

# BIOMECHANICAL ANALYSIS OF OPENING GLASS JARS: USING KINEMATICS TO INFORM DESIGN

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## INTRODUCTION

Most of the published research regarding the usability of jars focuses on opening forces (Langley et al., Yoxall et al., Crawford et al., Voorbij and Steenbekkers) while few studies address the kinematics. Other factors that may play a role in how people open jars include dexterity, hand size, handedness, or laterality. The goals of research presented here include:

- Development of a methodology for capturing kinematic data when opening a jar in restrained and unrestrained conditions.
- Determination of whether or not requiring the jar to remain on a support surface during opening impacts kinematics.

## METHODS AND PROCEDURES

It is theorized that there are three motions that exist when opening jars with lug style closures. These motions are: (1) only the hand on the closure moves, (2) the hand placed on the base of the jar rotates while the hand on the closure remains nearly stationary, (3) and a combined movements of both hands.

Twelve subjects, 7 men and 5 women with an average age of 25 and without a history of injury to the hands, wrists, arms or shoulders were selected for testing. Prior to testing

subjects, demographic information was collected. Subject anthropometrics, laterality and preferred dexterity were also recorded. Grip strength and pinch strength (lateral, tip and key) were tested in accordance with tests standards specified by the American Society of Hand Therapists.

Pilot work suggested that subjects employed two styles of opening. In method one, the subject placed their hand on the closure and the other hand around the center of the jar. Subjects that employed the second opening style put one hand on the closure, and used the other hand to grasp the base of the jar, i.e. the palm spanning the jar's bottom thus making the two palms parallel. Two fixtures were created to accommodate each of the two opening styles for testing. This preliminary test of opening style served to inform researchers which of two test fixtures subjects would require during testing.

Two jars with diameters of 87mm and 109mm were used for testing, each with a closure diameter of 70mm and a height of 150mm. Prior to each trial, test jars were fitted with a new closure and torqued to 35 in-lb. Two conditions were tested, one where the subjects were asked to keep the jar on a table and open it (restrained), and a second condition where subjects were asked to pick up the jar and open it (unrestrained). Each subject opened a

total of twelve jars; three trials were recorded for each of the two jars in the restrained and unrestrained conditions. Trials were randomized to mitigate any effect of fatigue on test results. Data were recorded using a five camera Qualisys motion capture system and software.

## RESULTS

Preliminary findings indicate that right handed individuals open the jar by placing the right hand on the closure and their left hand on the jar. This is true for both the restrained and unrestrained conditions. Eleven of the 12 subjects opened the restrained jars by rotating their closure hand. Therefore, the dominate hand moved when opening in the restrained condition. Table 1 shows a sampling of the motion data

Gender	Preferred Dexterity	Top Hand	R Hand	L Hand
M	R	R	77	3
M	R	R	89	0
F	R	R	40	0
F	L	L	37	31

**Table 1.** Sample of the opening motion when restricted to opening the jar on a table at a fixed height of 36” (values in degrees).

In order to open the jars, a total of 30 degrees of rotation is needed. Instances where the total rotation was greater than 30 degrees resulted from the continuation of the movement past the initial point of opening; this is likely due the force necessary to overcome the torque applied prior to opening.

## DISCUSSION

Current data suggests that when restricted, subjects tend to use one of two motions to open jars, the closure hand alone, or a combination of both hands. However, further testing is needed to generalize this finding.

## SUMMARY

Preliminary findings indicate that only two of the opening motions are used when subjects are required to keep the jar on the table. Further analysis will compare differences in the kinematics for each subject between unrestrained and restrained protocols. This research provides a methodology for use in future research evaluating the affects of ageing on accessibility of packaging.

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