J. Phys. Ther. Sci. 29: 2215–2219, 2017

The Journal of Physical Therapy Science

Original Article

Assessing the adjustability of grasping force using the iWakka in elderly individuals

Tatsuya Kaneno, OTR, MS[1)*], Akihiro Sato, OTR, MS[1)], Kazunori Akizuki, RPT, PhD[2)], Arisa Yamaguchi, OTR[3)], Kiyoshi Yasaki, OTR[1)], Yoshifumi Morita, PhD[4)]

[1)] *Department of Occupational Therapy, Mejiro University: 320 Ukiya, Iwatsuki-ku, Saitama-shi, Saitama 339-8501, Japan*
[2)] *Department of Physical Therapy, Mejiro University, Japan*
[3)] *Department of Occupational Therapy, Musashimurayama Hospital, Japan*
[4)] *Graduate School of Engineering, Nagoya Institute of Technology, Japan*

Abstract. [Purpose] To ensure that elderly individuals continue performing their activities of daily living, rehabilitation specialists have focused on several intervention programs, including programs that help maintain the functionality of digits. Grasping motion, including the ability to adjust grip, both spatially and temporally, is important for the elderly to continue independent living. The iWakka is a device used to measure the adjustability of grasping force and developed in Japan in 2012. This study aimed to evaluate the range of error of the iWakka, and verify its usefulness for evaluating adjustability of grasping force in elderly subjects. [Subjects and Methods] In 36 community-dwelling elderly subjects, over 65 years old, two readings of adjustability of grasping force, in the dominant and non-dominant hands were obtained using the iWakka, and a Bland-Altman analysis of the data was performed. [Results] The results demonstrated significant fixed bias in the dominant and non-dominant hands, but no significant proportional bias was observed. The limits of agreement were −2.8 to 4.4 g for dominant hand and −2.6 to 3.9 g for non-dominant hand. [Conclusion] Therefore, it is possible to measure the efficacy of interventions and detect declines in adjustability of grasping force using iWakka. Interventional programs can be designed for daily life based on the grasping force results shown by iWakka.

Key words: Bland-Altman analysis, Adjustability for grasping force, iWakka

(This article was submitted Aug. 30, 2017, and was accepted Sep. 25, 2017)

INTRODUCTION

The number of elderly people is increasing worldwide and is expected to continue to increase in the future[1)]. In particular, Japan has the highest rate of growth in the proportion of elderly people and the problems related to higher proportions of elderly people are gaining international attention[1)]. The ability to perform activities of daily living (ADLs) has been reported to decline with age[2)]. Therefore, it is important to support elderly people so that they can continue to carry out their ADLs.

Rehabilitation specialists help the elderly so that they can live independently in the community. The digits in particular perform many functions such as gripping, grasping, pinching, hooking, scooping, and holding objects; thus, they play an important role in carrying out ADLs[3)]. Thus, intervention programs are often designed for daily life based on the results of an evaluation of digital function. In evaluating this, grasping force is an important factor in predicting autonomy in daily life, and the usefulness of evaluating grasping force has been previously reported[4, 5)]. Additionally, because grasping force is easily measured, it is often used in the clinical setting. However, to take purposive and efficient actions, one's abilities in "temporal" (i.e. quickly or slowly), "strength" (i.e. with reasonable strength), and "spatial" (i.e. exactly in the intended

*Corresponding author. Tatsuya Kaneno (E-mail: kaneno@mejiro.ac.jp)

©2017 The Society of Physical Therapy Science. Published by IPEC Inc.

This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial No Derivatives (by-nc-nd) License. (CC-BY-NC-ND 4.0: http://creativecommons.org/licenses/by-nc-nd/4.0/)

direction) adjustments have been reported as necessary[6]. Furthermore, even in grasping motions, not only maximum muscle strength, but also the ability to adjust the strength of force, temporally and spatially (hereafter referred to as adjustability for grasping force, AGF), depending on the shape, weight, and material of an object, without dropping it, is required in daily life.

Currently, in addition to evaluating grasping force, other methods used to evaluate the functioning of digits are the Purdue peg board test[7], the O'Connor Finger Dexterity Test[8, 9], the Jebsen-Taylor hand function test[10], and physical capacities of hand skill[11]. However, these methods are evaluated based on the time taken to accomplish, and the degree of achievement, of tasks. They do not use tasks specialized for evaluating AGF and, hence, they cannot be accurately evaluated. Thus, iWakka was developed to measure the AGF of digits, which had not been possible in the past[12–14]. The iWakka can measure the deterioration in one's ability with aging more accurately. It can quantify AGF and, hence, can be used not only to objectively indicate the functional status of an elderly person, but also to assess the effects of interventions.

The measurement values obtained by an evaluation consist of true values and two types of errors: random errors and systematic errors[15]. Random error is a variation in the readings that happens by chance at each measurement, resulting from individual differences or measurement errors. Systematic errors are further divided into fixed bias and proportional bias errors. Fixed bias is an error occurring in a specific direction regardless of the magnitude of the true value, while proportional bias is an error that increases in proportion to the magnitude of the true value. In general, the presence or absence of error is often assessed by Pearson's correlation coefficient or interclass correlation coefficient, but these methods cannot detect systematic errors such as fixed bias and proportional bias. Additionally, their disadvantage is that they cannot specify the type and extent of error. Systematic errors are not easily offset by repeated measurements; therefore, no method is effective in detecting systematic errors that occur during planning and implementation of a test. It has been reported that it is clinically important to understand the presence or absence of systematic error in an evaluation[15].

We reported the usefulness of the iWakka because it did not show either fixed bias or proportional bias in young adults[16]. However, in the elderly, there have been no reports on the type and extent of measurement error in the evaluation of AGF using iWakka. The purpose of this study was to investigate the type and extent of measurement errors using the measuring device, iWakka, and verify its usefulness in the evaluation of AGF.

SUBJECTS AND METHODS

Thirty-six elderly people, 65 years and over, living in Saitama prefecture, with Mini-Mental State Examination (MMSE) scores ≥24, without disorders of digits that required orthopedic surgery or neurological diseases that affect daily life, were included in this study. Written informed consent was obtained from all subjects prior to conducting the study. This study protocol was approved by the institutional review board of Mejiro University (approval number: 16-002).

This study used iWakka to evaluate AGF. The iWakka is made of a PVC pipe which is cylindrical in shape with a height of 80 mm and a diameter of 65 mm. One end of the PVC pipe is fixed with a hinge, on which leaf springs, crossing each other, are attached[17] (Fig. 1). By measuring the distortion of the leaf springs caused by the opening and closing of iWakka, the grasping force and its changes are displayed as a graph on a computer monitor in real time. The maximum target value displayed on the monitor when subjects adjust their grasping force is 400 g and changes are displayed at regular time intervals. Quantitative evaluation is possible by calculating the absolute value of error, between the target value and the measured value of grasping force as AGF. The smaller the absolute value of error, the better the AGF.

The set-up for the measurements was as follows (Fig. 1). The height of the table was set based on the height of the seat so that the subjects could easily operate iWakka. The distance between the table and the body was 10 cm. The measurement was made in a quiet environment. There was no backrest for the subjects and they maintained a constant position and posture by resting on their legs at shoulder width. The knee joint was kept in a 90 degrees flexed position. The monitor was placed 50 cm from the edge of the table. In order to eliminate the influence of muscles of the arms and to keep the heights of both shoulders constant, participants was held with the elbow resting on the table and the forearm in an intermediate position between supination and pronation. The iWakka was placed on an acrylic board and so that it would not tilt.

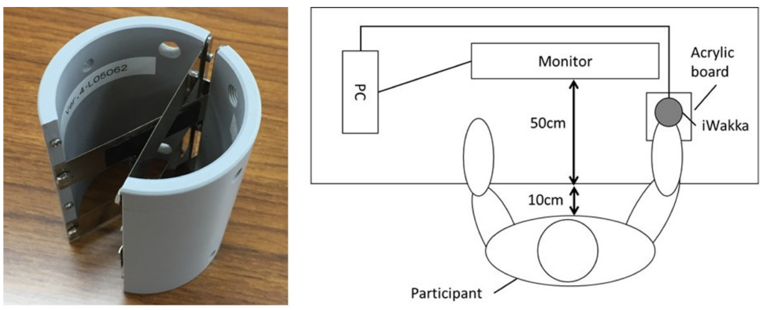

Fig. 1. iWakka and the measurement environment.

Prior to the actual measurements, the subjects practiced tasks with target values different from those of the evaluation tasks in order to understand the task. After a 5-minute break following the practice tasks, the subjects performed an evaluation task. In the evaluation task, data was collected for two trials on the dominant hand and non-dominant hand separately, and the average value was documented. The second measurement was obtained 90 minutes after the first measurement.

The evaluation with iWakka consisted of two types of tasks: mountain task, in which the target line graph had the shape of a mountain, and valley task, in which the target line graph had the shape of a valley (Fig. 2). In order to eliminate the effect of order in which the tasks were performed, subjects were randomly assigned to one of four groups: a group that started with the mountain task with the dominant hand; a group that started with the valley task with the dominant hand; a group that started with the mountain task with the non-dominant hand; and a group that started with the valley task with the non-dominant hand. In order to determine the dominant hand, the Laterality Index was calculated using the Edinburgh Handedness Inventory[18]. According to the standards set by Sakano[19], a laterality index of 100 to 80 and −20 to −100 was assigned to the right hand and left hand, respectively.

In this study, a Bland-Altman analysis was used to examine the extent and type of error involved[20]. To begin with, a scatter diagram (Bland-Altman plot) was created with the difference (d) between the first and second measurements depicted on the y-axis and the mean of the two measurements on the x-axis. To determine if there was a fixed bias between the measurements, the 95% confidence interval (95% CI) of the average of d ($\bar{d}$) was calculated. When the 95% confidence interval did not contain the value 0, it signified that the measured values were distributed in a certain direction, and it was determined that there was a significant fixed bias. Next, in order to determine if proportional bias was present, regression analysis was performed. When a significant result was observed, it was determined that there was a proportional bias. When fixed bias or proportional bias was observed, the limits of agreement (LOA) of error of the measured values were calculated. The Bland-Altman analysis was performed with Microsoft Office Excel 2013 with a significance level of 5%.

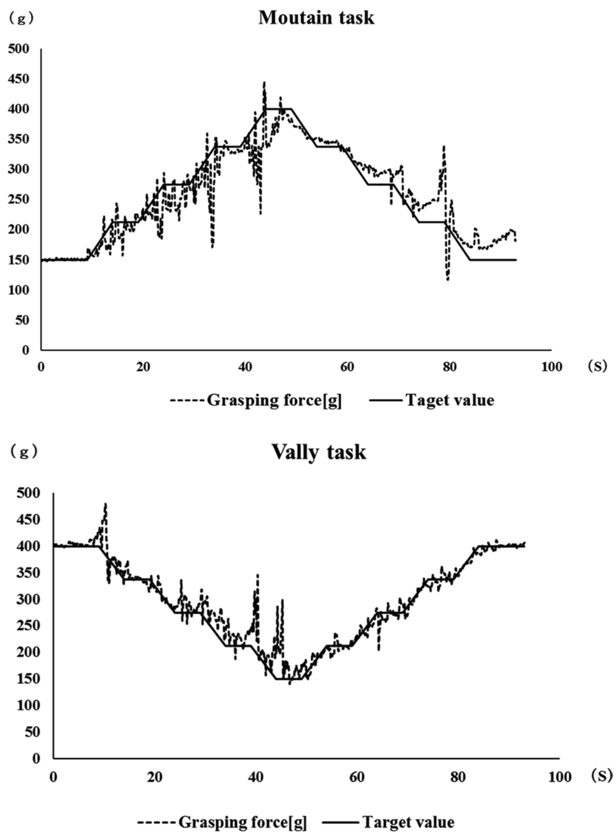

Fig. 2. Evaluation tasks of iWakka.
The x-axis shows elapsed time from the start of the task and the y-axis shows grasping force. Adjustability of grasping force can calculate from the absolute value of error, between the target value and the measured value of grasping force.

RESULTS

The mean age of the subjects (27 males and 9 females) was 70.9 ± 3.8 years [95% CI: 69.7–72.2]. The mean MMSE score of the subjects was 28.4 ± 2.1 points [95% CI: 27.7–29.1]. Thirty-five out of 36 subjects were right-handed.

The mean values of the two measurements for the dominant and non-dominant hands were 8.5 ± 3.6 g [95% CI: 7.3–9.7] and 7.7 ± 3.2 g [95% CI: 6.6–8.8], respectively. The $\bar{d}$ in the dominant and non-dominant hands was 0.8 ± 2.6 g and 0.7 ± 2.3 g, respectively (Table 1). The Bland-Altman analysis found a significant fixed bias with a 95% CI of 0.2–1.3 g and 0.2–1.2 g for the dominant and non-dominant hands, respectively. Finally, we performed a regression analysis, which revealed no significant proportional bias in either the dominant hand (y=0.2x −0.9, R^2=0.07, p=0.11) or the non-dominant hand (y=0.1x −0.3, R^2=0.02, p=0.32) (Table 2). The LOA was −2.8 to 4.4 g for the dominant hand and −2.6 to 3.9 g for the non-dominant hand.

DISCUSSION

The conventional methods of evaluating digital function based on the time taken to accomplish tasks and their degree of achievement; however, the content of the task includes not only digit movements but also movements of the upper limbs. Thus, they cannot measure the AGF during the task. The iWakka is a new evaluation device, specialized in evaluating AGF of digits and it can quantify the results. The obtained results can be used for planning intervention programs and verifying the effectiveness of such interventions. The importance of analyzing absolute reliability of such a new evaluation method in terms of clinical efficacy has been pointed out[15]. The analysis of absolute reliability is a method of identifying the type and extent of measurement errors, and highlighting the “true change” that can help researchers and clinicians make decisions.

Kaneno et al.[16] reported that fixed bias and proportional bias were not involved in the evaluation of AGF in young people using iWakka. However, the present study found that a fixed bias was involved in the evaluation of AGF of elderly people using iWakka. This indicated that elderly people had lower AGFs than young people and elderly people had more scope for improvement in their AGF. Therefore, it likely to cause fixed bias due to a learning effect. Additionally, the LOA for the dominant hand was more widely distributed than the LOA for the non-dominant hand. This also indicated that the dominant hand had lower AGFs than the non-dominant hand and this was likely to cause a wider range of error due to a learning effect.

The type and extent of error involved in the evaluation of AGF of elderly people using iWakka is unknown and guidelines on interventions based on AGF have not been established. The Bland-Altman analysis in this study found that only fixed bias was involved in the evaluation of AGFs of elderly people using iWakka. The LOA for the dominant hand and non-dominant hand was −2.8 to 4.4 g and −2.6 to 3.9 g, respectively. The results demonstrate that LOA values beyond these ranges indicate “true changes.” Additionally, evaluation of AGF of elderly people using iWakka is sensitive and can lead to early detection of a decline in their AGF. Therefore, the rehabilitation specialists can design intervention programs for daily life based on the results of evaluation of AGF using iWakka. We suggest that evaluating AGF using iWakka can be useful in clinical practice.

The subjects were healthy elderly people living in the community; therefore, it is hard to generalize the results to include

Table 1. Adjustability for grasping force measured by iWakka (g)

	Dominant hand				Non-dominant hand			
	1st measurement (g)	2nd measurement (g)	Mean of 1st and 2nd measurements (g)	Difference between 1st and 2nd measurements (g)	1st measurement (g)	2nd measurement (g)	Mean of 1st and 2nd measurements (g)	Difference between 1st and 2nd measurements (g)
Mean	8.9	8.1	8.5	0.8	8.0	7.4	7.7	0.7
SD	4.2	3.5	3.6	2.6	3.6	3.3	3.2	2.3

Table 2. Bland-Altman analysis of the evaluation method using iWakka

	Bland-Altman analysis				LOA (g)
	Fixed bias		Proportional bias		
	95% CI	Yes/No	Slope of regression line	Yes/No	
Dominant hand	0.2 to 1.3	Yes	0.2	No	−2.8 to 4.4
Non-dominant hand	0.2 to 1.2	Yes	0.1	No	−2.6 to 3.9

95% CI: 95% confidence interval; LOA: limits of agreement.

those with disabilities. This study is a basic research and further studies will be required to gather data from people with various disorders for clinical application. The iWakka displays the grasping force during a task as a graph in real time and the subjects can see the deviation in their own grasping force from the target value on a computer monitor. Thus, this visual information functions as feedback on task performance for subjects and it can immediately improve the AGF. However, the interval between the first and second measurements was short (90 minutes) and it is possible that a practice effect remained. These factors may have contributed to fixed bias; therefore, further studies are required to evaluate the effect of measurement intervals in subjects with disabilities and to verify the results of this study.

REFERENCES

1) United Nations: World population prospects. https://esa.un.org/unpd/wpp/publications/files/key_findings_wpp_2015.pdf (Accessed Feb. 15, 2017).
2) Fisher AG, Jones KB: Assessment of motor and process skills, 8th ed., Vol. 2, Revised ed. Fort Collins: Three Star Press, 2014, p 370.
3) Neumann DA, Kelly ER: Kinesiology of the musculoskeletal system: foundations for physical rehabilitation, 2nd ed. St. Louis: Mosby/Elsevier, 2010.
4) Ishizaki T, Watanabe S, Suzuki T, et al.: Predictors for functional decline among nondisabled older Japanese living in a community during a 3-year follow-up. J Am Geriatr Soc, 2000, 48: 1424–1429. [Medline] [CrossRef]
5) Miyahara H, Takeshita J: The relation of exercise performance with healthy life span in the community dwelling elderly: a three-year follow-up study. J Jpn Phys Ther Assoc, 2004, 31: 155–159 (in Japanese).
6) Fukui K, Fujita T, Miyasaka M: Nosocchu saizensen, 4th ed. Tokyo: Ishiyaku, 2009, pp 183–187 (in Japanese).
7) Tiffin J: Purdue Pegboard examiner manual. Chicago: Science Research Associates, 1968.
8) Chen HM, Chang JJ: The skill components of a therapeutic chopsticks task and their relationship with hand function tests. Kaohsiung J Med Sci, 1999, 15: 704–709. [Medline]
9) Casanova JE, Casanova JS, Young MJ: Hand function in patients with diabetes mellitus. South Med J, 1991, 84: 1111–1113. [Medline] [CrossRef]
10) Jebsen RH, Taylor N, Trieschmann RB, et al.: An objective and standardized test of hand function. Arch Phys Med Rehabil, 1969, 50: 311–319. [Medline]
11) Bell E, Jurek K, Wilson T: Hand skill measurement: a gauge for treatment. Am J Occup Ther, 1976, 30: 80–86. [Medline]
12) Yamazaki K, Kitayama K, Nakajima S, et al.: Development of measurement device for quantitative evaluation of sensorimotor integration function during grip motion. Jap J Soc Welf, 2014, 16: 20–25 (in Japanese).
13) Morita Y, Ukai H, Sato N, et al.: Japanese Unexamined Patent Application Publication No. 2014–57636, 2012.
14) Morita Y, Ukai, H, Hamasaka J, et al.: Japanese Unexamined Patent Application Publication No. 2012–24394, 2010.
15) Ludbrook J: Statistical techniques for comparing measurers and methods of measurement: a critical review. Clin Exp Pharmacol Physiol, 2002, 29: 527–536. [Medline] [CrossRef]
16) Kaneno T, Sato A, Yasaki K, et al.: The error range of the assessment method of grip force adjustment ability. Rigakuryoho Kagaku, 2017, 32: 117–121 (in Japanese). [CrossRef]
17) Morita Y, Nakajima S, Yamazaki K, et al.: Quantitative evaluation system of adjustability for grasping force. Jap J Soc Welf, 2016, 18: 5–10 (in Japanese).
18) Oldfield RC: The assessment and analysis of handedness: the Edinburgh inventory. Neuropsychologia, 1971, 9: 97–113. [Medline] [CrossRef]
19) Sakano N: Latent left-handedness: its relation to hemispheric and psychological functions. Jena: VEB G. Fischer Verlag, 1982.
20) Bland JM, Altman DG: Statistical methods for assessing agreement between two methods of clinical measurement. Lancet, 1986, 1: 307–310. [Medline] [CrossRef]