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Original Article

# Effect of fingernail length on the hand dexterity

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**Abstract.** [Purpose] The fingernails allow for increased sensory perception at the finger pulp, and contribute to the accurate picking up of small objects. The purpose of the present study was to clarify the effect of fingernail length on hand dexterity using subjects' own fingernails. [Subjects and Methods] The hand sizes and fingernail configurations of 38 young healthy volunteers (eighteen males and twenty females) were measured. The effect of fingernail length (0 and 2 mm) on hand dexterity also was investigated using the simple test for evaluating hand function. [Results] The hand and finger sizes as well as fingernail widths were significantly larger in males than in females. The time taken for each subtest of the simple test for evaluating hand function was generally shorter at a fingernail length of 2 mm than at 0 mm, and it was significantly shorter for a number of subtests. There was little significant difference in the time taken for the subtests between genders. [Conclusion] It was clear that a fingernail length of 2 mm had an advantageous effect on hand dexterity, with little gender difference observed. These findings suggest that the fingernail lengths of the subjects should be standardized when evaluating changes in their hand dexterity with time.

**Key words:** Fingernail, Hand dexterity, Simple test for evaluating hand function (STEF)

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## INTRODUCTION

Dexterity is defined as appropriate voluntary activity used to manipulate objects during a specific task[1)]. Dexterity is among the most important examination methods for the determination of neuromotor function of the hand, which involves integration of motor and sensory functions. Dexterity also was the best predictor of independence in activities of daily living[2)]. Hand dexterity is affected by many factors, such as age, gender, educational level, and hand dominance[3, 4)].

Few previous studies, however, examined the effect of fingernail length on hand dexterity, and the few published studies were conducted using artificial fingernails of several lengths attached to the subjects' own fingernails[5, 6)]. Jansen et al. reported that the degree of hand manipulation decreased with increased fingernail length, and they recommended that patients cut their fingernails to 5 mm in length[5)]. Uetake reported that the upper limit of fingernail length for handwork efficiency and fashion considerations was 2 mm[6)].

Nandgaonkar also reported that the contribution of the fingernails to hand dexterity using the subjects' own fingernails[7)]. It was found that there is a significant correlation between the duration of fingernail cutting and the tasks on the modified Rivet and Eyelet Deftness test[7)]. However, there is a limitation in that the fingernail length was not quantified.

The fingernail consists of the nail plate, nail fold, nail bed and hyponychium. Beasley et al. suggested three basic categories for the contributions of the fingernails to hand function; (1) fingernails are utilitarian, (2) they are environmental

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receptors for sensory input, and (3) they are esthetic elements of our hands that are constantly exposed to scrutiny[8]. Seah et al. also reported that fingernails play a passive role in increasing sensory perception at the pulp by providing the counterpressure necessary for the compression of sensory end organs between the palmar skin and the fingernail[9]. Furthermore, Zook reported that the fingernails allow for increased sensory perception in the pad of the finger as well as for the efficient and accurate picking up of small objects[10]. The purpose of the present study was to clarify the effect of fingernail length on hand dexterity using the subjects' own fingernails as the fingernails play a role as perceptual receptors.

## SUBJECTS AND METHODS

Thirty-eight healthy university student volunteers (eighteen males, twenty females) with a mean age of 21.4 years (range, 21–22 years) participated in the study. All subjects were right-hand dominant. None of subjects had a history of injury or surgery to the upper extremities, or had neuromuscular diseases. The study was approved by research ethics review committee of Hokkaido Bunkyo University (approval number: 28010), and informed consent was obtained from all subjects.

In order to evaluate fingernail size, the length and width of the nail on the right thumb, index finger and middle finger of each subject were measured according to the method of Jung et al[11]. The length of the fingernail was defined as the greatest longitudinal distance from the groove at the junction of the eponychium and proximal nail fold to the tip of the finger. The width of the fingernail was defined as the greatest transverse distance between the two lowest points of the fingernail in the lateral nail groove.

The length of the right thumb, index finger and middle finger, width of the respective distal interphalangeal joints, and length and breadth of the right hand were also measured for each subject. The length of thumb and two fingers was defined as the distance between the metacarpophalangeal joint and the fingertip. The distal interphalangeal joint (DIPJ) width was defined as the distance across the DIPJ. Hand length also was defined as the distance from the distal wrist crease to the midpoint of the tip of the middle finger. Hand breadth was also defined as the distance across the finger knuckles along the proximal and distal palmar creases. These dimensions were measured using an electronic caliper (Shinwa Rules Co., Ltd., Sanjo, Japan).

The fingernail lengths to be compared in the study were set at 0 mm and 2 mm, which was regarded as both fashionable and allowing efficient handwork based on the report of Uetake[6]. According to the previous study of Jansen et al.[5], fingernail length was defined as the length from tip of the finger to tip of the fingernail on the sagittal plane (Fig. 1). The state in which the nail extended 0 mm from tip of finger was defined as a fingernail length of 0 mm, while that in which the nail extended 2 mm from tip of finger was defined as a fingernail length of 2 mm.

Hand function and dexterity were assessed using the simple test for evaluating hand function (STEF, Sakai Medical Corp., Tokyo, Japan). The STEF was developed as a standardized battery by Kaneko et al.[12] for the simple and objective evaluation of the functional movement ability of the upper limbs including the fingers. We selected this battery for use in the study as the STEF was designed on basis of various hand activities[12], and as it was used for the evaluation of motor skills of the hand and upper extremities in a number of earlier studies[13, 14].

The STEF battery consists of 10 types of subtests. Subjects were required to grasp, pinch or turn over objects of different shapes and sizes and to carry them to an arranged area, and were valuate the speed of manipulation of objects using one upper limb. The objects consisted of large sphere (70 mm in diameter, 5 pieces), middle-sized sphere (40 mm in diameter, 6 pieces), large rectangular box (100 × 100 × 47 mm, 5 pieces), middle-sized cube (35 × 35 × 35 mm, 6 pieces), thick wooden disk (20 mm in diameter, 10 mm in thickness, 6 pieces), small cube (15 × 15 × 15 mm, 6 pieces), thin cloth (90 × 80 mm, 6 pieces), thin metal disk (20 mm in diameter, 2 mm in thickness, 6 pieces), small sphere (5 mm in diameter, 6 pieces) and pin (3 mm in diameter, length in 42 mm, 6 pieces).

The time required for the manipulation of each object using the right hand measured in the study. First, STEF times were measured after cutting the nails of the right thumb, index and middle fingers to 0 mm in length. As the fingernails grow at a rate of about 3 mm a month[15], after 20 days the fingernails were cut to 2 mm in length and STEF times were remeasured. Measurements were taken in the sitting position three times at each fingernail length.

As the Shapiro-Wilks test indicated non-normal data distribution, non-parametric analyses were used. The

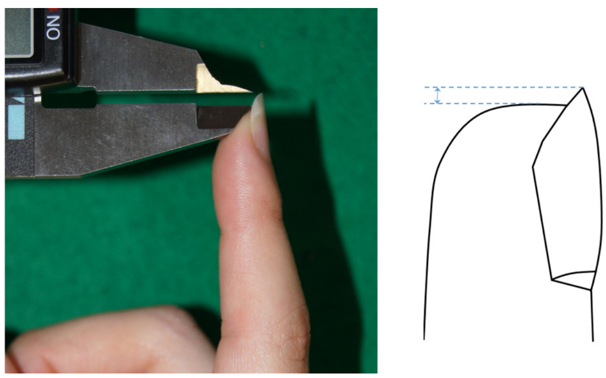

**Fig. 1.** Measurement of fingernail length
The fingernail length was measured as the length from tip of the finger to tip of the nail on the sagittal plane. The fingernails were cut to 0 mm or 2 mm of extension from tip of fingers.

**Table 1.** General characteristics of the subjects

| Characteristic | Males (N=18) | Females (N=20) | p[a] |
|---|---|---|---|
| | Mean ± SD | Mean ± SD | |
| Age (years) | 21.5 ± 0.5 | 21.3 ± 0.4 | |
| Hand length (mm) | 181.4 ± 10.0 | 168.7 ± 5.5 | ** |
| Hand breadth (mm) | 86.6 ± 3.8 | 76.2 ± 2.6 | ** |
| Finger length (mm) | | | |
| Thmub | 66.0 ± 3.2 | 59.4 ± 2.8 | ** |
| Index | 93.2 ± 4.0 | 87.1 ± 4.7 | ** |
| Middle | 106.2 ± 5.9 | 99.4 ± 7.0 | * |
| Distal interphalangeal joint width (mm) | | | |
| Thmub | 19.7 ± 1.3 | 17.5 ± 0.7 | ** |
| Index | 15.4 ± 1.0 | 13.8 ± 0.6 | ** |
| Middle | 15.6 ± 1.2 | 14.0 ± 0.7 | ** |
| Fingernail length (mm) | | | |
| Thmub | 13.7 ± 1.2 | 13.5 ± 0.9 | |
| Index | 12.3 ± 1.1 | 11.8 ± 1.1 | |
| Middle | 13.4 ± 1.3 | 12.6 ± 0.8 | * |
| Fingernail width (mm) | | | |
| Thmub | 13.6 ± 0.5 | 12.1 ± 1.1 | ** |
| Index | 10.6 ± 0.6 | 9.1 ± 0.5 | ** |
| Middle | 11.4 ± 0.8 | 10.0 ± 1.1 | ** |

SD: standard deviation
[a]Scores were compared between males and females using Mann-Whitney test.
*p<0.05, **p<0.01

**Table 2.** Times for STEF subtests with fingernails at 0 mm and 2 mm

| STEF subtests | 0 mm fingernails | 2 mm fingernails | p[a] |
|---|---|---|---|
| | Mean ± SD | Mean ± SD | |
| Large sphere | 4.9 ± 0.5 | 4.8 ± 0.6 | |
| Middle-sized sphere | 4.6 ± 0.7 | 4.4 ± 0.5 | * |
| Large rectangular box | 6.8 ± 0.8 | 6.8 ± 0.8 | |
| Middle-sized sphere cube | 6.8 ± 0.7 | 6.6 ± 0.8 | |
| Thick wooden disk | 4.8 ± 0.8 | 4.6 ± 0.6 | |
| Small cube | 5.9 ± 0.7 | 5.6 ± 0.6 | ** |
| Thin cloth | 4.7 ± 0.7 | 4.5 ± 0.6 | |
| Thin metal disk | 9.5 ± 3.7 | 8.3 ± 0.9 | |
| Small sphere | 7.9 ± 1.1 | 8.2 ± 1.2 | |
| Pin | 10.4 ± 3.1 | 8.9 ± 1.1 | ** |

SD: standard deviation
[a]Scores were compared between fingernails at 0 mm and 2 mm using Wilcoxon signed-rank test.
*p<0.05, **p<0.01

differences between males and females in term of age, and length and breadth of the right hand were compared using the Mann-Whitney test. Finger length, DIPJ width and fingernail configuration of the right thumb, index finger and middle finger also were compared using the Mann-Whitney test. The time of each STEF subtest with fingernails at 0 mm and 2 mm were compared using the Wilcoxon signed-rank test. The times with fingernails at 0 mm and 2 mm were also compared between males and females using the Wilcoxon signed-rank test. Furthermore, the times at each fingernail length were also compared between males and females using the Mann-Whitney test.

All analyses were performed using SPSS Version 11.5 J for Windows. The level of significance was set at p<0.05.

## RESULTS

The mean age was 21.5 years in males and 21.3 years in females. There was no significant difference between gender in terms of mean age (p=0.20). The mean hand length and breadth were both significantly larger in males than in females (p<0.01, p<0.01, respectively). The mean length of the thumb, index finger and middle finger were also larger in males than in females (p<0.01, p<0.01, p=0.013, respectively). Moreover, the mean DIPJ widths of these fingers were similarly larger in males (p<0.01, p<0.01, p<0.01, respectively). Although there were no significant differences in the mean fingernail length of the thumb and index finger between genders (p=0.44, p=0.44, respectively), that of the middle finger was significantly larger

**Table 3.** Times for STEF subtests with fingernails at 0 mm and 2 mm in males and females

| STEF subtests | Males | | | Females | | |
|---|---|---|---|---|---|---|
| | 0 mm | 2 mm | $p^a$ | 0 mm | 2 mm | $p^b$ |
| | Mean ± SD | Mean ± SD | | Mean ± SD | Mean ± SD | |
| Large sphere | 5.0 ± 0.9 | 4.8 ± 0.6 | | 4.9 ± 0.4 | 4.8 ± 0.5 | |
| Middle-sized sphere | 4.7 ± 0.7 | 4.9 ± 0.6 | | 4.5 ± 0.6 | 4.4 ± 0.5 | |
| Large rectangular box | 6.7 ± 0.7 | 6.7 ± 0.9 | | 6.9 ± 0.8 | 6.9 ± 0.7 | |
| Middle-sized cube | 6.8 ± 0.7 | 0.6 ± 0.8 | | 6.8 ± 0.7 | 6.6 ± 0.8 | * |
| Thick wooden disk | 5.0 ± 0.9 | 4.6 ± 0.6 | * | 4.6 ± 0.7 | 4.6 ± 0.6 | |
| Small cube | 6.0 ± 0.6 | 5.7 ± 0.7 | ** | 5.8 ± 0.7 | 5.6 ± 0.6 | ** |
| Thin cloth | 4.9 ± 0.6 | 4.6 ± 0.5 | | 4.5 ± 0.7 | 4.4 ± 0.6 | |
| Thin metal disk | 10.8 ± 4.9 | 8.5 ± 1.0 | | 8.3 ± 1.3 | 8.2 ± 0.9 | |
| Small sphere | 8.2 ± 1.0 | 8.5 ± 1.0[c*] | | 7.6 ± 1.1 | 7.9 ± 1.3[c*] | |
| Pin | 11.6 ± 4.1 | 9.1 ± 1.2 | ** | 9.4 ± 1.1 | 8.7 ± 1.0 | ** |

SD: standard deviation
[a]Scores were compared between fingernails at 0 mm and 2 mm in males using Wilcoxon signed-rank test.
[b]Scores were compared between fingernails at 0 mm and 2 mm in females using Wilcoxon signed-rank test.
[c]Scores were compared between males and females with fingernails at 2 mm using Mann-Whitney test.
*$p<0.05$, **$p<0.01$

in males (p=0.03). The mean fingernail widths of the thumb, index finger and middle finger were also significantly larger in males than in females (p<0.01, p<0.01, p<0.01, respectively) (Table 1).

The time for each STEF subtest with fingernails at 2 mm was generally shorter than that with fingernails at 0 mm. The Wilcoxon signed-rank test showed that the mean times for the middle-sized sphere, small cube and pin with fingernails at 2 mm were significantly shorter than those with fingernails at 0 mm (p=0.03, p<0.01, p<0.01, respectively) (Table 2).

The Wilcoxon signed-rank test also showed that the mean times with fingernails at 2 mm were significantly shorter than those with the fingernails at 0 mm in subtests with the thick wooden disk, small cube, and pin for males (p=0.03, p<0.01, p<0.01, respectively). The mean times with fingernails at 2 mm were also significantly shorter than those with fingernails at 0 mm in subtests with the middle-sized cube, small cube, and pin for females (p=0.048, p<0.01, p<0.01, respectively) (Table 3).

The Mann-Whitney test showed that the mean times with fingernails at 0 mm were not significantly different between males and females (p>0.05, p>0.05, respectively), but the mean time with fingernails at 2 mm for females was significantly shorter than that for males on the subtest with the small sphere alone (p=0.03) (Table 3).

## DISCUSSION

We observed that the time for each STEF subtest with fingernails at 2 mm was generally shorter than that with fingernails at 0 mm, and it was significantly shorter in a number of subtests. These findings indicated that fingernails at 2 mm are advantageous to hand dexterity. In particular, fingernails cut to a length to allow them to be used to hook objects was important for manipulation in the pin subtest, with fingernails cut at 2 mm appearing to have an advantage. However, in the subtests with the middle-sized sphere, thick wooden disk and small cube, in which there is less need to hook objects with the fingernails, fingernails of 2 mm in length also showed a significant effect. These results suggest that a certain length of fingernail is necessary for performing dexterous manipulation in terms of the receptive function for sensory input proposed by Beasley et al[8].

Although the distribution of sensory receptors in the nail plate is not clear, mechanical forces applied to the nail plate are transmitted to the mechanoreceptors in the nailbed, nail matrix and the nailfold[9]. The distribution of Merkel cells, which are slowly adapting type I mechanoreceptors, has been described in the nail matrix and nailfold[16, 17]. Ruffini-like spray endings, which are slowly adapting type II (SA-II) afferents, have also been reported in the nailbed[18] and the half-moon[19, 20]. Birznieks et al. have demonstrated that SA-II nail afferents, distributed in skin bordering the lateral edges of the nails, respond reliably to forces applied to the fingertips that primarily come into contact with objects in manipulation tasks[21]. Furthermore, signals in populations of SA-II nail afferents contain directional information about fingertip forces.

The time taken for subtests in it was less necessary to hook the objects with the fingernails was significantly shorter with fingernails at 2 mm in the present study. Fingernails at 2 mm in length might have advantages in transmitting information to these mechanoreceptors distributed around the fingernail as the area of the fingernail is relatively larger than that for nails cut to 0 mm.

Regarding the effect of fingernail length on hand performance, Jansen et al. investigated the speed and quality of finger manipulations using a functional dexterity test with artificial fingernails extending 5 mm, 10 mm and 20 mm beyond the tips of the fingers. It was revealed that the time and penalty increased as the length of the artificial fingernails increased. From these results, they recommended that patients cut their fingernails to 5 mm in length[5]. Uetake examined the effect of fingernail length on hand work efficiency with artificial fingernails of 4 different lengths: 0 mm, 2 mm, 4 mm and 6 mm. She reported that work efficiency is best with fingernails at 0 mm, and work efficiency decreased as fingernail length increased, so fingernail length should be limited to 2 mm or less for handwork efficiency and fashion considerations[6].

In the present study, hand dexterity with fingernails at 2 mm was superior to that at 0mm, which is in disagreement with the results of Uetake[6]. One possible reason could be that the sensory perception of fingertips differed from that in the Uetake study[6] as our study was performed using the subjects' own fingernails. Nandgaonkar reported that the subjects' own fingernails definitely contribute to hand dexterity. As the number of days from when the fingernails were cut increased, the dexterity score on the tasks requiring fingernails also increased[7]. However, fingernail length was not quantified.

The time required with fingernails at 2 mm for females was significantly shorter than that for males on the small sphere subtest alone, and there were no significant gender-based differences in the other subtests in the present study. Previous studies using Purdue pegboard tasks showed that females had advantage in hand performance compared to males[22, 23]. There is some reason to believe that the larger hand size of males handicaps their performance in the manipulation of small objects[23]. In the present study, hand and fingers size were significantly smaller in females than in males. However, the difference in hand performance between males and females was slight as the STEF used in this study was composed of 10 objects of various sizes.

The results from the present study indicate that the fingernail length of the subjects should be standardized when evaluating hand dexterity and motor skill changes with time so that the hand dexterity is affected by fingernail length. We believe that the influence of fingernail length on the evaluation of hand dexterity and motor skills could be eliminated by standardizing fingernail length.

This study had a few limitations. First, subjects consisted of only healthy young adults. With increased age, the fingernails flatten and the contours are modified[11], resulting in platonychias and koilonychias[24]. Fine motor hand movements also decline with aging[25, 26], and the effect of the fingernail length on such movements in the elderly is unknown. Second, a practice effect could have affected results for motor skills with fingernails at 2 mm despite the fact that the measurement interval was more than 20 days. Further studies are necessary to clarify the influence of fingernail length on hand dexterity in various ages.

In conclusion, the effect of the length of the fingernails on hand dexterity in subjects using their own fingernails was clarified using the STEF. The time for each STEF subtest with fingernails at 2 mm was generally shorter than that with fingernails at 0 mm, and it was significantly shorter in number of subtests. There was little significant difference in the time taken for each subtest between males and females. Our findings suggest that the fingernail length of subjects should be standardized when evaluating the hand dexterity and motor skill changes with time.

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