



## HAND GRASPS IN THE KITCHEN -OCCUPATIONAL PERFORMANCE DURING THE ACTIVITY

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### ABSTRACT

**Backgrounds:** Grasp is defined as the static posture of the hand, through which an object is securely grasped regardless its orientation. Daily living activities are carried out using different types of grasps. Feeding is one of these activities where grasps are carried out on objects, utensils or products. It is associated with the "process of preparing, disposing of and bringing food or fluids, from the dish or glass, to the mouth". **Objectives:** With this study we intend to characterize the grasps used in activities of daily living, namely in the preparation of meals. **Methods:** As a descriptive-correlational study, relationships between variables are described to understand the use of grasps configurations and establish relationships between grasps, frequency, duration and types of objects. Four participants (two females and two males) selected by convenience, without pathology of the hand, with 18 to 64 years, who cook four times a week, were filmed performing the tasks in question. Data confidentiality and blind analysis of investigators were guaranteed. **Results:** Were found that in cooking activities, which elapsed for 18786 seconds, the most frequently used hand and for longer periods, was the right one. Thirty-one different types of holds were used and those that stood out for frequency and duration were the "Extension Indicator", "Thumb Adducted" and "Quadríade". Thus, force holds (with palmar and digital contact with all sets of force vectors, mostly with the thumb adducted), intermediate (with lateral contact, with all sets of forces except when the thumb is abducted) and precision (with palmar and lateral contact with all sets of force vectors) were used. Thus, we found that the greater the weight and diameter of the object, the greater the number of force vectors involved, which means more fingers in contact with the object. Therefore, we conclude that it is the prehensile object that influences the apprehension to be adopted, regardless of the sex and age of the individual. **Conclusion:** This work allows health professionals to know this activity considering the hand grasp and anticipate difficulties in occupational performance, make decisions about the intervention to be implemented, support assistive devices to be use, tasks to be adapted or training to be developed.

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## INTRODUCTION

Due to the complexity of the human hand and the wide variety of movements it accomplishes, many of the factors influencing the human grasp choice are still poorly understood (Feix, 2014).

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The hand is positioned in the most distal part of the upper limb, representing a fundamental role in the communication and interaction between people and objects. This segment, with sensory and motor functions, has many degrees of freedom that enables humans to perform a large variety of actions required in several tasks (Roda-Sales, 2019). These functions make possible to perform activities of daily living, including those that require greater precision (Pina, 2015). The human hand consists of twenty-seven bones which, organized into three parts: the carpal, metacarpal and phalanx.

The hand and fingers movements are only made possible through the 38 muscles actions<sup>3</sup>. The main function performed by the hand is to grasp. Grasp can be coarser, for bulkier objects or precise for smaller objects. As part of this study we will use the definition of grasp, proposed by Feix, Romero, Schmedmayer, Dollar & Kragic (Feix, 2016). These authors consider as grasp the static posture of the hand that allows safe grasping of a certain object, regardless the orientation of the hand or object in space (Feix, 2016). "Activities of Daily Living" is a commonly used term in rehabilitation and Occupational Therapy, referring to set of everyday tasks critical for unassisted living (Bullock, 2015). One of the Activities of Daily Living is the meal preparation and clean-up (American Occupational Therapy Association, 2014). The preparation of meals is defined as "preparing and serving meals (American Occupational Therapy Association, 2014).

The most recent studies on grasps use the new taxonomy developed by Feix in 2016, which originated a table of settings with 33 of the most used grasps in daily life grouped, considering their characteristics (Feix, 2016) (Figure 1).

Oppr	Power						Intermediate			Precision					
	3-5	2-5	2	2-3	2-4	2-5	2	3	3-4	2	2-3	2-4	2-5	3	
Thumb Adducted	11 Finger Extension	12 Index Finger Extension	13 Middle Finger Extension	14 Ring Finger Extension	15 Little Finger Extension	16 Power Grasp	17 Lateral Grasp	18 Medial Grasp	19 Tripod Grasp	20 Precision Grasp	21 Precision Grasp	22 Precision Grasp	23 Precision Grasp	24 Precision Grasp	
Thumb Abducted	25 Power Grasp	26 Power Grasp	27 Power Grasp	28 Power Grasp	29 Power Grasp	30 Power Grasp	31 Lateral Grasp	32 Medial Grasp	33 Tripod Grasp	34 Precision Grasp	35 Precision Grasp	36 Precision Grasp	37 Precision Grasp	38 Precision Grasp	

Figure 1. Grasp Taxonomy (Feix, et al. 2016)

In a recent study, using this taxonomy, two machinists and two housekeepers were observed performing their daily work-related tasks for seven hours and 45 minutes (Bullock, 2013; Bullock, 2015). For each subject, a surprisingly large number of grasps and grasp transitions, representative of their profession, were registered, approximately 4,700 per subject (Bullock, 2013). The authors only analysed the dominant hand and conclude that the machinists used ten different types of grasps and the housekeeper's five (Bullock, 2013). The grasps are performed according to the objects used in the tasks but also the same object can be grabbed in different ways, depending on the individual preferences (Feix, 2016). Previous grasps studies have primarily focused on strength or on hand configurations used for preselected objects. A recent study analyses the grasps in activities as food preparation (breakfast), housekeeping, folding clothes and ironing, the upper-body inertial motion and range in 13 participants (five females and eight males), from 19 to 42 years (Saudabayev, 2018). There were identified two highest duration grasps in food preparation, the Index Finger Extension and the Writing Tripod, around 19% and 14% of total duration, respectively<sup>7</sup>. The outline and distribution of grasp duration and frequency look mostly similar except for few cases, in this study

(Saudabayev, 2018). Replicating human hand grasping and manipulation have been, for long time, the objectives of researchers from multidisciplinary (Saudabayev, 2018). The analysis of the different types of grasps, in real context is fundamental in several aspects, in a large number of domains including industrial automation, humanoid robotics, medical rehabilitation and prosthetics (Saudabayev, 2018). The importance given to this analysis is justified by the complexity of the hand, its massive use throughout the daily activities in the execution of numerous tasks and the scarcity of information related to the types of performing grasps. This theme still has lower scientific evidence, and above all, there are few relations between grasps and tasks. The problem under study is based on the understanding of the grasps carried out in the different tasks of the activity of preparing a meal, including the discrimination of the grasp characteristics performed in each task, the type of applied strength (force, intermediate and precision), the thumb position (adduction or abduction), the contact between the object and the surface of the hand (palm, pad or side) and the number of force vectors used (from two to five fingers)<sup>4</sup>. A research focused on the activity of daily life, in particularly the meal preparation, will be driving to understand the human capacities and description of the accomplishment of the task from the point of view of the grasp functionality. This study intends to understand the grasps, performed by the adult population, during the preparation of a meal, and establish relationships between the variables.

## METHODS

The specific objectives of this investigation are based on the identification and characterization of the grasps, from the point of view of the type of grasp, frequency, duration, prehensile object (weight, diameter, stiffness and shape) and task in which the grasp in question is performed. This study is descriptive-correlational. Participants were recruited for convenience, composing a sample of four (two females and two males), three right-handed. As inclusion criteria were considered Portuguese nationality, age between 18 and 64 and habits of cooking at least four times a week. Exclusion criteria were any history of injury, disability, diagnosed pathology of the hand or other health issues which could affect their performance. This study complies with all ethical assumptions inherent to research being approved by the Ethics Committee of the Polytechnic Institute of Leiria. Before engaging in the experiment, each subject was comprehensively briefed about the procedure. Additionally, it was provided a written description of the experiment and required participants to sign an informed consent form. In order to achieve the objectives outlined, there were collected video images of the participants performing the tasks, in their natural environment. To have the most realistic data, the meals to be prepared, the kitchen utensils and the products were selected by the participants, as they are used to do in their daily living, in the way they need and preferred. To ensure data anonymity and confidentiality all personal objects were removed from the hands and forearms of the participants, namely rings, watches and bracelets, and the images were collected by one of the researchers, focusing only on the hands and the tasks. To keep the identity of the participants and researchers confidential, they were numbered with a numerical alpha code. The analyses were carried out, separately, by two of the researchers, not involved in the collection of the videos.

This way each video was tagged by two researchers and, when the results of their analyses were significantly different, they were analysed by a third researcher. This step added a final review of the data to help reduce any bias from either of the rater researchers<sup>6</sup>. To analyze the video images the researchers were trained in classifying grasps according to their characteristics in the Grasp Taxonomy. The starting point of each grasp action was established when the researcher detects contact of the hand with an object, product or utensil. The end point of the action was established when the participant released the object or performed another grasp. The recorded images illustrate the confection of four meals, with simple and practical recipes, made by the four participants. Each participant prepared a soup, a dish of meat dish of fish and a dessert. The images were captured with a 4K type camera, recording the files in MOV format, and viewed with the Movie Maker Software<sup>®</sup>. The data were transcribed to an Image Registration Grid, constructed by the researchers considering the objectives of the study and treated through a descriptive analysis considering the study variables.

## RESULTS

The data analysis by participant (n=4) allowed to have results considering each of the prepared meals as well as all the cooking activity. Collections per participant, per dish and the general full meal cooking activity will be presented. Three of the participants were right-handed (Participant A, B and D) and used his right hand in higher number and time than the left hand.

**Results by participant:** Participant A performed 21 of the 33 grasps of the Grasp Taxonomy, with the "Quadpod" being the most used (53 times, 4.12% of total grasps) for 3757 seconds, 20% of all the activity time. The "Index Finger Extension" grasp was performed for 1059 seconds corresponding to 5.64% of the time. Participant B is right-handed, used his right hand more often, however the frequency of use of the left hand is very significant. During the four tasks, the participant performed 22 of the 33 grasps underlining the "Precision Disk" since it was performed 103 times (8% of the total frequency) for 1583 seconds (8.43% of total duration). Participant C is the only left-handed and used his left hand more frequent and for longer periods than the right hand. During the four tasks, the participant performed 26 of the 33 grasps illustrated in the new taxonomy underlining the Index Finger Extension, performed 54 times (4.20% of the total frequency) with 943 seconds (5.02% of total duration). Participant D, during the four tasks performed 25 of the 33 grasps illustrated in the taxonomy underlining the Lateral used 54 times (4.2% of the total frequency) in a total of 772 seconds (4.11% of total duration).

### Results per dish

**Soup:** The soup takes 3870 seconds of video (20.6% total duration). The most used hand and for longer was the right, confirming the expected results, since it is the dominant hand of most participants (75%). This was recruited 175 times (13.6% of the total frequency) for 2049 seconds (10.91% of total duration) and the left was recruited for 152 times (11.81% of the total frequency) for 1821 seconds (9.69% of total duration). Of the 33 grasps present in the Grasp Taxonomy, only eight were not used. They were the Fixed Hook, Distal,

Adduction Grip, Tip Pinch, Lateral Tripod, Stick, Palmar and Ring. Regarding the frequency and duration of the various types of grasp, the Thumb Adducted stands out. This grasp was used 50 times (3.89% of the total frequency), for 739 seconds (3.93% of total duration). Regarding other characteristics analysed and proposed by Feix et al., it should be noted that arrests of the type of force, intermediate and precision were carried out. In the force grasps, the palmar contact (force vectors two to five and three to five) and digital contacts (force vectors two to three and two to four) were used. In this type of grasp the thumb was mostly abducted, although there are arrests in adduction. Regarding the intermediates, was used the lateral contact (two force vectors) with the thumb adducted. In the precision grasps, pad contact was performed (force vectors two, two to three, two to four and two to five) and lateral contact (five force vectors) with the Writing Tripod grasp. In this type of grasp the thumb was mostly abducted, although there are arrests in adduction.

**Meat dish:** Regarding the meat dish, approximately 5214 seconds of video was analysed (27.75% of total duration). The most frequently used hand, and for longer, was the right, confirming the expected results, since it is the dominant hand of most participants. Therefore, the hand was recruited 193 times (15% of the total frequency) for 2697 seconds (14.36% of total duration) and the left was used 178 times (13.83% of the total frequency) for 2517 seconds (13.40% of the total). From the 33 grasps present in the Grasp Taxonomy, the participants did not perform eight: the Small Diameter, Light Tool, Power Disk, Writing Tripod, Tripod Variation, Adduction Grip, Palmar and Inferior Pincer. Regarding the frequency and duration of the various types of grasp, the Index Finger Extension stands out, 58 times (4.51% of the total frequency) totaling 1395 seconds (7.43% of total duration). For the other characteristics analysed and proposed by Feix et al., it should be noted that all types of grasps (force, intermediate and precision) were carried out. In the force contacts, the palmar (force vector two to five and three to five) and digital (force vectors two, two to three, two to four and two to five) contacts were used. In this type of grasp the thumb was mostly abducted, although there are arrests in adduction. The intermediates with lateral contact (force vectors two or three) with the thumb adducted were used. In the precision grasps, the pad contact was the most used (force vectors two, two to three, two to four and two to five). In this type of grasp the thumb was mostly abducted, although there are arrests in adduction. In the meat dish, about 8389 seconds of video was analysed (44.66% of total duration). The hand used more frequently and for longer was the right, being the expected, since it is the dominant hand of most participants.

This hand was recruited 237 times (18.41% of the total frequency) during 4242 seconds (22.58% of total duration) and the left was used 223 times (17.33% of the total frequency) during 4147 seconds (22.07% of the total duration). From the 33 grasps, the participants did not perform six: the Small Diameter, Power Disk, Fixed Hook, Tripod Variation, Adduction Grip, and Ring. Regarding the frequency of the different types of grasp, the Precision Disk, performed 67 times for 5.21% of the total frequency of the analysed data, stands out. In duration, it is noteworthy the Finger Index Extension, performed for 1440 seconds (7.67% of total duration). Regarding the other characteristics, it should be noted that arrests of the type of force, intermediate and precision were carried out. In the type of contact, the palmar

(force vectors three to five and two to five) and digital (force vectors two to three; two to four and two to five) contacts were used. In this type of grasp the thumb was mostly abducted, although there are arrests in adduction. The intermediate grasps with lateral contact (force vectors two and three), with the thumb adducted, were used. In the precision grasps, a pad contact (force vectors two, two to three, two to four and two to five) and a lateral contact (five force vectors) were made with the objects. In this type of grasp the thumb was mostly abducted, although there are arrests in adduction.

**Dessert dish:** The dessert dishes, with approximately 1313 seconds, 6.99% of total duration of the video was analysed. The hand most frequently used, and for longer, was the right, confirming the expected results. It was recruited 66 times (5.13% of the total frequency) for 775 seconds (4.13% of total duration) and the left, 63 times (4.90% of the total frequency) for 538 seconds (2.86% of total duration). Of the 33 grasps present in the GraspTaxonomy, the participants did not perform ten, being the Light Tool, Tripod, Fixed Hook, Writing Tripod, Tripod Variation, Adduction Grip, Tip Pinch, Lateral Tripod, Stick and Ring. The most frequent grasp used to make the desert dish was the Large Diameter, performed 23 times (1.79% of the total frequency). Regarding the duration, the Medium Wrap was the most adopted, for 291 seconds (1.55% of total duration). Regarding other characteristics different types of force, intermediate and precision grasps were carried out. In the force types, the Palmar contact (force vectors two to five or three to five) and pad contact (force vectors two to three; two to four and two to five) were used. In this type of grasps the thumb was mostly abducted, although there are arrests in adduction. The only intermediate with lateral contact (two force vectors) with the thumb adducted, the Adduction Grip, was used. In the precision grasps, a pad contact was made (force vectors two, two to three, two to four and two to five). In this type of grasp the thumb was mostly abducted, although there are arrests in adduction.

**Results for the activity:** The analysis of each dish, as mentioned, allows to study the activity of cooking a complete meal. The hand used more frequently and for longer was the right, confirming the expected results, since it is the dominant hand of most participants (75%). It was recruited 671 times (52.14% of the total frequency) for 9763 seconds (51.97% of total duration) and the left 616 times (47.86% of total duration) for 9023 seconds (48.03% of total duration). Of the 33 grasps present in the GraspTaxonomy, the participants did not perform two, the Tripod Variation and the Adduction Grip. Regarding the frequency and duration of the several types of grasps, the Large Diameter was performed 162 times during 3667 seconds (12.59% of frequency and 19.52% of total duration), the Adducted Thumb was executed 136 times during 2488 seconds (10.57% of frequency and 13.24% of total duration), the Quadpod was performed 122 times during 1500 seconds (9.48% of frequency and 7.98% of total duration), the Precision Disk was performed 112 times during 1695 seconds (8.70% of the frequency and 9.02% of the total duration) and the Lateral was made 102 times during 1108 seconds (7.93% of the frequency and 5.90% of the total duration). To prepare a meal are used a variety of objects with different weights, configurations and diameters, from mixers, magic wands, wooden spoons, knives, scissors, pots, dishes, groceries, fish, vegetables, fruits, and many others. This justifies the presence of several grasps of large, medium and small diameter and tweezers. The stiffness and shape of these objects and

materials influences the grasp adopted, and they vary between rigid, semi-rigid and soft, regarding stiffness, and round, ovals or rectangular, regarding the shape. These characteristics influence the type of contact of the hand with the objects, the number of force vectors involved and the position of the thumb. During the cooking activity, with a total of 18786 seconds, force, intermediate and precision grasps were used. In the force grasps, palmar and digital contacts with 2 to 5 force vectors were used and the thumb was mostly abducted. Regarding the intermediates with lateral contacts, two to three force vectors and the thumb were used. In the precision grasps, palmar contact with two to five force vectors and lateral contact with two force vectors were used. In this type of grasp the thumb was mostly abducted, although there are arrests in adduction.

## DISCUSSION

The preparation of a meal is composed, in general, of tasks that resort to grasps of strength and precision, being the less used the intermediate with the abducted thumb. The results show that this activity is performed most of the time, and with more frequency, with the dominant hand. Several are the studies complying with the same results<sup>2,5,6,7,9</sup>. The grasp strength and type are essential for performing activities of daily living and involve alternation of the static position of the fingers and thumb. A grasp implies, the flexion of the three joints of the fingers, that is, the metacarpophalangeal, proximal and distal interphalangeal, being the only exception is the Parallel Extension. The thumb is essential in the type of grasp as to precision or strength, since it can be placed in different planes in relation to the other fingers, allowing to grasp objects with different weights, dimensions and shapes. In precision tasks, the thumb is held in a perpendicular position to the hand with opposition to the other fingers<sup>10</sup>. Regarding the frequency and duration of grasps, these variables are neither proportional nor directly related. It was verified that, although there are grasps with a lower frequency of use, they have a longer duration, as well as the reverse.

The weight, diameter, stiffness and shape of the objects used during the activity influence the selected grasp, hence the presence of so many grasps configurations, from Large, Medium to Small Diameter, Pinches and Tweezers. The most used grasp configuration, in preparing a meal activity, is the Index Finger Extension. This result is aligned with the study conducted by Bullock<sup>5</sup>. The greater the weight, diameter and stiffness of the object, greater the number of force vectors involved and, consequently, the force applied by the hand to perform the grasp. With this analysis, it was also concluded that, in order to perform a certain task, the participants performed, mostly, the same type of grasp, regardless of age or gender. By example, to cut food with a knife, peel with a peeler or stir a preparation was used the Index Finger Extension grasp, to peel with a knife was used the Adducted Thumb and to grab and transport objects, such as pots or dishes, was used the Lateral grasp. Small variations depended on the objects used, since they differed between participants. Also, the hand can hold different tools, and appropriately interact with objects in a wide variety of ways<sup>11</sup>. In fact, different organisms have different types of evolution regarding the dynamical interaction between the maturing of the organism, the environment, and the task across the lifespan<sup>12</sup>.

## CONCLUSIONS

The literature consulted refers to the scarcity of information related to grasps during activities of daily living. The studies already carried out revealed results related to specific professions or different activities (analysis of human grasping behaviour: correlating tasks, objects and grasps). In this sense, this study becomes innovative and relevant because it focuses on a single activity performed in its natural context, the kitchen of the participant. The results for five hours and 20 minutes of images, approximately one hour and 20 minutes for each participant, to conclude the cooking activity with both hands, show that 31 of the 33 grasps configurations of the Grasp Taxonomy, were used during 1287 performed grasps. Thus, we consider that the collection of data from future studies should include a larger sample to perform the same task, in an equal period and place, making use of the same objects. During the implementation of this research, several obstacles were felt, among which we highlighted the analysis of the data. This analysis was hampered by the variety of angles of image capture, change in the brightness and the blur of the image, among other factors. The use of a Webcam positioned in the forehead of the participants could be a better solution.

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