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Hand tactile discrimination, social touch and frailty criteria in elderly people: A cross sectional observational study

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ABSTRACT

Frailty is a common syndrome among elderly and sensory decline may exacerbate functional decline. The hand function, the manual dexterity, the performance of the daily living skills and the social interactions are determined, in a large degree, by sensory integrity. However, hand tactile sensory deterioration has been little explored in frailty. We performed a cross sectional observational study with 181 of institutionalized elders. From the initial sample we selected 50 subjects (68–99 years) who met the inclusion/exclusion criteria. Our goals were (1) to analyse the relationship between tactile discrimination (TD) of the hand, avoidance behaviours and attitudes towards social touch (BATST) and phenotype frailty criteria (unintentional weight loss, self-perception of exhaustion, decrease grip strength – GS, slow walking speed, low level of physical activity), (2) to explore whether other variables can contribute to explain the differences between pre-frail and frail elders. The results showed that increasing age is related to decline of TD of the hand ($p = 0.021$) and to decrease in GS ($p = 0.025$); women have significantly lower level of GS ($p = 0.001$); TD decrease is correlated with higher avoidance BATST ($p = 0.000$) and with lower GS ($p = 0.000$); Lower GS corresponds to more avoidance BATST ($p = 0.003$). Hand TD also can differentiate frail and pre-frail elderly subjects in this sample ($p = 0.037$). Decreased TD of the hand may have implications on the functionality and on interpersonal relationships. TD of the hand also explains frailty levels in this sample. Hand TD should be used in assessment and intervention protocols in pre-frail and frail elders.

1. Introduction

Frailty is currently seen as a major problem in public health. It is a multidimensional syndrome of loss of physical, cognitive and health reserves among the elderly. It leads to great vulnerability and it is a predictor of disability, of the need for institutionalization, of the occurrence of falls, and of death (Malaguarnera, Vacante, Frazzetto, & Motta, 2013; Nowak & Hubbard, 2009; Rockwood et al., 2005).

There are several definitions for frailty and over time numerous attempts have been made to create a reliable instrument that can measure it. This reflects uncertainty about the term and its components (Rockwood et al., 2005).

The latest definition (Clegg, Young, Iliff, Rikkert, & Rockwood, 2013) portrays frailty as a state of vulnerability and precarious balance in which the response to stress factors is compromised, thus increasing the risk of falls, delirium, disability, long term care needs and death. This contemporary approach attempts to focus attention on a more holistic view of the elderly, their condition and their life contexts.

Frailty is not synonymous with comorbidity or disability because comorbidities are a risk factor for frailty and disability is a result of frailty (Fried et al., 2001; Lang & Michel, 2009).

These considerations and findings raise questions about how frailty in the elderly can be reliably detected, how it develops and how it can be prevented (Kan et al., 2008; Morley et al., 2013).

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There are several types of evaluation and amongst them the one that contains the largest number of objective criteria is the Phenotype of Frailty (Fried et al., 2001). These criteria have been validated independently and can be used to measure frailty in the context of clinical practice. However, they were selected at random from a cohort study that did not aim to study frailty and does not contain other very important factors for the frailty assessment such as the cognitive level, the presence of depression, or sensory function (Clegg et al., 2013; Lang & Michel, 2009).

One aspect that has been little explored, whether regarding frailty evaluation models or therapeutic interventions in older people with frailty, is the sensory function. Furthermore, whenever sensory function related to frailty is discussed, the only sensory modalities that are taken into account are vision and hearing. However data in the literature (Humes, Busey, Craig, & Kewley-Port, 2013; Schumm et al., 2009; Shaffer, Harrison, Shaffer, & Harrison, 2007) shows that other senses, such as smell, taste and touch are also affected with advancing age. Furthermore the sensory decline in all sensory modalities starts with motor decline.

The assessment of sensory function is an important outcome in health and it is essential to take into account that a sensory decrease can constitute a symptom or can be predictive of other health problems (Schumm et al., 2009).

Specifically related to touch, several authors (Brodoehl, Klingner, Stieglitz, & Witte, 2013; Carmeli, Patish, & Coleman, 2003; Kaneko, Asai, & Kanda, 2005; Wickremaratchi & Llewelyn, 2006) reported that tactile thresholds in healthy elderly are significantly higher than in younger healthy individuals. This fact is probably due to changes in the skin, in central and peripheral nervous system, in the decline in sensory nerve conduction velocity and also in the decrease of the amplitude of the sensory action potential.

For the visually and hearing impaired there are compensation mechanisms through technical aids that minimize these losses, which does not happen in the case of decreased tactile sensibility. With aging there is a sensory decline, and, in most studies related to tactile sensory changes in the elders, only certain body parts are studied, such as the knee and foot region, neglecting sensory changes in the hands (Carmeli et al., 2003).

In this study we will try to emphasize the hand, despite the importance of research in other body parts, including the foot. For instance, related with decreased sensation in the feet, Shaffer et al. (2007) concluded that the structural and functional decline of the somatosensory system that occurs with aging, potentially contributes to the postural instability and may lead to the risk of falls, because in order to maintain a proper and safe postural control we rely primarily on skin and proprioceptive inputs, in addition to visual and vestibular ones.

In the particular case of elderly people's hands, the deterioration of the tactile sensory function occurs due to age-related changes, such as musculoskeletal, vascular and nerve degenerative changes, and changes in the brain centres responsible for unisensorial processing (Brodoehl et al., 2013; Carmeli et al., 2003). There is also a relationship with decreased in grip strength (GS) (Wickremaratchi & Llewelyn, 2006), as well as with loss of hand functionality (Guclu-Gunduz, Citaker, Nazliel, & Irkec, 2012; Melchior, Vatine, & Weiss, 2007; Ranganathan, Siemionow, Sahgal, & Yue, 2001b, ; Wickremaratchi & Llewelyn, 2006). This loss is also associated with a greater dependence in the performance of daily activities (Kalisch, Tegenthoff, & Dinse, 2008).

Tactile perception, unlike other sensory modalities, always occurs within the personal space and plays a complex holistic role, as it influences and is influenced by emotions and the social context. In fact, the sense of touch, in addition to its discriminating function, plays an important role in communication, relationships, sharing of feelings (Craig & Rollman, 1999; Dunbar, 2010; Gallace & Spence, 2010; Olausson, Wessberg, Morrison, McGlone, & Vallbo, 2010) and mediating and regulating emotions (Hertenstein, Keltner, App, Bulleit, & Jaskolka, 2006).

This reasoning supports the "Social Touch" hypothesis. This hypothesis proposes that the mechanoreceptors non-myelinated afferents, known as C-Touch, provide a neurobiological basis for the development of the social brain, mediate social behaviour and are responsible for maintaining social relationships as they are involved in coding and processing tactile signals associated with affective touch (Björnsdotter, Löken, Olausson, Vallbo, & Wessberg, 2009; Gordon et al., 2013; Olausson et al., 2010). In order to complete the feeling of pleasant touch, a combination of CT and Aβ afferents is required.

Recent studies (McGlone, Wessberg, & Olausson, 2014; Mcglone et al., 2012) confirmed that CT-afferents are only present in hairy skin and not in the glabrous skin of the palm. However, a touch on the palm can also be perceived as pleasant for two reasons: (1) Aβ-afferents support pleasant sensations (McGlone et al., 2014); (2) Glabrous skin stimulation might be related to a more cognitive top-down evaluation of touch pleasantness, based on previous tactile experiences (Gordon et al., 2013; McCabe, Rolls, Bilderbeck, & McGlone, 2008; Mcglone et al., 2012).

Touch stimulation on the palm can provide both discriminative and affective input to the brain (Gordon et al., 2013).

However, the relationship between tactile sensory decline of the hand and avoidance behaviours and attitudes towards social touch (BATST) in frail elderly people is not explored in the literature.

In this sense, the first goal of this study is to analyse the relationship between the tactile discrimination (TD) of the hand, avoidance BATST and frailty criteria as defined by Fried et al. (2001) in a sample of institutionalized elderly people. The second goal is to explore whether other variables can contribute to explain the differences between pre-frail and frail elders.

We have studied some variables related to the sensory, motor and mental functions (sensory tactile discrimination, unintentional weight loss, self-perception of exhaustion, grip strength), with the activity (walking speed, level of physical activity) and with social participation (behaviours and attitudes towards social touch) in an attempt to perceive the individual in a holistic way.

2. Methods

2.1. Participants

Three urban residential homes agreed to participate in the study. Of the 181 seniors who live in these institutions, a sample of 50 subjects was established after verifying compliance with the inclusion and exclusion criteria. This is a convenience sample and the inclusion criteria established were the following: to be older than 65 years of age, be institutionalized in a residential home, be willing to participate in the study, and sign an informed consent. Exclusion criteria defined were not to present comorbidities that would lead to changes in sensibility (such as stroke, head trauma, degenerative disease or diabetes), to have no medical diagnosis of dementia, not to possess any cognitive impairment that would prevent the evaluation protocol, and not to have any communication or behaviour impairment.

Throughout the planning and during the study some ethical considerations were made; we received prior approval from an institutional review board and subjects gave their written informed consent in accordance with the Declaration of Helsinki. We also took into account particular ethical issues related to greater vulnerability, both in the physical and psychosocial point of view of the subjects. Secrecy due of the obligation of professional secrecy was safeguarded, ensuring total confidentiality of the data.

2.2. Protocol

After deciding on the sample (participants), on the right procedures and measures to use, the authors felt the need to build an assessment protocol for this study. This protocol is comprised of (1) a sample characterization questionnaire; (2) an analysis of different risk factors for frailty including: the body mass index (BMI), the number of different medication ingested per day (polypharmacy) and the cognitive level; (3) a self-perception questionnaire of the subjects' sensory difficulties and; (4) the assessment of the three variables that address the main objectives of this study: Phenotype of Frailty (unintentional weight loss, self-perception of exhaustion, decrease grip strength, slow walking speed, low level of physical activity), hand TD and BATST. The assessment consisted of hetero-application instruments and some functional tests, such as GS and a walking speed test, and required the active participation of the subjects.

2.3. Procedures and measures

A team of three professionals was organized for data collection (two Physiotherapists and one Speech Therapist, all of which having over 25 years of professional experience). Planning and training sessions were held in order to increase consistency in data collection, as well as reliability. These sessions covered: (1) appropriation of the objectives of the study, (2) creation of the assessment protocol, (3) contact with the institutions and applications for authorization, (4) role playing and problem-solving training. Data collection was carried out at the residential homes, in a single visit to each home that lasted for about 60 min.

2.3.1. Sample characterization questionnaire

Sociodemographic data of each subject who participated in the study was collected through a verbally administered questionnaire. This questionnaire requested information about age, gender, level of education and handedness. All participants had right hand dominance, verified by the Portuguese version of the Waterloo Handedness Questionnaire-Revised (WHQ-R) (Elias, Bryden, & Bulman-Fleming, 1998).

2.3.2. Risk factors for frailty

We have considered as risk factors for frailty the BMI, the number of different medication ingested per day (polypharmacy) and the cognitive level. Beside the fact that BMI is a geriatric risk factor, its calculation was also useful to determine the GS value. To calculate the BMI, weight (kg) and height (cm) were measured according to the recommendations of Task Force BMI (Rockenbach et al., 2010).

According to recent studies, there is a strong association between frailty and having a very low or very high BMI (Hubbard, Lang, Llewellyn, & Rockwood, 2010). The same authors proposed cut-off values for frail older adults, i.e. a BMI greater than 30 and lower than 18.50 is indicative of frailty.

Medication data was collected from the subjects' clinical files. We classified those who took four or more different medication as polymedicated (Denneboom, Dautzenberg, Grol, & De Smet, 2006). Since frailty is related to the presence of multiple comorbidities it leads to polymedication (Lang & Michel, 2009).

The cognitive level was measured by the Mini Mental State Examination (MMSE). It is considered a valid practical and objective instrument for screening global cognitive functions in clinical practice and in research, especially in studies with elderly people. In addition it is the instrument used to measure cognitive level in the institutions that the subjects belonged to. It can also be applied quickly and it requires about 5–10 min for execution, but the actual run time is not timed. It features 30 questions divided into six cognitive domains: orientation, retention, attention and calculation, recall, language, and constructive ability. Each question is scored either with 0 or 1, and the total score ranges from 0 to 30. A higher score correspond to better performance (Morgado, Rocha, Maruta, Guerreiro, & Martins, 2009). According to the standardization of the Portuguese population, new cut-off values have been recently recommended relating to literacy levels to allow differentiation between individuals with and without cognitive impairment. A subject with 0–2 years of education is considered to have cognitive impairment if the results of his test score are equal to or lower than 22; with 3–6 years of education, the subject is considered to have cognitive impairment if he scores are equal to or less than 24; finally, with 7 or more years of education the subject is considered to have cognitive impairment if the score is equal to or less than 27 (Morgado et al., 2009). Several studies have proven the existence of a relationship between cognitive impairment and the presence of frailty in elders (Fried et al., 2001; Kim, Park, Hwang, & Kim, 2014; Malaguarnera et al., 2013).

However, a recent study of older people with frailty concluded that cognition showed no predictive effect for increasing disability (Ament, Vugt, Verhey, & Kempen, 2014).

2.3.3. Self-perception of sensory difficulties

The subjects were asked several questions in order to understand whether they had difficulties in activities of daily living, due to the impairment of smell, taste, vision, hearing and touch ("Do you have difficulties in your daily living due to diminished smell and taste? Do you have difficulties in your daily living due to lack of vision? Do you have difficulties in your daily living due to lack of hearing? Do you have difficulties in your daily living due to a decrease of sensitivity to touch?).

The use of self-perception measures regarding sensory difficulties, along with objective assessments, should be considered because these may constitute important information about the elderly people's awareness regarding their real abilities (Schumm et al., 2009).

2.3.4. Frailty assessment (phenotype of frailty)

In order to assess frailty, it was used the model described by Fairhall et al. (2008), adapted from the original model (Fried et al., 2001). This decision was made because the authors of that study introduced some simplifications which facilitate its practical application, particularly in institutionalized elders, such as the use of simple and objective questions to assess the level of physical activity. According to the model, each criterion that evaluates frailty is defined by a dichotomous variable (positive/negative criteria).

The five criteria are: (*Criteria 1*) Unintentional weight loss of at least 4.5 kg (not as a result of diet or exercise); (*Criteria 2*) Self-perception of exhaustion evaluated according to the answers given to the following questions taken from the questionnaire of the Centre for Epidemiologic Studies of Depression (Radloff, 1977) Question 1: Have you felt like everything you did in the last week was an effort?; Question 2: Have you felt a lack of energy during the last week? Possible answers are: 0-never/rarely (if for less than 1 day); 1-occasionally (for 1–2 days); 2-with some frequency (for 3–4 days); 3-very often/always (for 5–7 days). If the subject answers at least one of the questions with a value of 2 or with a value of 3, then the criteria is considered positive according to the dichotomous variable explained above. (*Criteria 3*) Muscle weakness assessed by GS, measured with a hydraulic manual dynamometer, J00105 Jamar® model. This is a valuable tool both in research and in clinical practice (Bohannon, Peolsson, Massy-Westropp, Desrosiers, & Bear-Lehman, 2006; Roberts et al., 2011) and is the measurement instrument recommended by the

American Society of Hand Therapists (ASHT). We have used ASHT assessment protocol that recommends that the subject should be seated comfortably, shoulder adducted and in extension, elbow flexed at 90°, forearm in neutral position and wrist position extended between 0 and 30°. The final objective is to register the maximum and average value of three alternating measurements recorded in the dominant hand and measured in kilograms (kg). The isometric strength is recorded in three periods of 10 s with a 60 s rest period in between, and the final result is cross-referenced with BMI and gender. (*Criteria 4*) Decrease in walking speed measured by evaluating the time spent in seconds to cover a distance of 4.6 m with regular steps, attuned to sex and height, with or without the use of a walking aid. The criteria was considered positive if the time spent is equal or above 6 s; (*Criteria 5*) Low level of physical activity. A subject is considered 'inactive' if in the preceding three months he has not carried any weights, has spent more than 4 h a day sitting and/or conducted a small walking tour only once a month or less.

An elderly person is considered to be "frail" if he has 3 or more positive criteria, "pre-frail" if he has 1 or 2 positive criteria and "not frail" if all criteria are negative.

2.3.5. Hand tactile discrimination (TD) assessment

Tactile Discrimination (TD) decreases with age and tactile threshold of excitability increases (Kaneko et al., 2005). To assess the level of TD within elderly people, the two-point discrimination test has proven to be a valid measurement test (Alsaeed, Alhomid, Zakaria, & Alwhaibi, 2014; Bowden & McNulty, 2013; Kaneko et al., 2005; Schumm et al., 2009; Shimokata & Kuzuya, 1995).

There are some considerations in literature about the psychometric limitations of the two-point discrimination test. These limitations are mainly due to lack of detailed description of the assessment protocol, and especially lack of standardization of applied pressure. One way to solve this problem is to apply a force matching the gravity weight of the assessment tool, the Disk-Criminator™ (10–15 g), or to use a force transducer coupled to a computer with specific software (Tassler & Dellon, 1995). This equipment has demonstrated its usability in laboratory context but not in the context of clinical practice or in the field of studies, due to the complexity of the device (Lundborg & Rosen, 2004).

The evaluation of TD of the index finger has proven not to be a very sensitive indicator for evaluating age-related sensory loss (Bowden & McNulty, 2013). In the same study, the median threshold interval found in elders for two-point discrimination in the hypothenar eminence was 8 mm [6–11 mm].[1] This value is significantly higher than that on the fingertip (3 mm). They concluded that the best region to test tactile discrimination in elderly people is the hypothenar eminence, where the largest and most consistent sensory changes occur with age. Indeed sensory changes on the palm of the hand may cause greater difficulties in motor control than sensory loss at the fingertips, particularly in activities that involve the whole hand.

In most studies related to tactile sensory loss with aging, no relation was found with gender or with manual laterality (Bowden & McNulty, 2013; Dunn et al., 2013; Schumm et al., 2009; Shimokata & Kuzuya, 1995), and some authors (Dunn et al., 2013) recommend that the test should be applied to the dominant hand.

A calm environment with mild temperatures was selected for the evaluation, with reduced possibility of distractions, and each subject was seated comfortably with the elbow at about 90° and forearm resting on a low table to promote greater stabilization. The wrist and hand were placed on a small cushion with palm facing up. The procedure was explained to every subject and the kind of stimulus that was going to be applied was demonstrated on the forearm while the subjects had their eyes open. The researcher sat in front of the subject, with elbows resting and without touching the subject. The subject was then asked to close his eyes. Two Disk-Criminator™ were used, one with a two-point stimuli variation range between 20 and 9 millimetres and the other between 8 and 2 mm. As such, two-point tactile stimulations were successively applied in the distal hypothenar region of the dominant hand, going from the highest to the smallest distance between the two points in the Disk-Criminator™ (Bowden & McNulty, 2013). We underline that immediately after the application of the two-point first stimuli, one stimulus was applied with just one point so that the subjects could become aware that the stimuli were not the same throughout (Schumm et al., 2009). This single stimulus test was not considered in the final result. The same question was asked in every stimulation: "Have you felt one or two points?". The minimal two points stimuli detected (MTPSD) by the subject was then recorded (Schumm et al., 2009). It is paramount to emphasize at this point that throughout the study an increase of the value of MTPSD corresponds to a decrease on the value of TD (i.e. the bigger the distance felt between two points, the lower the TD). All evaluations were made by the same experienced researcher, in order to assure that the protocol was always applied in the same way, and that the amount of pressure used in the test was as controlled as possible, i.e., always corresponding to the weight of Disk-Criminator™ (Lundborg & Rosen, 2004).

2.3.6. Behaviours and attitudes towards social touch (BATST) assessment

To measure BATST we have used a Portuguese version of the Social Touch Questionnaire (Wilhelm, Kochar, Roth, & Gross, 2001). This questionnaire provides data on a variety of issues related to feelings and attitudes toward social touch. Each subject answered the questionnaire using a rating on a scale from 0 to 4 regarding the accurateness of each statement (0 for 'absolutely not' and 4 for "extremely"). The total score is thus obtained by summing the scores for each of the answers and the spectral quantification of the total score is presented on a scale from 0 (lowest avoidance of social touch) to 80 (highest avoidance of social touch). In the original study (Wilhelm et al., 2001) internal consistency (Cronbach's α) of the overall questionnaire was 0.89, with a 0.29 average item intercorrelation. No study has been found involving frailty in the elderly and BATST.

2.3.7. Statistical analysis

The analysis starts with a series of descriptive statistics to characterize the sample (frequency distributions, means and standard deviations) and to identify linear associations between metric variables (Pearson correlation coefficient) such as age, MTPSD, phenotype frailty criteria (unintentional weight loss, self-perception of exhaustion, decrease grip strength (GS), slow walking speed, low level of physical activity) and BATST. Parametric hypothesis tests, more specifically the *t*-test for equality of two population means, is then applied to measure the effect of gender on MTPSD, phenotype frailty criteria and BATST whenever the assumption of normal population group distributions was met; in case of violation of the last assumption, a non-parametric alternative was used, i.e., the Mann-Whitney test for equality of two population distributions based on two independent samples. To test for population distributions, the Shapiro-Wilk test was applied because it is more appropriate for small sample dimensions.

The statistical analysis continues with a multivariate inferential approach to estimate an explanatory model of the degree of frailty. A multiple linear regression approach was first applied to the total

[1] Median threshold interval found in young adults was 5 mm [3–8 mm] (Bowden & McNulty, 2013).

Table 1
Sample characteristics and risk for factors for frailty (n = 50).

Age (years)	84.4[a] ± 6.8[b]; 68–99[c]
Gender (m:f)	42%:58%
Education (years)	5.2[a] ± 5[b]; 0–16[c]
BMI (Kg/m^2)	26.6[a] ± 5.5[b]; 16.8–45.3[c]
Polypharmacy (four or more prescription medications) (%)	80%
MMSE (Portuguese-European version)	25.6[a] ± 4.6[b]; 11–30[c]

BMI – Body mass index; MMSE – Mini mental state examination.
[a] Mean.
[b] Standard Deviation.
[c] Minimum-Maximum.

score of frailty and a number of different predictor variables were considered in this analysis – age, gender, years of education, polypharmacy, MTPSD and BATST.

Multiple linear regression modelling assumptions included: linearity of the relationship between the dependent and the independent variables, normality of the random error, null mean and constant variance of the random errors, independence of random errors, and absence of collinearity between independent variables. However, violation of some of the previous assumptions was verified which might result in biased and inefficient estimates, so an alternative logistic regression model was applied to explain the probability of frailty (1) over pre-frailty (0).

Binary logistic regression was adopted to model the effect of several independent variables on the likelihood of being frail. The variable to be explained was whether an elderly person has reached a frail situation or can still be considered as pre-frail. This dependent variable is understood as a dichotomous binary variable. Regression coefficients were estimated using the Maximum Likelihood method and the model included the following explanatory variables: (1) Gender – having two categories (1-Male, 0-Female); (2) Education – which represents the number of years of education with three categories (1 = 0 years; 2 = 3 to 6 years; 3 = 12 or more years); (3) MTPSD – on a discrete metric scale, from 5 to 13; (4) BATST – on a discrete metric scale, from 15 to 52.

A *p*-value of 0.05 was taken as the reference level of significance and SPSS version 22 was used for all statistical analysis.

3. Results

A total of 50 institutionalized elderly people, participated in this study. The sample average age is 84.4 years and it is mostly composed of women (58%); the average level of education is low (5.2 years of education); the MMSE average (25.6) does not reveal major cognitive deficits; mean BMI is 26.6 kg/m2 suggesting an above normal weight (overweight), noting however some cases of underweight (body mass index (BMI) <18.5) and other cases of overweight (obese) (BMI >30). It is noteworthy that most subjects (80%) take more than four different types of medications (Table 1).

In this sample, elderly people report that they feel interference in their daily tasks due to degradation of smell, taste, vision and hearing. However there is no perception that there is change of tactile sensibility (100% of the sample) (Table 2).

In Table 3 we can see that the majority of the sample is frail (56%) and no not-frail subjects have been found. Regarding frailty criteria, the most prevalent in this sample is the decreased GS (92%), followed by decreased walking speed (70%) and low level of physical activity (56%). The MTPSD average on the distal hypothenar area of the palm was 8.6 ± 2.5, reflecting a decrease in cutaneous sensation. The average of the BATST was 32.9 ± 9.3 suggesting the existence of some avoidance behaviours and attitudes towards social touch.

We have also tried to understand gender effects in MTPSD, phenotype frailty criteria and BATST. Within the phenotype frailty criteria the only one with statistically significant effect (Table 4) was the GS (p = 0.001), with women being the group that presents the weaker values of GS.

As it can be seen in Table 5, age is a factor positively and significantly correlated with MTPSD (r = 0.29; p = 0.021) but not with BATST. Once again, the only phenotype frailty criterion with statistically significant effect was GS. In this case, age is a factor negatively correlated with GS (r = 0.28; p = 0.025).

Because of the negative correlation between MTPSD and TD (i.e. to a greater value of MTPSD corresponds a decrease in TD) it is fair to state that, in this study sample, older people present a decrease in TD values and there is a decrease in GS.

Regarding the purpose of the study, in Table 6 we correlated the variables TD (using MTPSD values), phenotype frailty criteria and BATST. From all the frailty criteria, the only one with statistically significant effect was, once again, GS. As it can be seen in Table 6,

Table 2
Sample distribution of self perception of sensory impairment (% without self perception) (n = 50).

No Self-perception of visual impairment%	48%
No Self-perception of hearing impairment%	46%
No Self-perception of smell and taste impairment%	66%
No Self-perception of touch impairment%	**100%**

Bold value shows *p* < or = 0.05.

Table 3
Sample distribution of Frailty – Physical Phenotype and Criteria, MTPSD and BATST (n = 50).

Frailty Phenotype (Pre-frail: Frail)	44%:56%
Weakness – Grip strength%	92%
Unintentional weight loss%	16%
Slow walking speed%	70%
Self-reported exhaustion%	46%
Low physical activity level%	56%
MTPSD (millimetres)	8.6[a] ± 2.5[b];5–13[c]
BATST	32.9[a] ± 9.3[b]; 15–52[c]

MTPSD – Minimal two points stimuli detected; BATST – Behaviours and attitudes towards social touch.
[a] Mean.
[b] Standard Deviation.
[c] Minimum-Maximum.

Table 4
Effect of gender on MTPSD, GS and BATST (n = 50).

	Means		
	Males	Females	p-value
MTPSD[b]	8.2	8.8	0.939
GS[a]	18.7	12.1	**0.001**
BATST[a]	31.3	34	0.313

MTPSD – Minimal two points stimuli detected; GS – Grip strength; BATST – Behaviours and attitudes towards social touch.
Bold value shows *p* < or = 0.05.
[a] *T*-test for equality of two means.
[b] K-S test for equality of two distributions.

Table 5
Correlation between age, MTPSD, GS and BATST (n = 50).

		MTPSD	GS	BATST
Age	Pearson Correlation	0.290	−0.279	0.000
	p-value	**0.021**	**0.025**	0.499

MTPSD – Minimal two points stimuli detected; GS – Grip strength; BATST – Behaviours and attitudes towards social touch.
Bold value shows $p <$ or = 0.05.

MTPSD is linear and positively correlated with avoidance BATST (r = 0.80; p = 0.000), i.e, elderly with lower levels of TD have higher levels of avoidance BATST (negative correlation between TD and BATST); MTPSD is negatively correlated with GS (r = −0.49; p = 0.000), i.e. elderly with lower levels of TD have lower levels of GS (positive correlation between TD and GS). Lower levels of GS corresponds to more avoidance BATST (r = −0.38; p = 0.003) (negative correlation between GS and BATST).

Table 7 presents the estimates of regression coefficients and respective standard errors, and the *p*-value of the Wald Chi-Square test for all independent variables. The table also shows the exponential of the model coefficients which estimates the ratio of the changes of the dependent variable by unit of the independent variable.

The percentage of cases correctly classified by the model is high (68%) although the goodness of fit Nagelkerke R^2 indicator is low (less than 21.8%) thus indicating that the likelihood of frailty might be influenced by other factors not included in the model. But 68% of the cases are well predicted by the model, whereas 56% are well predicted just with a constant, so accuracy of prediction has improved over the null model, but only by 12%. The Hosmer and Lemeshow test shows an adequate fit (*p*-value = 0.389), meaning that the model prediction is not significantly different from the observed values. Although all measures suggest an improvement of the logistic model over the null model (with no predictors, just a constant), they also allow to conclude that the adequacy of the model is not optimal.

The results show that the probability of being frail: (1) Is lower for males, when compared to females, but the difference is not significant; (2) Is higher for those with no education or with 3–6 years of education, when compared to those with more education (12 or more years), but these differences are not significant; (3) Decreases when the level of avoidance BATST decreases, again with no significant difference; (4) Increases for each unit increase of MTPSD. This is the only significant coefficient. The chance of being frail increases 76.5% when the minimum distance perceived between two points increases one unit, i.e., when the level of TD decreases.

4. Discussion

As stated before, the first goal of this study was to analyse the relationship between TD of the hand, avoidance BATST, and frailty criteria, as defined by Fried et al. (2001), in a sample of institutionalized elderly people. A second goal was to explore whether other variables could contribute to explaining the differences between pre-frail and frail elders.

Table 6
Correlations between MTPSD, GS and BATST (n = 50).

		GS	BATST
MTPSD	Pearson Correlation	−0.491	0.808
	Sig. (1-tailed)	**0.000**	**0.000**
GS	Pearson Correlation		−0.380
	Sig. (1-tailed)		**0.003**

MTPSD – Minimal two points stimuli detected; GS – Grip strength; BATST – Behaviours and attitudes towards social touch.
Bold value shows $p <$ or = 0.05.

Table 7
Results for the binary logistic model for frailty (n = 50).

	B	S.E.	Wald	df	Sig.	Exp(B)
Gender (1)[a]	−0.592	0.638	0.863	1	0.353	0.553
MTPSD	0.568	0.265	4.582	1	0.032	1.765
BATST	−0.088	0.064	1.867	1	0.172	0.916
Education[b]			1.834	2	0.400	
Education (1)	1.258	0.962	1.712	1	0.191	3.519
Education (2)	0.888	0.822	1.168	1	0.280	2.431
Constant	−2.184	1.494	2.138	1	0.144	0.113

MTPSD – Minimal two points stimuli detected. [c]Explanatory power of the regression analysis (Nagelkerke R^2) = 0.218.
[a] Gender reference category: Female.
[b] Education reference category: 12 or more years.

Throughout the study we have tried to elevate tactile sensibility for two main reasons: (1) it is proven to be a sensory modality that degrades with age; (2) because research studies regarding assessment, consequences and intervention in Frailty Syndrome have not taken tactile sensibility into account.

Many authors (Brodoehl et al., 2013; Carmeli et al., 2003; Kaneko et al., 2005; Shimokata & Kuzuya, 1995) have reported the existence of tactile sensory deterioration with increasing age. The results of our sample confirm these findings and the minimum average distance felt between two points is consistent with what has been reported in the literature (Bowden & McNulty, 2013) for the same age group, with data collected from the hypothenar region.

The same authors found significant statistical differences between genders in the tactile threshold of excitability. Men showed a higher threshold, denoting greater sensory loss. But in other studies that difference has not been identified (Ranganathan et al., 2001b). In our sample we also found that there were no differences between genders in terms of the tactile threshold of excitability. Some authors point out some causes for this finding and argue that men have lower density of Meissner's corpuscles in comparison with women but tactile acuity is not different between genders (Dillon, Haynes, & Henneberg, 2001).

Tactile information extracted from objects is critical for hand functionality and, as in other investigations with frail elderly subjects (Ranganathan et al., 2001b), we found that there is a statistically significant correlation between decrease in hand strength and decreased in hand sensibility, with women showing the highest decrease in strength (Frederiksen et al., 2006; Ranganathan et al., 2001a, 2001b). In fact the average GS in women of all ages is lower than that of men and this may have to do with genetic differences in muscle mass but also to environmental differences (Andersen-Ranberg, Petersen, Frederiksen, Mackenbach, & Christensen, 2009). However, the reason why the difference becomes more pronounced towards the end of life can stem from further decrease in bone density in women (Dixon et al., 2005).

In our experiment, from all the phenotype frailty criteria, GS was the only one with significant correlations values with TD and with BATST. In fact, GS has been indicated as a possible sole criterion in the evaluation of frailty (Syddall, Cooper, Martin, Briggs, & Sayer, 2003) and is an indicator of decreased general strength and a predictor global loss of functionality (Bohannon, 2008).

With regard to the association between TD and BATST we found that there is no evidence in the literature concerning this relationship in frail elderly people. However, in our study we found a statistically significant correlation between these two variables, and it has been found that a greater reduction of TD corresponds to a greater amount of avoidance BATST.

Dunn (1999, 2001) states that the sensory processing involves the physiological dimension, related to the nervous system integrity, but also involves the behavioural dimension. Ben-Avi (2012) suggests that sensory processing is also linked to psychological and social dimensions, and that some interpersonal difficulties, such as social alienation and social isolation, are characteristic of individuals with a sensory avoidance profile. The "Social Touch" hypothesis is also corroborative of this relationship (Walker & McGlone, 2013).

In order to become aware of spatial relationships with other persons and with the environment, it is crucial to have undamaged sensory receptors, not only the tactile ones but also in all other sensory modalities. The amount of information that can become conscious when the stimuli are presented through the tactile modality is influenced by the amount of visual, auditory and olfactory information. As a matter of fact, these stimuli begin to be processed simultaneously and this multisensory interaction leads to the recognition, reproduction and maintenance of interpersonal relationship patterns (Gallace & Spence, 2008).

These aspects are fundamental in institutionalized elderly people, because avoidance BATST can lead to a physical social isolation associated to a subjective feeling of isolation, of not being integrated, and to a lack of companionship (Perissinotto, Cenzer, & Covinsky, 2012). As a matter of fact, in a residential home, elderly people are not alone but they may feel alone, and such feeling of loneliness can predict functional decline and death.

In this sample, besides the criteria that explain the level of frailty (unintentional weight loss, self-reported exhaustion, decrease GS, slow walking speed and low physical activity level) we found another variable that can also differentiate frail and pre-frail elderly subjects, namely the TD of the hand. So far this factor has not been given significant recognition by the scientific community and it does not come into play in either assessment or intervention protocols in frail elderly people.

Nevertheless, scientific evidence proves that sensory deterioration of the hand is strongly related to the decrease of muscle strength and of functionality. The hand is a major tactile sensory part of the body and the right processing of the sensory input is essential for manipulation and for different activities of daily living. For these reasons and taking into account the results of this study we recommend the TD of the hand to be included in assessment and intervention protocols in frail and pre frail elderly people.

The risk factors for frailty analysed (BMI, polypharmacy and cognition) revealed that only polypharmacy should be considered as a risk factor for frailty. The mean values obtained for both BMI and cognition have not shown enough relevance to be considered as valuable risk factors regarding the sample used for this study.

In general, no great relevance is being given to sensory aspects, except to the limitations that elderly people are aware of or that have a great impact on their daily activities. In this sense, the measures of self-perception showed great importance in this study, noting that the perception of the subjects is not always in line with reality, as it can be seen in the case of self-perception of tactile sensory difficulties. Indeed none of the elderly attributed their difficulties in activities of daily living to tactile sensory problems. But in reality the results indicate that there is a decrease of the hand TD and, since tactile information from the hand is essential for grasping and dexterous manipulation, this could contribute to a decrease in functional activities. However and unlike other sensory modalities, there is no awareness of the tactile sensory decrease.

Pre-frail condition is a strong indicator of physical decline associated with aging (Fernández-Garrido, Ruiz-Ros, Buigues, Navarro-Martinez, & Cauli, 2014) and pre-frail individuals have twice the risk of becoming frail in the next three years than non-frail individuals (Fried et al., 2001). However, Frailty Syndrome in the elderly can be prevented and reversed (Lang & Michel, 2009) and in the literature we can find several proposals for intervention in frailty. However, despite considering many variables, they do not consider the tactile sensory function. Nevertheless, there are studies on healthy elderly people that conclude that it is possible to improve sensorimotor function through passive tactile sensory stimulation because it promotes perceptual learning (Fahle, 2005; Kalisch et al., 2008; Ragert, Kalisch, Bliem, Franzkowiak, & Dinse, 2008; Seitz & Dinse, 2007). Despite the importance of unisensorial stimulation protocols, multisensory stimulation protocols are more effective for sensorimotor learning and in the case of elderly people there is evidence that there is an increase or maintenance of brain multisensory processing, regardless of continuous decline in unisensoriais systems. The multisensory processing is critical during aging because it helps to minimize the consequences of the unisensorial decline (Freiherr, Lundström, Habel, & Reetz, 2013). In this sense it is required that tactile sensory stimulation of the hand is applied in combination with the stimulation of another sensory modality, such as verbal stimulation, appealing to feel the hand.

In intervention studies in frail elderly subjects that include exercise, the exercise is always directed either to increase the strength of the lower limbs or to promote general mobility, but it is never done for hand functionality (Daniels, Metzelthin, van Rossum, de Witte, & van den Heuvel, 2010; Gustafsson, Edberg, Johansson, & Dahlin-Ivanoff, 2009; Oswald, Gunzelmann, Rupprecht, & Hagen, 2006). Regarding the increase of hand functionality, several studies were conducted with healthy elderly subjects, who reported that improvement is possible by practicing different motor tasks, and that the increase of functionality is due to the interaction between the motor and sensory system (Ranganathan, Siemionow, Sahgal, Liu, & Yue, 2001a). As such, and regarding the intervention programs with frail elderly people, we recommend that strategies directed to hand functionality should be envisaged.

An individual-centered approach is required because each individual constitutes a single entity, and may present different problems when compared to others, in terms of structure and function, functional activity and participation, as well as in terms of self-influence factors (Clegg et al., 2013; Fairhall et al., 2008).

This clinical reasoning should guide us in formulating the assessment protocols for frailty elderly people and should also shape the type of intervention.

Due to the small number of subjects in the sample, our results should be considered as preliminary. In that sense it is recommended that the sample should be extended and the results compared with community-dwelling elderly sample, applying the same methodological assumptions.

5. Conclusion

The decline of sensorial tactile discrimination of the hand is related to increasing age, to the decrease in grip strength and to higher avoidance behaviours and attitudes towards social touch. Sensorial tactile discrimination of the hand also explains frailty levels in the sample evaluated in the current study, i.e. frail elders have greater loss of sensorial discrimination then pre-frail elders. According to these results hand tactile discrimination should be used in assessment and intervention protocols in pre-frail and frail elders.

Conflict of interest

None declared.

Ethical approval

Ethical approval from an institutional review board of Alcoitão School of Health Sciences, Santa Casa da Misericórdia de Cascais, Centro Social Paroquial de S. Pedro e S. João do Estoril, Portugal.

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