with the Kinect-based system could be useful to evaluate relative changes of the anterior bending angle during standing.

The SEM values for the anterior and lateral bending angles in the eyes-open and eyes-closed conditions were low. These results suggested that the present posture evaluation protocol — in which the user stood in front of the Kinect sensor with eyes open and eyes closed for 30 s each and the average anterior and lateral bending angles in the eyes-open and eyes-closed condition were estimated — was sufficient to provide reliable values.

The Kinect sensor was set 2.5 m from the subject's standing point in the present study. We confirmed that the test-retest reliability of the anterior and lateral bending angles measured in this set-up was good in healthy young subjects. We concluded that 2.5 m was an appropriate distance because at that distance, the Kinect sensor could detect the subject's whole body and the accuracy of measurement was good. Loose-fitting clothes of users could decrease the precision of the tracking system, since our Kinect-based system estimated the shoulder and hip joint centers from the depth information of the Kinect sensor and calculated the anterior and lateral bending angles. Controlling the conditions such as the subject's clothing and distance from the Kinect sensor was important to obtain accurate and reliable values.

We tested our developed Kinect-based system for in-home posture evaluation and visual feedback training to improve abnormal posture in an individual with PD in experiment 2. The participant executed almost all of the scheduled sessions of posture evaluation and visual feedback training with the Kinect-based system by himself, and no adverse effects were observed. We could remotely check the implementation status of his posture evaluations and visual feedback training and their results via the internet. The ratio of the number of valid data to the number of total sessions of postural evaluation was very high. These results indicate that self-administered in-home posture evaluation and visual feedback training with our Kinect-based system was feasible in an individual with PD with moderate thoracolumbar flexion.

We found that the anterior bending angle in the eyes-closed condition was significantly larger than that in the eyes-open condition in the first week, although the difference was small. Such consistent tendency was observed during the 3-week study period. The Kinect-based system was able to constantly detect the slight differences caused by his adjusting posture with visual sense. This phenomenon indicated that his visual dependence in keeping his posture upright in the sagittal plane was increased, consistent with a previous finding concerning the increased visual dependence in keeping upright in the frontal plane in individuals with PD with lateral flexion [27]. The participant's increased visual dependence suggests impaired processing of proprioceptive, somatosensory and vestibular information. Our present findings support the notion that training which consists of self-correcting one's posture with visual feedback and maintaining the posture while focusing attention on proprioceptive and somatosensory feedback might correct misperceptions of the vertical position and improve standing posture.

We also observed that the visual feedback training with the Kinect-based system significantly improved the participant's anterior bending angle during the training and immediately after the training during the second week. In addition, his anterior bending angle in the second week was significantly reduced compared to the angle achieved in the first week. It was recently reported that balance and gait training with feedback on the performance of training tasks indicated by a score ranging from 0% to 100% improved balance and gait performance [28]. Augmented feedback is considered important for motor learning in individuals with PD. Visual feedback tools such as a camera and a mirror can provide additional visual information concerning self-posture but not explicit feedback such as the anterior and lateral bending angles during standing. Our Kinect-based system can provide users with explicit feedback in the form of the present anterior and lateral bending angles during training. Additional explicit feedback about his posture in the sagittal plane might have promoted the participant's recognition of his posture and corrected the disintegration of proprioceptive, somatosensory and vestibular information for maintaining his upright posture in the sagittal plane. The appropriate position of center of pressure or center of mass was an important factor to good posture. Therefore, the use of tools such as Wii balance board measuring center of pressure was future issue for improving abnormal posture.

The lateral bending angle in the second week as a training phase was significantly larger than the angle in the first and third week. However, the difference (0.5-1.0 degree) was below the instrumental error (0.6-1.9 degree) reported in our previous study [24]. Since the lateral bending angle in the present case was small, our Kinect-based system could not possibly detect the change of lateral bending angle.

The anterior bending angle in the second week was significantly small than the angle in the first week, but the angle in the third week was significantly larger than the angle in the second week. These results indicated that the participant's short-term improvement of the anterior bending angle during standing achieved with the visual feedback training did not continue to the next week. This lack of continued improvement might be due to the following reasons. The first reason is that the feedback was given throughout the participant's visual feedback training sessions. In a previous study mentioned above, the 5-min practice session immediately improved the performance of individuals with PD and the improvement was maintained the next day; however, feedback about the knowledge of results (KR) was not provided during the practice trial (only after each practice trial [26].

The frequency of KR on motor performance after trials has been shown to be an important variable for motor learning. In a study concerning the frequency of KR in motor learning [29], practice in a 50% KR-relative frequency condition actually improved motor learning as measured by motor performance on a delayed no-KR retention test, compared to practice in a 100% KR-relative frequency condition. In visual feedback training to improve posture with the Kinect-based system in individuals with PD, a lower frequency of KR after visual feedback training might be better because of the beneficial aspect of trial-and-error.

A second possible reason for the lack of continued improvement in the present study is that the amount of visual feedback training was small. The length of the visual feedback training was only 5 min, and the training period was only 1 week. The length of the visual feedback training session was set at 5 min in accord with a previous study, as mentioned above. However, a greater amount of training is necessary for motor learning in general [30]. Previous motor learning research suggested that individuals with mild to moderate PD show a preserved ability to benefit from practice as a means of improving balance-task performance, and that the efficiency of motor learning is reduced in individuals with PD [31,32]. A larger amount of visual feedback training might be better to improve posture in an individual with PD with postural abnormality. The results of the present case study provide important suggestions for improving the timing, frequency and amount of visual feedback concerning the KR in visual feedback training to achieve greater improvement of posture with a Kinect-based system in individuals with PD with postural abnormalities.

The limitations of this study are as follows. The reliability and validity of the measurement of anterior and lateral bending angles during standing with the Kinect-based system have been confirmed only in healthy subjects, not in individuals with PD with postural abnormalities. The test-retest reliability of the anterior and lateral bending angles was affected not only by instrumental reliability and by anthropometric characteristics of the analysed subjects (posture, height, weight) but also by the subjects' capability to repeat the test in the same way. Further investigations of the reliability and validity of the measurements with the Kinect-based system in individuals with PD with postural abnormalities are needed. In addition, this case report is based on a single individual with PD and cannot be generalized to the greater population with PD. A larger number of participants assessed in a controlled study are needed. In addition, the duration of the present study (3 weeks) was short. The long-term feasibility of posture evaluation and visual feedback training with a Kinect-based system and the long-term effects should be investigated in individuals with PD.

The results of this study demonstrated that (1) the results of posture evaluation in the sagittal plane with the Kinect-based system is relatively reliable as compared with those in the frontal plane and absolutely reliable in both planes in healthy subjects, and (2) in-home posture evaluation and visual feedback training with the Kinect-based system by oneself with checking by a healthcare professional is feasible. In an individual with PD with moderate postural abnormality, the visual feedback training improved the anterior bending angle immediately and in the short term, but the improvement did not continue to the week following the visual feedback training. The Kinect-based system has potential as a novel assessment and intervention tool for in-home rehabilitation in individuals with PD. Study limitations and future research suggestions for the development of the Kinect-based system were also identified.

Acknowledgment

We would like to extend my sincere appreciation to Dr. Kentaro Tokuhisa in Nishiyamato rehabilitation hospital for the insightful statistical analyses of our data. This work was supported by a Grant-in-Aid for Scientific Research from Japan Society for the Promotion of Science (No. 23240028).

References

1. Doherty KM, van de Warrenburg BP, Peralta MC, Silveira-Moriyama L, Azulay JP, et al. (2011) Postural deformities in Parkinson's disease. Lancet Neurol 10: 538-549.
2. Ho B, Prakash R, Morgan JC, Sethi KD (2007) A case of levodopa-responsive camptocormia associated with advanced Parkinson's disease. Nat Clin Pract Neurol 3: 526-530.
3. Cannas A, Solla P, Floris G, Tacconi P, Serra A, et al. (2009) Reversible Pisa syndrome in patients with Parkinson's disease on dopaminergic therapy. J Neurol 256: 390-395.
4. Yamada K, Goto S, Matsuzaki K, Tamura T, Murase N, et al. (2006) Alleviation of camptocormia by bilateral subthalamic nucleus stimulation in a patient with Parkinson's disease. Parkinsonism Relat Disord 12:372-375.
5. Sako W, Nishio M, Maruo T, Shimazu H, Matsuzaki K, et al. (2009) Subthalamic nucleus deep brain stimulation for camptocormia associated with Parkinson's disease. Mov Disord 24: 1076-1079.

6. Asahi T, Taguchi Y, Hayashi N, Hamada H, Dougu N, et al. (2011) Bilateral subthalamic deep brain stimulation for camptocormia associated with Parkinson's disease. Stereotact Funct Neurosurg 89: 173-177.

7. Fietzek UM, Schroeteler FE, Ceballos-Baumann AO (2009) Goal attainment after treatment of parkinsonian camptocormia with botulinum toxin. Mov Disord 24: 2027-2028.

8. Furusawa Y, Mukai Y, Kawazoe T, Sano T, Nakamura H, et al. (2013) Long-term effect of repeated lidocaine injections into the external oblique for upper camptocormia in Parkinson's disease. Parkinsonism Relat Disord 19: 350-354.

9. de Sèze MP, Creuzé A, de Sèze M, Mazaux JM (2008) An orthosis and physiotherapy programme for camptocormia: a prospective case study. J Rehabil Med 40: 761-765.

10. Bartolo M, Serrao M, Tassorelli C, Don R, Ranavolo A, et al. (2010) Four-week trunk-specific rehabilitation treatment improves lateral trunk flexion in Parkinson's disease. Mov Disord 25: 325-331.

11. Okada Y, Kita Y, Nakamura J, Tanizawa M, Morimoto S, et al. (2012) Galvanic vestibular stimulation for camptocormia in Parkinson's disease: a case report. J Nov Physiother S1-001.

12. Kataoka H, Ikeda M, Horikawa H, Ueno S (2013) Reversible lateral trunk flexion treated with a rehabilitation program in a patient with Parkinson's disease. Parkinsonism Relat Disord 19: 494-497.

13. Clark RA, Pua YH, Fortin K, Ritchie C, Webster KE, et al. (2012) Validity of the Microsoft Kinect for assessment of postural control. Gait Posture 36: 372-377.

14. Clark RA, Pua YH, Bryant AL, Hunt MA (2013) Validity of the Microsoft Kinect for providing lateral trunk lean feedback during gait retraining. Gait Posture 38: 1064-1066.

15. Guerrero C, Uribe-Quevedo A (2013) Kinect-based posture tracking for correcting positions during exercise. Stud Health Technol Inform 184: 158-160.

16. Galna B, Barry G, Jackson D, Mhiripiri D, Olivier P, et al. (2014) Accuracy of the Microsoft Kinect sensor for measuring movement in people with Parkinson's disease. Gait Posture 39: 1062-1068.

17. Romano G, Viggiano D (2014) Interception of moving objects in karate: an experimental, marker-free benchmark. Muscles Ligaments Tendons J 4: 101-105.

18. Xu H, Yu Y, Zhou Y, Li Y, Du S (2013) Measuring accurate body parameters of dressed humans with large-scale motion using a Kinect sensor. Sensors (Basel) 13: 11362-11384.

19. Vaugoyeau M, Viel S, Assaiante C, Amblard B, Azulay JP (2007) Impaired vertical postural control and proprioceptive integration deficits in Parkinson's disease. Neuroscience 146: 852-863.

20. Vaugoyeau M, Azulay JP (2010) Role of sensory information in the control of postural orientation in Parkinson's disease. J Neurol Sci 289: 66-68.

21. Sage MD, Almeida Q (2009) Symptom and gait changes after sensory attention focused exercise vs aerobic training in Parkinson's disease. Mov Disord 24: 1132-1138.

22. Sage MD, Almeida Q (2010) A positive influence of vision on motor symptoms during sensory attention focused exercise for Parkinson's disease. Mov Disord 25: 64-69.

23. Funaya H, Shibata T, Wada Y, Yamanaka T (2013) Accuracy Assessment of Kinect Body Tracker in Instant Posturography for Balance Disorders. Proceedings of 7th International Symposium on Medical Information and Communication Technology (ISMICT).

24. Orito Y, Funaya H, Tamei T, Shibata T, Ikeda K, et al. (2014) Development of Low-cost and Accurate Posturography Using Kinect for In-home Rehabilitation of Balance Disorders. Proceedings of the 19th International Symposium on Artificial Life and Robotics 2014.

25. Sleivert G, Wegner H (1994) Reliability of measuring isometric and isokinetic peak torque, rate of torque development, integrated electromyography, and tibial nerve conduction velocity. Arch phys Med rehabil 75: 1315-1521.

26. Chiviacowsky S, Wulf G, Lewthwaite R, Campos T (2012) Motor learning benefits of self-controlled practice in persons with Parkinson's disease. Gait Posture 35: 601-605.

27. Duvoisin RC, Marsden CD (1975) Note on the scoliosis of Parkinsonism. J Neurol Neurosurg Psychiatry 38: 787-793.

28. Shen X, Mak MK (2014) Balance and Gait Training With Augmented Feedback Improves Balance Confidence in People With Parkinson's Disease: A Randomized Controlled Trial. Neurorehabil Neural Repair 28: 524-535.

29. Winstein C (1991) Knowledge of results and motor learning--implications for physical therapy. Phys Ther 71: 140-149.

30. Kottke F, Halpern D, Easton JK, Ozel AT, Burrill CA (1978) The training of coordination. Arch Phys Med Rehabil 59: 567-572.

31. Jessop RT, Horowicz C, Dibble LE (2006) Motor learning and Parkinson disease: Refinement of movement velocity and endpoint excursion in a limits of stability balance task. Neurorehabil Neural Repair 20: 459-467.

32. Nieuwboer A, Rochester L, Müncks L, Swinnen SP (2009) Motor learning in Parkinson's disease: limitations and potential for rehabilitation. Parkinsonism Relat Disord 15 Suppl 3: S53-S58.

Citation: Okada Y, Shibata T, Tamei T, Orito Y, Funaya H, et al. (2014) In-Home Posture Evaluation and Visual Feedback Training to Improve Posture with a Kinect-Based System in Parkinson's Disease. J Nov Physiother 4: 232 doi:10.4172/2165-7025.1000232