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Original article

Comparison of tactile sensitivity measured with a new digital esthesiometer (Beam Test) relative to Semmes–Weinstein monofilament analog esthesiometer

Évaluation de la sensibilité tactile par un nouvel esthésiomètre digital équivalent (test à la poutre) à l'esthésiomètre analogique des monofilaments de Semmes–Weinstein

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ABSTRACT

The assessment of tactile sensitivity uses many tests, of which monofilaments are considered the best. The aim of this study was to develop a tactile sensitivity test, similar to the monofilament test, which eliminates the error risk related to manipulations by the observer, and to establish a correspondence scale. We studied 29 healthy subjects (18 women and 11 men) with a mean age of 27.8 years. The Semmes–Weinstein monofilament (SWM) analog esthesiometer and a digital beam esthesiometer (DBE) were used. We evaluated the tactile sensitivity threshold on the fingertip of each subject's dominant index using the SWM and the DBE. The DBE test consisted of applying the index against the tip of the beam. During a cycle of four elevations/depressions, the subject would press a button each time he/she felt pressure. The test was repeated three times. The screen displayed an average force value between 0 and 200 allowing the result to be expressed in grams (g). The minimum perceived force was 0.06656 g (0.023, 0.166) on average with the SWM test and 0.51773 g (0.4824, 0.8062) with the DBE test. Our results confirm the DBE test suppresses the observer's manipulations and that a SWM correspondence scale can be established. With the DBE test, the normal sensation ranged from 0.4824 g to 0.757 g and light touch decreased from 0.758 g to 0.8062 g. The threshold value of pathological tactile sensitivity was 0.8063 g. The DBE test could therefore be used for preventive diagnosis of carpal tunnel syndrome in occupational medicine.

Mots clés :
Sensibilité tactile
Test aux monofilaments
Test de la poutre
Semmes–Weinstein

RÉSUMÉ

L'évaluation de la sensibilité tactile utilise de nombreux tests, dont les monofilaments sont considérés comme le meilleur. L'objectif était de mettre au point un test similaire supprimant le risque d'erreur lié à la manipulation de l'observateur et d'établir une échelle de correspondance. L'échantillon comprenait 29 sujets sains d'âge moyen 27,8 ans dont 18 femmes, un esthésiomètre analogique de Semmes–Weinstein (EM) et un esthésiomètre digital destiné au test de la poutre (EP). La méthode consistait à évaluer le seuil de sensibilité tactile de la pulpe de l'index dominant pour EM et EP. Le test EP consistait à appliquer l'index en regard de la poutre. Pendant un cycle de 4 élévations/abaissements, le sujet enclenchait un bouton chaque fois qu'il ressentait une pression. Le test était répété 3 fois. L'écran

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affichait une valeur moyenne comprise entre 0 et 200 permettant d'exprimer le résultat en g. La force minimale perçue était en moyenne de 0,06656 (0,023, 0,166) avec le test EM et 0,51773 (0,4824, 0,8062) avec le test EP. Nos résultats ont montré que le test EP permettait de supprimer les manipulations de l'observateur et qu'il était possible d'établir une échelle de correspondance avec EM. Avec le test EP, la sensation normale s'étendait de 0,4824 g à 0,757 g et le contact léger diminué de 0,758 à 0,8062. La valeur seuil de sensibilité tactile pathologique est 0,8063.

Le test EP pourrait dès lors être utilisé pour un diagnostic préventif du syndrome du canal carpien en médecine du travail.

1. Introduction

The evaluation of tactile sensitivity involves many tests. The most used tests in clinical practice are the cotton-tipped swab test [1], the static Weber test, the dynamic Weber test [2], and the Semmes–Weinstein monofilament test [3]. These analog tests are all performed manually by an observer, which brings about a significant risk of error [4]. The monofilament test is considered by some to be the best test for assessing tactile sensitivity [5].

The aim of this study was to develop a tactile sensitivity test, similar to the monofilament test, which eliminates the error risk related to manipulations by the observer, and to establish a correspondence scale.

2. Materials and methods

We studied 29 healthy adult volunteers free of tactile sensitivity impairment. The average age was 27.8 years with a range between 22 and 45 years. There were 18 women and 11 men, 27 were right-handed and 2 were left-handed. We compared the Semmes–Weinstein monofilaments (SWM) analog esthesiometer [6] to a digital beam esthesiometer (DBE) (Fig. 1). The method consisted of assessing the tactile sensitivity threshold of the index fingertip by an independent observer using the two tests: SWM and DBE.

Fig. 1. Image of the digital beam esthesiometer. 1. Contact hole with the beam on which the index fingertip of the subject's dominant hand is applied. 2. Acquisition button pressed by the subject when he feels pressure on the index fingertip. 3. Results display screen. 4. Button used by the experimenter to activate a cycle of four elevations/depressions of the beam.

The SWM test consisted of determining the lightest monofilament perceived from a kit of 20 calibrated monofilaments from 0.0045 g to 447.0 g (Semmes–Weinstein Monofilament® Baseline Tactile, Patterson Medical™, Warrenville, Illinois, USA). The monofilaments were applied one after the other perpendicular to the fingertip such that the wire bent slightly for 1.5 seconds. The measurement time (approach, pressure, removal of the monofilament) should not exceed 3 seconds. The test started with the lightest monofilament and ended when a minimum of three positive responses from five trials were collected. There is a correspondence table between the diameter of each monofilament and the force (g) exerted on the fingertip (Table 1). The study result, corresponding to the lightest monofilament perceived, was reported in grams.

The DBE test consisted initially of asking each subject to apply their dominant index fingertip against the end of the beam (Fig. 2). In the second step, the experimenter initiated the activation button for a cycle of four elevations/depressions of the beam Fig. 3). In the third step, subjects pressed the acquisition button when they felt pressure on their fingertip. Automatically, the beam went down, and then went up again. The subject had to press the acquisition button when pressure was felt again. The test was stopped automatically after the acquisition button was pressed four times. The device monitor displayed an average integer value between

Table 1
Comparison of applied force on the index fingertip of the subject's dominant hand by the monofilament (SWM) and the digital beam esthesiometer (DBE).

SWM		DBE	
Value (n)	Force (g)	Value (n)	Force (g)
1.65	0.0045		
2.36	0.0230		
2.44	0.0275		
2.83	0.0677		
3.22	0.1660		
3.61	0.4082	0	0.5
3.84	0.6968	3	0.6968
4.08	1.1940	10	1.1940
4.17	1.4940	15	1.4940
4.31	2.062	23	2.062
4.56	3.632	46	3.632
4.74	5.500	73	5.500
4.94	8.650	119	8.650
5.07	11.70	163	11.70
5.18	15.00	200	14.3
5.46	29.00		
5.88	75.00		
6.10	127.0		
6.45	281.5		
6.65	447.0		

In the DBE test, Value (n) = (Force (g) − 0.4824)/0.0689. In the SWM test, Value (n) = log (10 × force (mg)) or Value (n) = log (104 × force (g)).

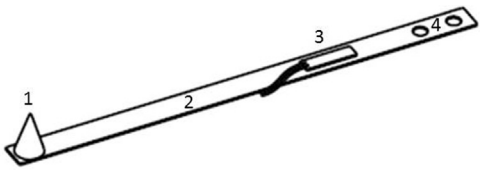

Fig. 2. Diagram of the digital beam esthesiometer. 1. Beam. 2. Beam support. 3. Strain gauge fixed on the support. 4. Holes for securing the support to a motor performing elevation and depression movements of the beam; the amplitude is correlated with the force applied on the subject's index fingertip.

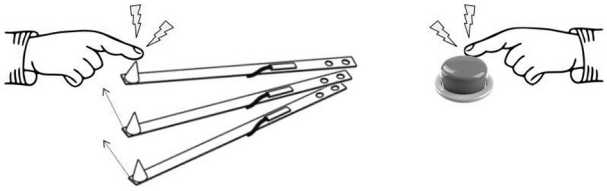

Fig. 3. Diagram of the digital beam esthesiometer in use. On the left, the dominant hand is placed next to the opening of the beam's tip. On the right, the non-dominant hand is placed next to the acquisition button. The arrows represent the elevation movement of the beam.

0 (maximum fingertip sensitivity) and 200 (anesthesia), corresponding to the result. The test was repeated three times. There is a table of correspondence between the value displayed on the screen and the force exerted on the fingertip in grams (Table 1). The study result, corresponding to the value displayed on the screen, was reported in grams.

3. Results

The analytical results are shown in Table 2. The minimum perceived force was 0.06656 g (0.023, 0.166) on average with the SWM test and 0.51773 g (0.4824, 0.8062) with the DBE test.

4. Discussion

Although the SWM test is considered the most reliable for measuring tactile sensitivity, several studies have shown the measurements obtained are not always reproducible. The reasons are many: environmental fluctuations (humidity and temperature) [7], force exerted on the monofilament by the observer, position of the monofilament during the test, wear and tear of the monofilaments [4]. For these reasons, we felt it was relevant to develop a test that eliminates manipulations by the observer. This is the DBE test.

Among the weaknesses of our study are the limited number of subjects and lack of interobserver data. Also, the mean value of the minimum force perceived with the SWM test was lower than that of the DBE test. This is likely because the mode of force application was different. In the SWM test, a flexible monofilament was applied, whereas in the DBE test, a rigid beam was used.

Our primary finding is that a tactile sensitivity test, comparable to the monofilament test, can be developed that eliminates the error risk related to observer manipulations. In the DBE test, the subject manipulated the digital esthesiometer for the testing beam.

We were also able to establish a correspondence scale between the two tests (Table 1). With the SWM test, most authors distinguish four levels of tactile sensitivity [3]. Normal sensation, which ranges from 0.0045 g to 0.0677 g, light touch from 0.1660 g to 0.4082 g, protective sensation from 0.6968 g to 2.062 g, and loss of protective sensation from 3.632 g to 447 g. The first two levels are often considered normal or subnormal. With the DBE test, normal sensation ranged from 0.4824 g to 0.757 g, and decreased light contact ranged from 0.758 g to 0.8062 g. Of course, the two pathological levels could not be determined since all subjects were healthy.

The threshold value for pathological tactile sensitivity was 0.6968 g with the SWM test and 0.8063 g with the DBE test. Based on these findings, one option would be to use the DBE test for preventive diagnosis of carpal tunnel syndrome in occupational medicine. But first, the discriminatory ability of the DBE test must be demonstrated on patients with carpal tunnel syndrome.

Table 2
Tactile sensitivity threshold of the dominant index fingertip in the monofilament test (SWM) and beam test (DBE) in 29 healthy subjects.

Subject (*N*)	SWM Force (g)	DBE Force (g)
1	0.1660	0.79
2	0.0275	0.4824
3	0.0275	0.503
4	0.0275	0.4824
5	0.0677	0.531
6	0.0230	0.4824
7	0.0275	0.4824
8	0.0275	0.4824
9	0.0230	0.4824
10	0.0677	0.4824
11	0.0275	0.4824
12	0.0275	0.531
13	0.0275	0.758
14	0.0230	0.4824
15	0.0275	0.4824
16	0.0275	0.4824
17	0.0275	0.4824
18	0.0275	0.4824
19	0.0275	0.4824
20	0.0275	0.4824
21	0.0275	0.4824
22	0.0275	0.4824
23	0.0275	0.4824
24	0.0275	0.4824
25	0.0230	0.8062
26	0.0275	0.4824
27	0.0275	0.4824
28	0.0275	0.4824
29	0.0275	0.4824

Disclosure of Interest

Philippe Liverneaux has a newcomer with Argomedical, Newclip Technics. The other authors declare that they have no competing interest.

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