# Tactile thresholds in healthy subjects

## Pragi zaznave statičnega dotika pri zdravih preiskovancih

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## Izvleček

**Izhodišča:** Z določanjem pragov zaznave ugotavljamo delovanje perifernih živčnih vlaken in njihovih povezav v osrednjem živčevju. Kvantitativna senzorimetrija je eden od načinov ocenjevanja občutljivosti, pri katerem želimo določiti jakost dražljaja, s katerim izzovemo občutek. Termotest in vibrometrija sta že uveljavljeni metodi določanja pragov zaznave toplotnih dražljajev in občutka vibracije. Ocenjevanje z monofilamenti se rutinsko še ne uporablja. Namen raziskave je bil ugotoviti prage zaznave statičnega dotika pri zdravih preiskovancih.

**Metode:** Pri 39 zdravih preiskovancih (19 moških), starih od 21 do 71 let, smo s von Freyevimi laski določili prag zaznavanja dotika na sedmih delih telesa na obeh straneh.

**Rezultati:** Zaznavanje dotika ni bilo odvisno do starosti in spola preiskovancev. Desna stran telesa je bila statistično značilno bolj občutljiva na zunanji strani goleni ($p = 0{,}001$). Leva stran telesa je bila statistično značilno bolj občutljiva na notranji strani podlahti ($p = 0{,}022$). Statistično značilno so se med seboj razlikovali tudi pragi zaznave na različnih delih telesa ($p < 0{,}001$), pri čemer so bili bolj občutljivi distalni deli telesa.

**Zaključek:** Z monofilamenti lahko ocenjujemo občutek za dotik brez potrebe po dragi in zapleteni opremi.

## Abstract

**Background:** The assessment of sensory thresholds provides a method of examining the function of peripheral nerve fibers and their central connections. Quantitative sensory testing is a variant of conventional sensory testing wherein the goal is to quantify the magnitude of stimulation needed to produce a particular sensation. While thermal and vibratory testing are established methods in the assessment of sensory thresholds, the assessment of tactile thresholds with monofilaments is not used routinely. The purpose of this study was to assess the tactile thresholds in normal healthy population.

**Methods:** In 39 healthy volunteers (19 men) aged 21 to 71 years, tactile thresholds were assessed with von Frey's hair in 7 parts of the body bilaterally.

**Results:** We found touch sensitivity not to be dependent on age or gender. The right side was significantly more sensitive in the lateral part of the leg ($p = 0.011$) and the left side in the medial part of the arm ($p = 0.022$). There were also significant differences between sites ($p < 0.001$), whereby distal parts of the body were more sensitive.

**Conclusions:** Von Frey filaments allow the estimation of tactile thresholds without the need for complicated instrumentation.

## Introduction

The assessment of sensory thresholds provides a method of examining the function of peripheral nerve fibers and their central connections. Quantitative sensory testing is a variant of conventional sensory testing wherein the goal is to quantify the level of stimulation needed to produce a particular sensation. While thermal and vibratory testing are established methods in the assessment of sensory thresholds, assessment of tactile thresholds with monofilaments is not used routinely.

Monofilament testing is an inexpensive, easy-to-use and portable test for touch sensation. It is recommended by several practice guidelines to detect peripheral neuropathy in otherwise normal feet.[1-3] Monofilaments are calibrated, single-fibre nylon threads with various values that generate a reproducible buckling stress. The higher the value of the monofilament, the stiffer and more difficult it is to bend. Three monofilaments (often called Semmes-Weinstein monofilaments) are commonly used to diagnose peripheral neuropathy. One of them, a 10-g monofilament is good for predicting foot ulceration, but is insensitive to the early detection of neuropathy.[4] Beside diabetic peripheral neuropathy, monofilaments are used to measure sensory abnormalities in complex regional pain syndrome, herpes zoster and other chronic pain syndromes.[5-7]

As this test is already widely used and advocated in many clinical guidelines, especially for diabetic patients, standardization of the method for the monofilament test and studies to define sensitivity of this method in clinical practice are important.[8] The aim of the present study was therefore to assess the touch sensation of the upper and lower limbs in a healthy population.

## Methods

Static touch thresholds were assessed with the set of von Frey's hairs (monofilaments) (Aesthesiometer, Somedic, Sweden) in 39 healthy volunteers in 7 body sites bilaterally. Nineteen subjects were men, aged 23 to 69 years (mean age 42.3 years, SD 13.2) and 20 were women, aged 22 to 71 years (mean age 41.9 years, SD 15.6). None of the volunteers had a history of any significant injury or previous surgery in the tested site. They had no known medical conditions associated with decreased sensation (e.g., diabetes, neuropathy from other causes, lumboischialgia).

The patients were requested to close their eyes after the site of testing had been shown.

**Table 1:** Comparison of sensitivity to von Frey's hair monofilament testing between men and women.

| | | Men (N = 19) | | Women (N = 20) | | |
|---|---|---|---|---|---|---|
| | | M | SD | M | SD | *p** |
| thenar | R | 4.79 | 1.23 | 4.80 | 1.44 | 0.981 |
| | L | 4.53 | 1.07 | 4.60 | 1.23 | 0.844 |
| hypothenar | R | 4.74 | 1.41 | 4.80 | 1.36 | 0.888 |
| | L | 4.89 | 0.99 | 4.70 | 1.38 | 0.618 |
| forearm | R | 6.16 | 1.21 | 5.90 | 1.29 | 0.525 |
| | L | 5.58 | 1.02 | 5.80 | 1.61 | 0.610 |
| leg | R | 5.84 | 1.80 | 5.50 | 2.19 | 0.598 |
| | L | 6.16 | 2.29 | 6.05 | 1.99 | 0.876 |
| lateral malleolus | R | 7.26 | 1.59 | 7.10 | 2.27 | 0.797 |
| | L | 7.53 | 1.50 | 7.35 | 2.35 | 0.781 |
| 1st metatarsal | R | 4.37 | 1.57 | 4.40 | 1.31 | 0.946 |
| | L | 4.63 | 1.42 | 4.55 | 1.43 | 0.859 |
| IP joint | R | 4.47 | 1.35 | 4.85 | 1.57 | 0.427 |
| | L | 4.68 | 1.34 | 4.75 | 1.41 | 0.882 |

*N = number, M = mean, SD = standard deviation, R = right, L = left, IP = interphalangeal*
** t-test for independend samples*
*Note: The values represent the number of the von Frey's hair that was sensed by the subjects as described in the Methods.*

Measurements were performed at seven sites bilaterally: on the thenar, hypothenar, medial part of the forearm, lateral part of the leg, lateral malleolus, 1st metatharsal and great toe's interphalangeal (IP) joint. The right side was always tested first and the upper limbs before the lower. Each site was tested five times; hairs were applied perpendicular to skin surface and with just enough pressure to buckle the hair. They were applied in order of increasing stiffness (i.e., from the thinnest to the thickest) until a positive threshold was reached or a negative threshold was recorded with the thickest hair. A positive threshold was detected when the subject could positively feel the hair at least three times out of five. The force needed to buckle the hairs ranges from 0.026 g on the first hair (N° 3) to 110 g on the last hair (N° 19); correspondingly, pressures range from 5 g/mm² to 178 g/mm². These values are not strict because the force needed to buckle the hair depends on air humidity. Our measurements were performed in a room with constant humidity and without draught (according to the producer's instructions).

Statistical analyses were performed using SPSS 15.0.1.1 for Windows (Chicago, IL, 2007). Independent samples *t*-test, paired *t*-test, exact Wilcoxon matched-pairs test, and repeated-measures analysis of variance (ANOVA) were used for analysing the differences between genders and tested sites. Statistical significance was set at $p \leq 5\,\%$.

The research protocol was approved by the National Medical Ethics Committee of the Republic of Slovenia; each patient enrolled was informed about the trial and its risk and gave a written informed consent before participating in the study.

## Results

We found touch sensitivity not to be dependent on age or gender (Table 1). We therefore pooled the data for further analysis. For men and women combined, the right side was significantly more sensitive in the lateral part of the leg ($p = 0.011$) and the left side in the medial part of the forearm ($p = 0.022$) (Table 2). This difference is probably not clinically significant for any individual patient. Hence, the mean touch sensitivity of each part of the body (Table 3) and differences between sites were calculated. There were significant differences between sites (repeated-measures ANOVA: $p < 0.001$), with the mean values being higher in the medial part of the arm, lateral maleollus and lateral part of the leg (Figure 1). Post-hoc comparisons (paired *t*-tests with Bonferroni correction) showed that the mean values on the forearm, lateral maleollus and the leg were significantly higher than on the thenar, hypothenar, 1st metatarsal and IP joints.

**Table 2:** Comparison of sensitivity to von Frey's hair monofilament testing between the right and left side.

| | Left (N = 39) | | Right (N = 39) | | | |
|---|---|---|---|---|---|---|
| | M | SD | M | SD | *p** | *p*** |
| thenar | 4.56 | 1.14 | 4.79 | 1.32 | 0.141 | 0.188 |
| hypothenar | 4.79 | 1.20 | 4.77 | 1.37 | 0.872 | 0.861 |
| forearm | 5.69 | 1.34 | 6.03 | 1.25 | 0.022 | 0.029 |
| leg | 6.10 | 2.11 | 5.67 | 1.99 | 0.011 | 0.015 |
| malleolus | 7.44 | 1.96 | 7.18 | 1.94 | 0.160 | 0.179 |
| 1st metatarsal | 4.59 | 1.41 | 4.38 | 1.43 | 0.058 | 0.096 |
| IP joint | 4.72 | 1.36 | 4.67 | 1.46 | 0.711 | 0.851 |

*N = number, M = mean, SD = standard deviation, IP = interphalangeal*
** paired-samples t-test*
*** exact p for Wilcoxon matched-pairs test*
*Note: The values represent the number of the von Frey's hair that was sensed by the subjects as described in the Methods.*

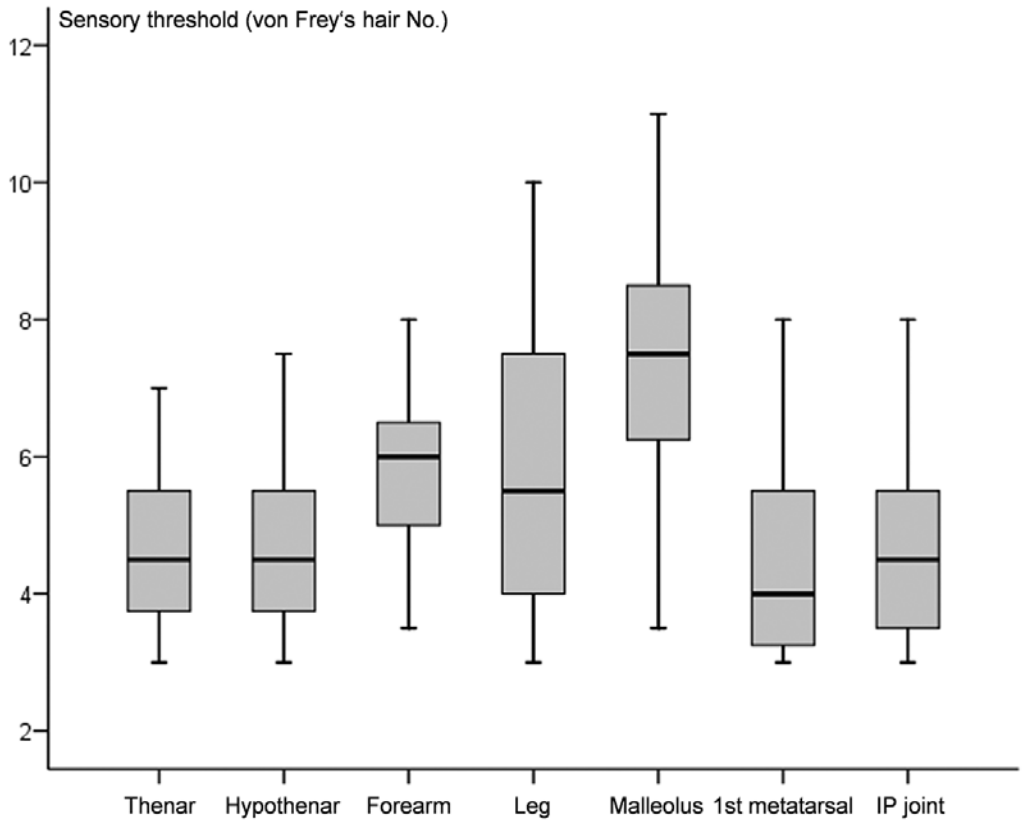


**Figure 1:** Comparison of sensitivity to von Frey's hair monofilament testing between different parts of the body (boxplots – median, 1st and 3rd quartile, non-outlier range).

## Discussion

The aim of our study was to assess the touch sensitivity of limbs in healthy population using a series of von Frey's hairs (monofilaments). There was no significant difference between men and women and across ages. To our knowledge, only one study published data on the normal touch sensitivity,[9] but in that study the difference between men and women was not tested and the population was younger. For other sensitivity (thermal, pain, vibration) some researchers found the difference,[10,11] and some did not.[12-15]

**Table 3:** Mean sensory thresholds in different parts of the body.

| | M | SD |
|---|---|---|
| thenar | 4.68 | 1.14 |
| hypothenar | 4.78 | 1.19 |
| forearm | 5.86 | 1.22 |
| leg | 5.88 | 1.99 |
| malleolus | 7.31 | 1.87 |
| 1st metatarsal | 4.49 | 1.38 |
| IP joint | 4.69 | 1.34 |

*M = mean, SD = standard deviation, IP = interphalangeal*
*Note: The values represent the number of the von Frey's hair that was sensed by the subjects as described in the Methods.*

Comparison between the right and the left side of the body showed some statistically significant differences on the forearm and the leg. Jeng et al.[9] also found the difference in some parts. This difference between body sides could be real, but it could also have been an element of impatience or lack of concentration on the part of the volunteer, or a mild and clinically insignificant trauma of a part of the body in the past. Because several comparisons were performed and the statistical tests were not adjusted for multiple comparisons, this could also be a statistical artefact. Furthermore, a closer look at our data shows that in both cases the sensory threshold is between the same two consecutive hairs, so we believe that this difference is probably not clinically important for any individual patient.

Touch sensitivity varied between different parts of the body ($p < 0.001$). Distal

parts were more sensitive than proximal. A similar – distal to proximal – pattern was found by Jeng et al.[9] on the foot. The least sensitive part in our and Jeng et al.[9] study was lateral malleolus. This could be due to frequent trauma in this part of the body. As such, lateral malleolus might not be an appropriate testing site for clinical purposes.

The mean sensitivity in each part of the body was between hair No. 4 and No. 6, except on the lateral malleolus. In day-to--day clinical practice 10 g Semmes-Weinstein monofilament is used to test the presence or absence of protective sensation in patients with diabetes mellitus. Many times the inability to feel this monofilament is interpreted as a sign of polineuropathy. The manufacturer of von Frey's hairs that we used claims that the force of 10 g Semmes-Weinstein monofilament is between hairs No. 10 and 11. This means that the inability to feel a 10 g Semmes-Weinstein monofilament represents the sensory threshold far larger than normal and confirms that the inability to feel a 10 g Semmes-Weinstein monofilament could be a sign of polineuropathy, though it may not be appropriate for early detection of neuropathy.

As the monofilament testing is already widely used, especially in diabetic patients, standardization of the method and studies to define the sensitivity of this method in clinical practice are important. The diagnostic value of the von Frey's hair test for the diagnosis of peripheral neuropathy in type 2 diabetes patients was already evaluated.[16] The test has moderate sensitivity and specificity and was recommended as a screening test. Further research should reveal an optimal standard test application procedure and reproducibility across all conditions wherein large nerve fibres are involved.

## Conclusion

In conclusion, von Frey's hairs allow the estimation of tactile thresholds without the need for complicated instrumentation. Normal thresholds for static touch are between von Frey's hair No. 4 and No. 6 and do not depend on age and gender. The procedure is fast and easy to perform in clinical practice.

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