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A quantitative assessment of the eating capability in the elderly individuals

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HIGHLIGHTS

- A new quantitative approach was established to measure eating capability.
- Hand, oral and tactile capabilities were recorded in elderly population.
- Hand gripping strength correlate linearly with oro-facial muscle forces.
- Eating capability scores allowed grouping of elderlies into separate clusters.
- The scores add modestly to the prediction of food oral manipulation difficulty.

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ABSTRACT

Ageing process implies physiologically weakened muscles, loss of natural teeth and movement coordination, causing difficulties in the eating process. A term "eating capability" has been proposed to measure objectively how capable an elderly individual is in overall food management. Our objectives were to establish feasible methodologies of eating capability assessment, examine correlations between hand and oro-facial muscle strengths and grade elderly subjects into groups based on their eating capabilities. This study was performed with 203 elderly subjects living in the UK ($n = 103$, 7 community centres, 2 sheltered accommodation) and Spain ($n = 100$, 3 nursing homes, 1 community centre). Hand gripping force, finger gripping force, biting force, lip sealing pressure, tongue pressing pressure and touching sensitivity were measured for elderly subjects. Measured parameters were normalised and scored between 1 and 5, with 1 being the weakest. Subjects were then grouped into 4 groups based on their eating capability scores, being participants of cluster 1 the weakest group and 4 the strongest. Perception of oral processing difficulty was assessed by showing food images. Hand gripping force showed a strong linear correlation with tongue pressure (UK: 0.35; Spain: 0.326) and biting force (UK: 0.351; Spain: 0.427). Biting force was strongly dependent on the denture status. Elderly of the first three groups perceived food products with more hardness and/or fibrous structure as difficult to process orally. The objective measurements of various physiological factors enabled quantitative characterisation of the eating capabilities of elderly people. The observed relationship between hand and oro-facial muscle strengths provides possibility of using non-invasive hand gripping force measurement for eating capability assessment.

1. Introduction

Ageing is a physiological process linked with the gradual deterioration of body's function. The progressive muscle degeneration, loss of natural teeth and gradual decline in motor coordination could make food consumption very difficult. This would not only lead to loss of the quality of life, but might also result in malnutrition. Malnutrition is a well recognized disease in the elderlies, and can result in more negative consequence including muscle wasting and impaired immune defences [1]. Furthermore, ageing affects the food enjoyment due to the decrease in the ability to taste and smell, chewing difficulties, the side effects of medications and deterioration in general health [2–4], which might lead to changes in the regulation of appetite and the lack of hunger (also known as "anorexia of ageing") [5].

However, it is worth mentioning that elderly population is significantly diverse in terms of their needs, abilities, difficulties and resources. Even population within the same age group might have different capabilities. For example, independent living elderly are healthier than those who live in a residential home [6]. Hence, addressing the individuality

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and designing the perfect food for this heterogeneous group of elderly arechallenges for the food industry and also for the care givers. Despite the fact that food for the elderly has attracted great research interests in the past few years and some abundant data are available in literature, implication has been limited in both food provision by food manufacturing and service industries and the wellbeing of elderly populations. This was partly due to the poor user connection of these researches and partly due to some fundamental questions on the overall eating process remaining unanswered.

The overall eating actions can be classified into external actions (hand and finger manipulation) and internal actions (food oral processing: first bite, mastication and swallowing). During eating, hands are used in different ways, to lift objects such as lifting and holding a glass of water, to manipulate cutlery, to manipulate packaging such as opening a lid of a yogurt and to bring food from the plate to the mouth. An aged individual may find difficulties in carrying out this overall eating process and even an external help might be needed. Those elderlies who suffer from skeletal muscle weakness will have problems in the hand grip precision and hand grip force [7]. Particular pathologies such as Parkinson's disease might lead to difficulty in coordination of cutlery on the plate such as cutting or getting hold of the piece of meat as well as transfer it from the plate to the mouth without frequently spilling [8]. Regarding the food oral processing, the elderly may have less mastication efficiency than younger population due to a combination of loss of muscle mass, muscle forces and lack of teeth [9]. This fact conditions the elderlies' food choice, making them to consume more frequently softer food such as purees, mashed food [10]. During the mastication and posterior swallowing of the bolus formed, the tongue plays an important role in selecting and transferring the food bolus particles and finally initiating the swallowing process [11,12]. When the whole process (mastication–breathing–swallowing) is not well controlled, individuals could suffer from dysphagia, that unfortunately affects specially the elderly, although the exact effect of ageing on the oropharyngeal swallowing is not yet fully understood [13].

Thus far, assessment of eating capability of an individual has been largely based on subjective measurements, through qualitative interviews or observation protocol during the meal [14,15]. There are few studies which have characterised some of the individual parameters that influence the eating performance, such as the measurement of hand grip force in elderlies [16,17], the influence of denture wearers with dentate subjects [18,19] or the tongue pressure [11] during the swallowing process. However, to our knowledge, there has been no quantitative study that gives objective assessment of all the actions such as lifting objects, manipulating cutlery, taking the food to the mouth, chewing, and masticating that an individual performs during the overall eating process using objective measurements. In the present study, we propose to measure the actions that are necessary during the eating process, especially those ones where their incapability could affect the eating performance, which could result in loss of their quality of life.

Using the concept of “eating capability” proposed by Laguna and Chen [20], this study aims to measure the overall eating capability using three key components: hand and oral capabilities, and tactile sensitivity. Hand and oral capabilities are essential for food handling and manipulation; tactile sensitivity is a key physiological factor for texture sensation. To measure the selected capabilities different devices have been chosen in function of the technique reliability, simplicity of the test to set up and conduct, and the non-requirement of a specialist to assist the test.

It is hoped that through this study, a systematic approach can be established to objectively categorise elderly consumers based on their individual eating capabilities. The hypothesis of this study is that a decline in eating capability conditions one's perception of the ease of eating in such a way that food of higher consistencies would be perceived more difficult to consume by individuals with lower eating capability scores.

2. Materials and methods

2.1. Participants and recruitment

2.1.1. United Kingdom

A total of 103 subjects (over 65 years old, 75 women and 28 men) were recruited from seven community centres and two sheltered accommodations through the Neighbourhood Network Scheme in the area of Leeds (Yorkshire, UK).

2.1.2. Spain

A total of 100 subjects (over 65 years old, 62 women and 38 men) were recruited in the area of Baix Emporda (Girona, Spain) from three different nursing homes and one community centre.

The inclusion criteria were: to be above 65 years old and having no acute pain in the upper extremities and oral areas. Participation in the study was voluntary. For the entire experimental procedures, participants did not need to travel but were visited by the researcher either in the community centres, private homes or nursing homes. Ethical approval was obtained from the Faculty Ethics Committee at the University of Leeds (MEEC 13-019) for the UK and from the Comitè Ètic d'Investigació Clínica Institut d'Assistència Sanitària, Girona for Spain. All the experimental procedures followed the rules and guidance set by the University of Leeds, UK.

2.2. Eating capability components

Eating capability is defined as the *physical, physiological, and cognitive capabilities of an individual in handling and consuming food*[21]. This work mainly focussed on the hand and oro-facial muscular capability. All measurements were done in triplicate.

2.3. Hand capability

Hand gripping force was measured with an adjustable handheld dynamometer (Fig. 1a) (JAMAR dynamometer, Patterson Medical Ltd., Nottinghamshire, UK). Participants were asked to squeeze the hand dynamometer with their maximum efforts and maintain that for approximately 3 s with both hands alternatively [22]. The intensity of hand gripping was displayed as the maximum force in the digital panel.

Finger gripping force was measured with a modified version of the device designed by previous authors[23]. It consists of a built-in thin flexible force transducer (see Fig. 1b) (Tekscan, South Boston, Massachusetts, USA) connected to a multimeter. Two self-adhesive 1 cm diameter neoprene discs were attached to the sensor to make the measurement comfortable for participants, as shown in Fig. 1b. The multimeter connected to the flexisensor registered the resistance in ohms (the larger the force, the lower the resistance). To convert the registered resistance data into force values, a calibration was conducted. Forces of magnitude from 5 N to 250 N were applied using a Texture analyser (Stable Micro Systems, Godalming, UK) and resistance at each applied force was recorded. A standard curve of the applied force (N) and registered resistance was produced. To perform the maximum finger force, subjects were asked to squeeze the neoprene adhesive with their thumb and index finger and the minimum resistance was recorded.

2.4. Finger-tactile sensitivity

The chosen technique for touching sensitivity was the Semmes–Weinstein Monofilament (SWM) test (North Coast Medical, Inc., Gilroy, California, USA) (Fig. 1c) [24]. A Touch Sense™ monofilament was pressed in perpendicular direction against the skin surface until the filament was bowed for approximately 1.5 s and then removed. Tests were begun with the strongest monofilament, which applied a force of 300 g and continued in a descending order down to the weakest