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Technical Note

The twisting force of aged consumers when opening a jar

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Abstract

Many people experience difficulty when opening a vacuum-sealed jar. Yet solutions to the problem continue to be tool-based rather than exploring the possibility of innovative changes in product packaging. Improvement depends on gaining knowledge of the capabilities of users, and of using that knowledge as a base for product innovation. To establish such a base we took a sample of 750 subjects and asked them two questions about how they opened jars at home. We then carried out torque measurements using a force transducer shaped like a jam jar. We reached the conclusion that if opening torque was reduced to 2 N m then 97.6% of users between 50 and 94 years of age and 100% of 20–30 year old users would have no difficulty opening a jar.

Keywords: Twisting force; Gerontechnology; Jar opening

1. Introduction

Opening vacuum-sealed jars can pose a problem for a large percentage of the elderly population (Berns, 1981; Steenbekkers and Logman, 1987) because they are unable to exert sufficient twisting force. Yet many consumer goods are packed in such jars. This points to a design problem, caused by the need for glass packaging that can be re-closed, can withstand vacuum and is suitable for preserving perishable foodstuffs. With such packaging a minimum torque is required to retain the vacuum. There are no regulations that prescribe the torque required to open a jar. The degree of torque applied in the manufacturing process is often large, because other factors are involved such as preventing people from opening jars accidentally or stopping consumers from tasting before buying.

At present no general solution for the easy opening of jars exists. Tools such as clamps, vacuum releasing levers or antiskid pads could be used, but these tools all have drawbacks in their design and are not always available. At present, the optimal solution is to design packaging that can be opened manually by the majority of the population. This should include all independently living adults. The starting point for this study is not to design an alternative-opening device, but to present information to manufacturers which will promote the use of the capacities of users as a basis for their packaging.

We decided to restrict ourselves to the circular turning lid, which is the one most commonly used in glass packaging. Imrhan (1993) found that for lid diameters under 74 mm, ridges and other patterns for increased grip do not result in an increased torque. Data are available on maximum twisting force as well as on opening jars (Ivergard et al., 1978; Berns, 1981; Rohles et al., 1983; Imrhan and Loo, 1988; Daams, 1994). However, information on the capacities of the elderly is scarce. Because the number of elderly people who live independently is increasing rapidly, the capacity of these consumers is now very relevant for package design and must be taken into account. Therefore, the aim of this study is to determine, in as close to a real life situation as possible, the maximum twisting force the elderly can apply when opening a jar.

2. Method and materials

This study is part of a larger study on the design-relevant capacities of ageing users (Steenbekkers and

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Van Beijsterveldt, 1998). In this study 79 variables were measured on 750 subjects: 123 of them were aged between 20 and 30 years and 627 were over 50 years of age. In Table 1 information on number, sex, body mass and stature is presented for comparison with other studies.

All subjects were selected for their ability to live independently, and none of them had needed to consult a medical specialist in the three months preceding the experiments. The variables were tested in two sessions on two separate days, each lasting about 2 h. Twisting force was measured in a session along with other physical variables such as gripping force, walking velocity and reach envelopes.

A written ADL (Activities of Daily Living) questionnaire was sent to each subject before they attended the measurement sessions. The questionnaire contained 44 questions. Questions 17a and b referred to the opening of jars. Subjects were asked to classify the problems they experienced when opening jars:

17a Can you twist off the lid of a new jar?
☐ *Yes, I can without any difficulty*
☐ *Yes, I can with some difficulty*
☐ *Yes, I can with great difficulty*
☐ *No, I cannot*

17b If you are able to open a jar, do you use an aid, such as a multi-opener?
☐ *Yes*
☐ *No*
☐ *Sometimes*

One of the most important aims of this study was to make the force measurements as realistic as possible. We therefore used a jar-shaped measuring unit that could be picked up and handled, which is in contrast with most other studies on twisting force. The twisting force was measured while the subject was standing. The subject was asked to adopt the posture normally used for opening jars. It was therefore possible to place the jar on a table or on a surface at worktop height, or to handle the jar without the use of any support. All possibilities were mentioned to the subject. The only limitation the subject had to cope with was a thin wire leading from the jar to an amplifier. An arrow on the lid indicated the twisting direction corresponding with opening.

The jar, which was made of aluminium, weighed 650 g and contained a torque transducer (Engineering Dept., Cambridge University). The jar-shaped unit was linked to a strain indicator (Peekel Instruments, CA690). The lid had a diameter of 66 mm, while at its widest point the jar was 75 mm in diameter. The total height was 113.5 mm (see Fig. 1). The dimensions of the jar were copied from a jam jar available in Dutch supermarkets.

Before the subjects exerted maximum twisting force, they were instructed to wipe their hands thoroughly to prevent the possibility of sweaty hands affecting their

Fig. 1. The handling of the jam-jar-shaped force meter, the subject was to choose how to hold the handle in his hands.

Table 1
Subject information

Age group	Number		Stature (cm)		Body mass (kg)	
	Men n	Women n	Men $\bar{x}(s)$	Women $\bar{x}(s)$	Men $\bar{x}(s)$	Women $\bar{x}(s)$
20–30	55	68	184.8 (8.0)	168.6 (6.6)	80.8 (14.3)	66.7 (9.6)
50–54	35	35	177.8 (8.1)	165.4 (5.5)	82.5 (11.7)	70.4 (12.4)
55–59	46	50	176.7 (7.5)	165.3 (6.3)	82.1 (12.8)	70.7 (11.2)
60–64	44	53	176.1 (5.7)	163.9 (5.9)	80.2 (8.9)	71.4 (11.6)
65–69	50	51	173.7 (6.9)	161.1 (4.9)	77.6 (9.0)	68.9 (8.6)
70–74	59	62	172.5 (7.0)	161.9 (5.7)	78.3 (10.1)	71.4 (12.0)
75–79	36	38	170.8 (6.0)	158.6 (7.0)	79.3 (9.5)	70.5 (9.7)
80	33	35	170.7 (6.4)	155.3 (5.9)	76.8 (10.2)	63.9 (10.2)

grip on the lid. During the actual maximum force exertion, one attendant verbally encouraged the subject. Subjects were not able to see the results, which were recorded on paper by an XT-writer. The subject was instructed to build up force to maximum and to hold this maximum force until the second attendant called a stop. This attendant checked for an acceptable length of the constant phase in the force graph (i.e. 1 s). The force exertion was repeated once after a 2 min period of rest.

The attendants noted the maximum force exerted in combination with the position and laterality of the hands for force exertion. The force graphs were analysed visually and the maximum force assessed was entered into the computer. All statistical analyses were performed with SPSS for Windows (SPSS Inc.).

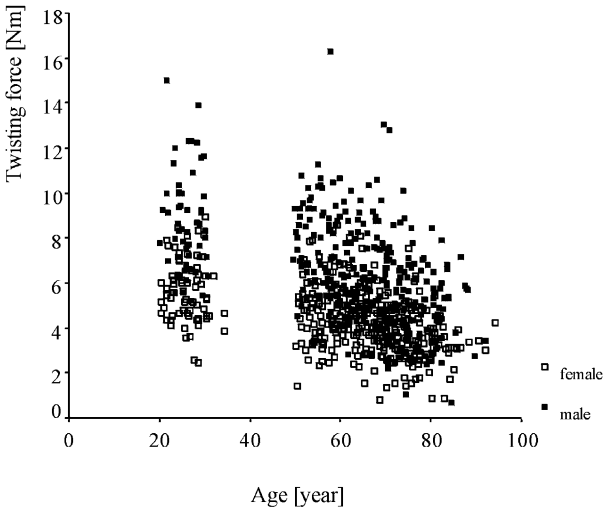


Fig. 2. Scatterplot of twisting force versus age. The black dots represent the men while the white ones represent the women. Men are generally stronger than women.

3. Results

There was no significant difference between the results of the first and second measurements of twisting force,

Table 2
Standard deviation, mean and 5th and 95th percentiles of twisting force[a]

Age group	Twisting force (Nm)							
	Men				Women			
	S.D.	P5	$\bar{x}$	P95	*S.D.*	P5	$\bar{x}$	P95
20–30	2.2	5.6	8.7	12.6	1.4	3.6	5.6	8.3
50–54	1.8	4.2	7.6	10.3	1.5	2.4	4.8	7.9
55–59	2.3	4.6	7.6	11.0	1.4	2.5	4.7	7.7
60–64	1.8	4.1	6.4	9.7	1.4	2.7	4.8	7.7
65–69	2.1	3.8	6.5	10.5	1.2	1.9	4.0	6.2
70–74	2.1	2.4	5.4	9.0	1.1	1.6	3.7	5.2
75–79	1.7	2.5	5.0	7.9	1.3	1.7	3.5	6.2
80+	1.7	1.9	4.9	8.0	0.9	0.9	3.4	4.7

[a] The results are presented per age group for males and females seperately, because age and sex influence twistig force. When the coefficient of variation is considered, it can be found that for the male this coefficient differs between the age groups, ranging from 4.2 to 2.8. The correlation coefficient between the mean and standard deviation is, however, insignificant. The coefficients of variation of the age groups of females are comparable in figures to those of the males, but show smaller differences, ranging from 4 to 2.7. However, the correlation coefficient between mean en standard deviation is 0.77 and significant ($p<0.05$).

Table 3
Numbers on hand configuration and laterality. Left handed subjects tend to open the jars differently from right handed subjects

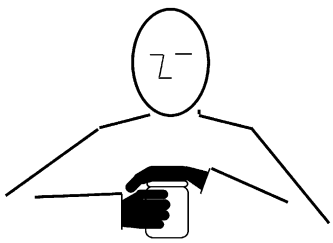
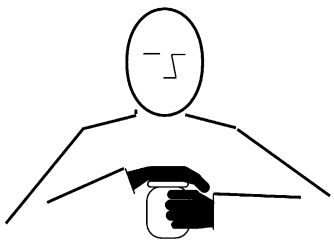
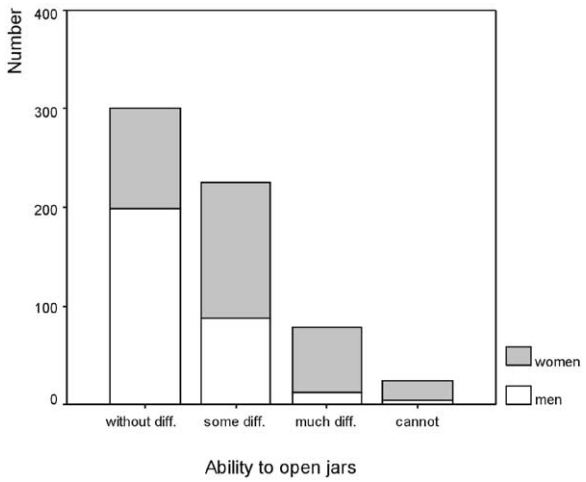
	 A: Right hand grasping the jar number	 B: Left hand grasping the jar number
Right-handed subjects	511	147
Left-handed subjects	23	62

Table 4
Answers to ADL-questionnaire for subjects over 50

Ability to open a jar per sex



Ability to open a jar with or without tools

	No difficulty (47.2%)	Some difficulty (35.9%)	Much difficulty (12.4%)	Cannot (3.8%)
Use of tools (%)				
No	35.7	20.0	16.7	16.7
Yes	25.3	40.4	55.1	70.8
Sometimes	39.0	39.6	28.2	12.5

so the mean of both measurements represent was taken to twisting force. Fig. 2 is a scatterplot of twisting force in relation to the age of the subjects. The highest twisting force found was 16.3 N m and the lowest was 0.7 N m. Table 2 contains information on the average twisting force, the standard deviation and the 5th and 95th percentiles. The results are presented per age group.

All subjects used both hands in the force exertion. One hand was on the lid while the other grasped the jar. An effect of laterality was found in the use of the hands. Most right-handed people preferred to have their left hand on the lid while the other hand grasped the jar, most left-handed persons used the other hand combination (see Table 3). This difference in handling was significant according to the frequency distribution $\chi^2_{(1)} = 93.3$ ($p = 0.000$).

In Table 4, the answers to the questions in the ADL-questionnaire are presented per answer for the subjects over 50.

The subjects from 20 to 30 years of age had considerably fewer problems. None was unable to open a jar and only 1.6% had much difficulty in opening a jar. The use of tools was less common in this age group (60.7% never use one).

4. Discussion

Opening a jar often involves a great deal of effort. In a group of elderly persons we found that 16.2% had great difficulty, while 3.8% were unable to open a jar without help. Only 47.8% had no problems. Although the figures mentioned here might not be general knowledge, it is generally recognised that opening jars can be difficult. It is strange, therefore, that the packaging industry has not yet addressed the problem by changing this type of packaging. In The Netherlands there are some regulations concerning food and packaging. With respect to the closing of lids, maximum opening force is not prescribed by law. A Dutch producer of jam packed in jars measured the opening torque of those jars and found that, depending on the type of jar, the required opening torque was between 2.9 and 5.5 N m.

The present study is an attempt to answer the question of what maximum torque should be allowed for opening a jar. This information needs to be transformed into a design requirement for reclosable glass packages.

The elderly population is of increasing interest because, when living independently, they combine the

lowest force levels with considerable consumption of jar-packed food. Therefore, the majority of the subjects we studied were over 50 years of age. We also studied subjects between 20 and 30 years of age as a reference group. Because we wanted to find out what happened in an everyday situation we allowed the subjects to adopt their own natural position during force exertion. We encouraged them during the actual force exertion, because in daily life they would be motivated by a wish to reach the contents of the jar.

We used a lid with a diameter of 66 mm, which represents the size of a common jam jar. This size also enables comparison with data on opening torque found by Rohles et al. (1983). Their subjects were aged between 62 and 91 years and for comparison we selected subjects in the same age category. The data of Rohles et al. (1983) and our data from this study were found to be comparable; for men 6.5 and 5.7 N m, respectively and for women 3.6 and 3.9 N m, respectively. Comparison with other studies, such as Ivergard et al. (1978), Berns (1981) or Imrhan and Loo (1988), is difficult primarily because of different test situations. A different lid diameter, for example, can have an effect on force exertion (Imrhan, 1993).

With respect to the facilitation of easy opening by means of modifications made to the jar, it should be realised that all subjects used both hands, and that modifications should not hinder hand configuration as preferred by left- and right-handed consumers. We did not study the non-preferred hand configuration, but it would be an interesting subject of study to check if this lowers the maximal twisting force that can be exerted.

Products will always be designed on the basis of compromise between conflicting optimal solutions for specific aspects but we feel that, as this concerns food, it is essential that the majority of consumers are able to open the product without help. Therefore, in our recommendations we accept that only 2–3% of our sample should be in need of help.

Interpreting our data in order to provide a recommendation for manufacturers, results in a limitation of opening torque to 2 N m. This implies that only 2.4% of people over 50 years of age would remain unable to open a jar without help. In view of the large number of elderly people who actually have problems with opening a jar (52.2%) we conclude that the present torque requirement is much higher than the recommended 2 N m.

From this study we conclude the following:

- The preferred way of opening a jar is with both hands; one on the lid and one on the jar.
- Laterality is significant: the preferred hand grasps the jar.
- The required torque for opening a jar should not exceed 2 N m.

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