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# Ergonomic Redesign of Pill Jars: Reducing Hand Strain and Enhancing Usability for the Older Adults Suffering from Osteoarthritis

**Reenu Singh**

Indian Institute of Management Mumbai, Annandale, VA, USA
Email: ar.reenusingh@gmail.com

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## Abstract

Older adults frequently find standard pill-jar designs challenging, leading to muscle and tendon strain, frustration, and even missed doses. This investigation identifies the precise hand-strain points when opening two different jar styles. Motion analysis shows that gripping and twisting actions place the greatest load on the thumb's base and tip—overworking the flexor pollicis longus—while inflamed knuckles that cannot fully curl burden the flexor digitorum profundus. Repeated gripping also exhausts the index and middle fingers, stressing both the extensor and flexor digitorum profundus tendons. A Rapid Upper Limb Assessment (RULA) comparing the old and new jars yielded RULA scores of 5 and 2, respectively, reflecting significant improvements in thumb, wrist, and palm posture and reduced strain. Among the different regions of the fingers subjected to strain during the operation of common pill jars, the study identified two areas experiencing particularly high levels of stress. This increased strain poses challenges for elderly individuals with osteoarthritis, making it difficult for them to open containers and manage their daily medications. Findings indicate that repeated loading is concentrated at the dorsal digital expansion—the extensor hood, a specialized connective tissue on the back of the fingers where multiple muscle tendons converge. This suggests the fingers are engaged in complex fine motor tasks, including extension, stabilization, and precise adjustments. Furthermore, the flexor digitorum profundus—a deep muscle responsible for bending the fingers at the tips—is also under significant strain, pointing to intense gripping, pulling, or sustained finger flexion likely performed with force or over extended periods. These findings underscore the necessity for pill-jar redesigns that accommodate age-related limitations: intuitive opening mechanisms, ergonomic shapes that alleviate strain, and high-friction, non-slippery materials. Since swollen knuckles impede finger flexion, minimizing required pinch force is essential to ensure effortless, strain-free operation.

**Keywords**

Aging, Ergonomics, Physical Strain, Pill Jars, Product Design, RULA

## 1. Introduction

The aging population is a growing global concern, with more individuals living longer than ever before [1]. As people age, they often face physical and cognitive challenges that can impact their daily lives [2]. One such challenge is managing medication, with pill jars becoming a common struggle. The need to organize and accurately administer multiple medications can be daunting, particularly for older adults with conditions such as arthritis, vision impairments, or memory loss [3]. These struggles highlight the importance of designing solutions that make medication management easier and more accessible for the aging population. As people age, the physical strength is reduced [4], likewise, the ability of the muscles involved in gripping objects to generate force (tensile strength) becomes weaker. This reduction in muscle strength can affect hand function, making tasks that require a strong grip (such as opening jars or holding objects) more difficult as a person gets older. Opening a pill jar involves various movements and several forces come into play, depending on the design of the jar. These include: Grip force, defined as the pressure applied by the fingers and palm to securely hold an object, plays a vital role in stabilizing jars during opening tasks, preventing slippage, and allowing controlled motion [5]. Among elderly individuals, studies show that diminished grip strength is directly linked to difficulties in opening jars and medication bottles, a condition often exacerbated by ailments such as arthritis and muscle atrophy [6]. Similarly, pinch force—the force applied between the thumb and fingers, typically the index and middle fingers—is crucial for handling caps that demand squeezing, pulling, or precise rotational actions [5]. Reduced pinch strength in older adults can make it particularly hard to access child-resistant packaging, posing challenges to medication adherence. Torque, or rotational force measured in Newton-meters (Nm), is another essential factor in opening containers, particularly those with push-and-turn mechanisms that demand simultaneous downward pressure and rotational effort. Individuals with arthritis or compromised dexterity often find these movements difficult [7]. Compression force, referring to the downward force necessary before initiating a twist, is another barrier for elderly users who experience reduced hand strength and joint pain. High compression force requirements are known to hinder access to medications, prompting suggestions for redesigning pharmaceutical packaging [8]. Pulling or tensile force, used to lift or remove caps secured by friction or press-fit mechanisms, is particularly relevant in the case of snap-on lids, which often require significant force. Such demands can lead to frustration or even non-compliance among elderly users. Frictional force, the resistance between fingers and the cap surface or between the cap and bottle threads, can both aid and hinder the opening process; textured surfaces may improve grip, but excessive friction may require more force to overcome and increased torque. Understanding the combined effects of grip, pinch, and twisting forces is crucial for designing accessible and user-friendly packaging, particularly for aging populations with diminished hand strength and dexterity. Existing research identifies a notable gap in user-centered pill jar designs that effectively address these limitations [9]. There remains a critical need for innovative container designs that account for grip strength, pinch force, wrist-twisting ability, and gender-related differences to enhance usability. This study presents the following hypotheses:

Hypothesis A: Older adults exhibit high RULA scores when opening standard pill jars, indicating an increased risk of musculoskeletal discomfort or injury, particularly among individuals with pre-existing conditions such as arthritis.

Hypothesis B: Ergonomically redesigned pill jars, requiring lower torque, grip, and compression forces, are associated with significantly lower RULA scores, suggesting improved biomechanical efficiency and reduced physical strain.

Normative data on wrist-twisting strength among elderly populations offers valuable insight into their capacity to manipulate twist-based closures and informs ergonomic packaging improvements. Addressing these challenges through informed design interventions holds the potential to greatly enhance medication accessibility and compliance for older adults.

## 2. Method

A case study was conducted to examine and evaluate the challenges faced by elderly individuals when opening standard pill jars available in pharmacies across the US. The subject of the case study, an 80-year-old woman [10], encountered difficulties in taking her blood pressure medication, which comes in pill jars, as depicted in **Figure 1**. She struggled with holding the jars, accurately gripping the lids, and applying pressure to unlock the child-safe locking mechanism.

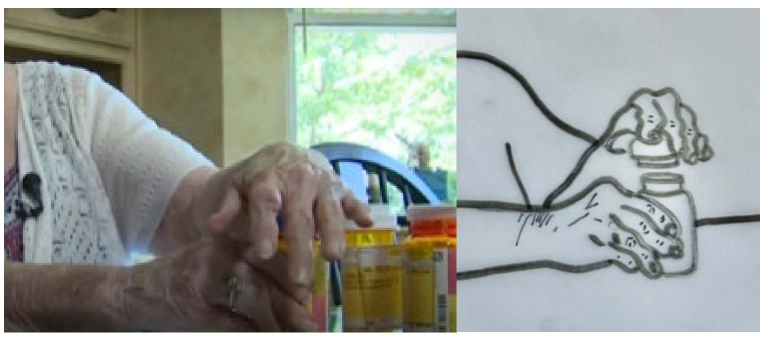


**Figure 1.** An elderly woman uses both hands to press and open the child-safe pill jar.

Throughout this process, the user experienced strain in various parts of both hands. These challenges can be attributed to the design of the pill jars, which require the use of both hands to dispense a pill during medication administration. The elderly often manage multiple medications from different pill jars throughout the day, which further aggravates their pre-existing conditions, such as arthritis and osteoporosis in the fingers. The exertion required in handling these jars causes strain on the muscles and tendons, leading to frustration, and in turn, discourages consistent adherence to prescribed medications. The study explores the strain experienced by muscles and tendons in the hands while retrieving pills from two different types of pill jars. Pill Jar Type-1 (Figure 2) is a narrow container with a small lever on its rim; to close it, the lid is turned counterclockwise, locking into place as its outer edge slides beneath the protruding lever. Some variants include a reversible lid system, requiring users to push down and twist the lid to open, and then reattach it by flipping it over to align with internal threads. Pill Jar Type-2 (Figure 3), on the other hand, lacks this locking mechanism and does not allow the lid to be reversed. It requires simultaneous downward pressure and twisting to open and close, similar to standard child-resistant designs. Elderly users often repeat this process several times in one sitting to access various medications stored in separate jars. To support the design of more accessible pill jars for older adults, the study included a motion analysis and Rapid Upper Limb Assessment (RULA). Observations of hand strain and posture provide critical insights for developing solutions that reduce physical stress and improve ease of use.

## 2.1. Motion Study of Opening Pill Jar Type-1

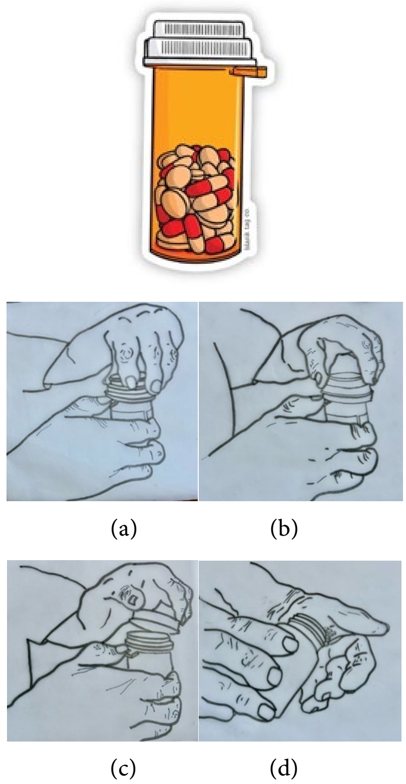
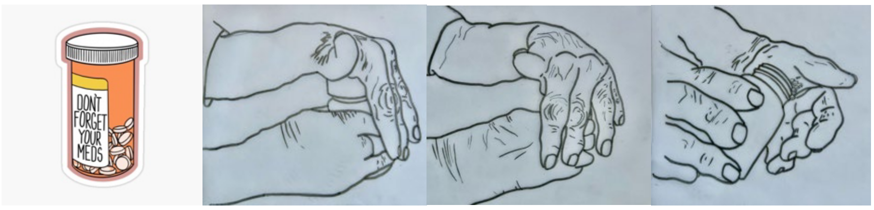


Figure 2. Hand movements in opening the child-safe pill jar type-1. Pill jar image source: https://www.blanktag.co/products/the-bottle-of-pills-sticker.

A comprehensive study, akin to a motion analysis (such as the hand motion study by Singh *et al.* [9], provides valuable insights into the regions of the palm that experience strain. The user kept her pill jars on a stable surface; in her case, it was her dining table. She then grabs the pill jar with her right hand while moving her left fingers to hold the lid (**Figure 2**). The right thumb is placed on the lock, which is a protruding piece of plastic attached to the mouth of the jar. She struggles with keeping her right thumb pressed on the lock, this takes excessive effort as her knotty knuckles and swollen fingers provide limited room for flexion. She then removes the lid by twisting the lid in a clockwise direction using her left fingers and thumb. All this is achieved with limited flexion movement, which makes it hard for the user to keep on holding the jar and lid for the entire duration of the jar-opening process. Repeated challenging movements lead to musculoskeletal disorders [11], worsening any pre-existing physical ailments in the hands and forearm. The total time taken by the user to remove the lid was around 3.5 seconds.

## 2.2. Motion Study of Opening Pill Jar Type-2

The user places her pill jars on a stable surface, such as the dining table. She then grabs the pill jar with her right hand while using her left fingers to grasp the lid (https://www.amazon.com/Plastic-Medicine-Bottles-Child-Resistant/dp/B08R6447F3?th=1). She presses down on the lip of the lid using her full force, applying pressure with her palm (**Appendix A**) to unlock the child-safe mechanism (**Figure 2**). Despite her effort, she struggles to maintain the pressure for more than 5 seconds. After much exertion, she finally unlocks the lid and removes it by twisting it clockwise with her left fingers and thumb. Throughout this process, limited flexion movement makes it difficult for her to sustain a firm grip on both the jar and the lid. The total time taken for her to remove the lid was approximately 6 - 8 seconds (**Figure 3**). It is difficult to predict whether the time will decrease with practice, as age-related muscle loss, joint rigidity, and reduced flexion capability hinder quick movements. Such stressful, repetitive, long duration tasks become cumbersome and give rise to counterintuitive [12] adverse effects instead of giving the intended benefits of medication. These physical limitations make it challenging to improve speed, even with repeated use.




(a) (b) (c)

**Figure 3.** Hand movements in opening the child-safe pill jar ntype-2. Pill jar image source: https://www.redbubble.com/shop/pill+stickers. (a), (b) & (c) illustrate the sequence of opening the pill jar 2.

### 2.3. Muscles and Tendons Under Strain

The muscles and tendons under strain when opening pill jars 1 and 2 are illustrated in Appendix B. Postures 1 to 6 depict the strain experienced by the hand—particularly in individuals with swollen, stiff joints such as those with rheumatic arthritis [13]—during jar use. As the fingers, especially on the right hand, curl around the jar, several muscles and tendons are stressed. The right flexor digitorum superficialis bears the load of the gripping action, and this discomfort is exacerbated by arthritic changes in the finger joints. Twisting and gripping the lid with the thumb places additional strain on the first dorsal interosseous muscle, the extensor pollicis brevis tendon, and the flexor interosseous tendon. The palmar surface of the right index finger also experiences strain, impacting the dorsal digital expansion, while the intermediate phalanx of the left index finger undergoes stress that affects both the flexor digitorum profundus and the dorsal digital expansion. Swollen, rigid knuckles impede full finger flexion, further increasing strain during the grip. Likewise, the intermediate phalanx of the left middle finger is strained, involving the same tendons. When the user rotates the lid, the wrist endures added stress—particularly on the extensor digitorum tendon. The raised base of the thumb is forced downward, straining the flexor carpi ulnaris tendon due to knuckle stiffness. Finally, pressing the thumb against the jar's lock to release it imposes further load on the first dorsal interosseous muscle and its tendon. The strain extends to the second knuckle, which remains in an extended position during this action, placing additional stress on the extensor pollicis longus and extensor pollicis brevis tendons. The first knuckle of the right hand also experiences strain, particularly in the flexor pollicis longus. Repeated actions—such as applying pressure to the pill-jar lock—exhaust the thumb muscles and tendons [14], notably the flexor digitorum profundus and the dorsal digital expansion. Over time, this repetitive effort leads to fatigue and discomfort, especially when users must open multiple pill jars throughout the day as part of their prescribed medication regimens. The left hand faces similar strain. The base of the left thumb, pressed against the lid to maintain grip during opening and closing, is subjected to stress, as is the abductor pollicis muscle, which controls thumb movement. While the left-hand fingers grip the lid, the bases of those fingers remain flexed, straining the extensor digitorum tendon. Additionally, engaging the fingertips in gripping the lid places strain on the dorsal digital expansion, particularly at the first knuckle of the left middle finger. Swollen, stiff knuckles prevent full finger curling, further increasing stress on the dorsal digital expansion in both the index and middle fingers of the right hand. Overall, repetitive pill-jar opening imposes a significant physical toll on the hands—especially for individuals with arthritis or other conditions affecting joint flexibility—and leads to discomfort and fatigue with frequent use.

### 2.4. RULA Assessment of the Hand Posture in Opening the Existing Pill Jars

The RULA method was developed by McAtamney and Corlett [15] as a survey tool for assessing posture-related risks of upper limb disorders in the workplace. Analysis of Stress Based on the RULA Worksheet (**Figure 4**) helps uncover the following. The Wrist Score in **Figure 4**. This indicates that the wrist posture, combined with wrist twist, muscle use, and force/load, results in a moderate risk. The overall score from Step 8, which combines upper arm and lower arm with adjustments, leads to a Wrist and Arm Score of 4. This suggests that the arm's position and usage contribute to the overall stress on the upper limb. The Neck Score from Step 9 and its adjustments is 3. This points to some degree of neck strain, likely due to the observed neck posture (flexion). The Trunk Score from Step 10, with adjustments, is also 3. This indicates that the trunk posture (likely flexion or twisting) is placing stress on the back. The Leg Score is 1, suggesting that the legs are relatively well-supported and not a primary source of stress in this assessment. Combined Effect: **Figure 4** combines the Wrist and Arm Score [4] with the Neck, Trunk, and Leg Score [5] to produce a Final Score of 5. The final score of 5 indicates that "further investigation, change soon" is needed. The assessment highlights that the primary areas of concern are the wrist and arm, and the neck and trunk. The postures and forces involved in the task place a moderate level of stress on these regions, which could lead to musculoskeletal disorders if not addressed. While the legs are not currently a major concern, it's important to consider that prolonged awkward postures in the upper body can sometimes be related to or exacerbated by inadequate leg support [16].

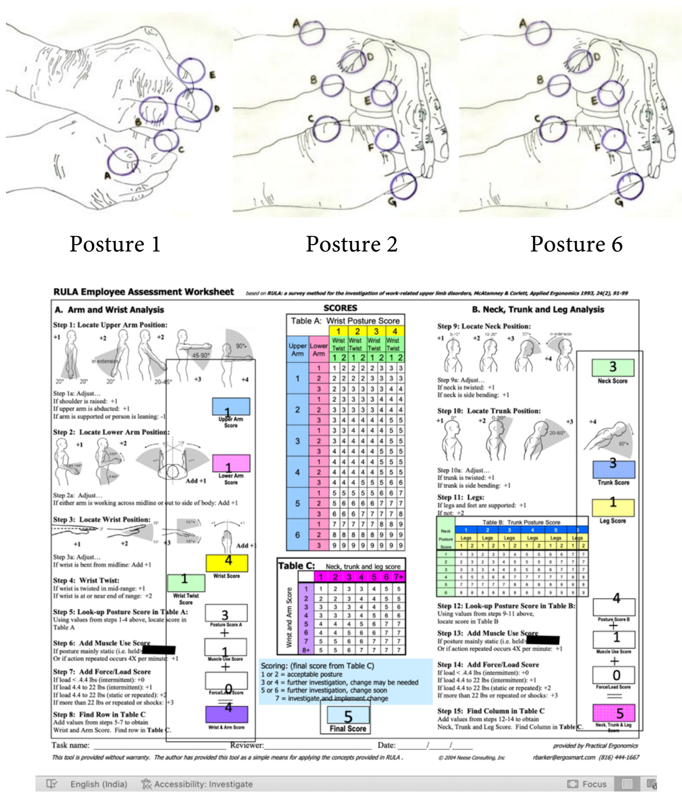



**Figure 4.** Rapid upper limb assessment of posture 1, 2 and 6 (Appendix A) while opening the pill jar1 and 2 designs.

The wrist twist score for postures 1, 2, and 6 is 1, while for postures 3, 4, and 5 it is 2 (**Figure 5**). Consequently, the combined Arm and Wrist scores are 4 for postures 1, 2, and 6, and 5 for postures 3, 4, and 5.

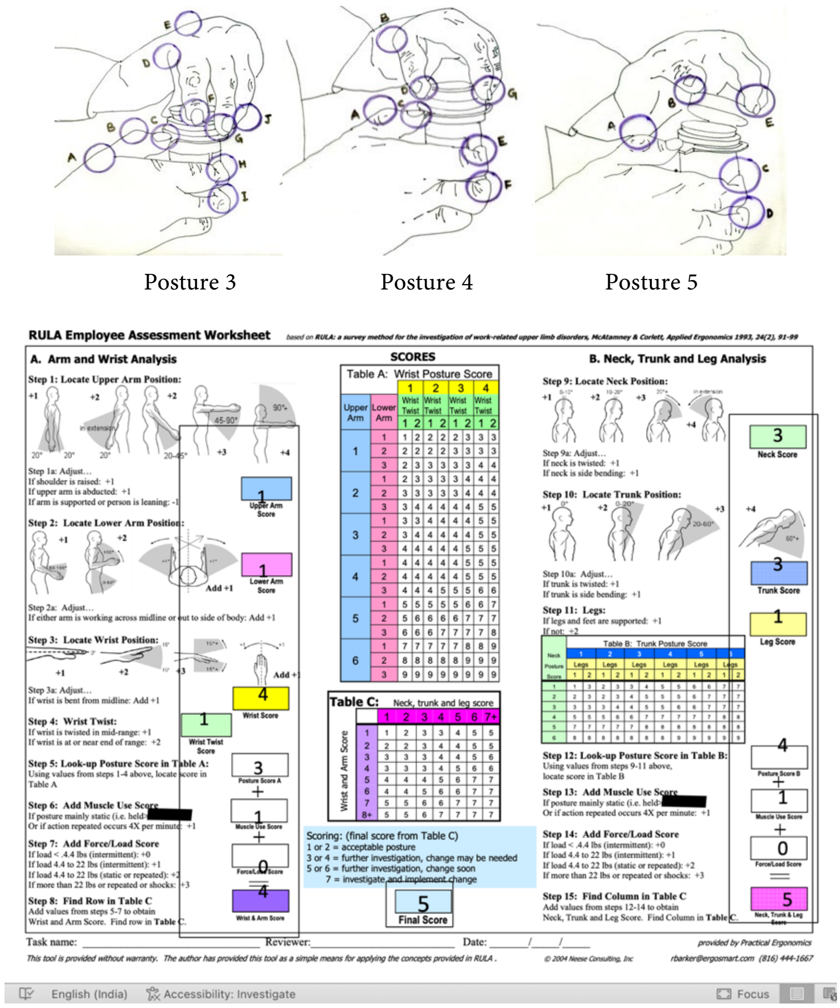



**Figure 5.** Rapid upper limb assessment of posture 3, 4 and 5 (Appendix B) while opening the pill jar1 and 2 designs.

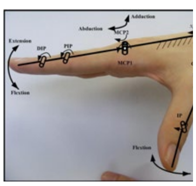
Meanwhile, the scores for Neck, Trunk, and Legs remain consistent at 5 across all postures. The resulting RULA scores for postures 1 through 6 are presented in **Table 1**.

**Table 1.** RULA scores of postures.

| Posture | RULA score |
|---|---|
| 1 | 5 |
| 2 | 5 |
| 3 | 6 |
| 4 | 6 |
| 5 | 6 |
| 6 | 5 |

To develop ergonomically designed pill jars that accommodate natural finger movements, one can identify optimal ranges of motion using data from Lee [17], which draws upon values from previous studies [18]-[24]. These studies employed diverse methods and participant groups: some measured volunteers in hospital settings [18]. Hume *et al.* [21] compared the range of motion of the thumb and fingers in young, healthy participants with that of older adults (aged 55 and above) suffering from osteoarthritis; while others used fresh-frozen cadavers [23]. However, details on gender proportions, age ranges, or hand laterality are not specified. By identifying mean values for each finger joint across these studies, we can calculate an optimal range of motion. **Table 2** presents the analysis for each finger joint.

**Table 2.** Range of motion of the fingers and thumb.

| | CMC | MCP | IP | PIP | DIP |
|---|---|---|---|---|---|
| Thumb, Mean (standard deviation) | 49˚ (range: 45 - 52.9˚), 49 (6) | 61˚ (range: 50 - 77˚), 61 (14) | 81˚ (range: 80 - 81˚), 81 (1) | | |
| Index finger, Mean (standard deviation) | | 80˚ (range: 62 - 97˚), 80 (13) | | 104˚ (range: 100 - 104), 104 (5) | 68˚ (range: 57- 80˚), 68 (11) |
| Middle finger, Mean (standard deviation) | | 85˚ (range: 64 - 100˚), 85 (15) | | 104˚ (range: 100 - 110˚), 107 (6) | 68˚ (range: 57 - 80˚), 70 (12) |
| Ring finger, Mean (standard deviation) | | 87˚ (range: 67 - 107˚), 87 (16) | | 107˚ (range: 103 - 114˚), 107 (3) | 70˚ (range: 57 - 80˚), 66 (9) |
| Little finger, Mean (standard deviation) | | 87˚ (range: 67- 107˚), 86 (17) | | 104˚ (range: 99 - 111˚), 104 (6) | 69˚ (range: 58 - 78 ˚), 69 (10) |
| Optimal range of motion | 45 - 52.9˚ (Thumb) | 62 - 107˚ (Across all fingers) | | 99 - 114˚ (Across all fingers) | 57 - 80˚ (Across all fingers) |
|  **Source:** Zheng & Li, (2010). | CMC: Carpometacarpal joint (the joint at the base of the thumb).<br>MCP: Metacarpophalangeal joint (the joint between the hand and fingers).<br>IP: Interphalangeal joint (the joint in the fingers, specifically in the thumb, between the two bones).<br>PIP: Proximal interphalangeal joint (the first joint in the fingers, between the first and second bones).<br>DIP: Distal interphalangeal joint (the joint between the second and third bones in the fingers). | | | | |

## 2.5. Application to Design

The range of motion (ROM) data was measured in older adults performing various activities, including both static hand movements and activities of daily living (ADLs) [25], such as walking, bathing, eating, dressing, toileting, and transferring from seating and vehicles. These ROM requirements are similar to those needed for tasks like opening pill jars.

- Pill jar opening: The range of motion in MCP, PIP, and DIP joints (**Table 2**) is important in determining how a user grips and twists the lid of a pill jar. Ensuring the lid diameter and texture are designed to facilitate these movements with minimal strain is key.
- Grip size: The size of the pill jar should be adjusted to the optimal grip angles, keeping in mind the 85˚ range of motion for the middle finger MCP and the 104˚ range of motion for the PIP joints.
- Ease of access: Given the thumb's relatively larger range of motion (49˚ at CMC), the design should allow the thumb and index finger to engage with the jar opening without excess force.
- These ranges suggest the physical dimensions of the pill jar, ensuring it fits comfortably within the natural grasping limits of the human hand.

### 2.6. Design Parameters for Improved Pill Jars for the Elderly

To enhance the accessibility and usability of pill jars for individuals with limited hand strength and dexterity, future designs should prioritize the following key parameters. i) ***Opening Mechanisms***: Effortless and intuitive opening mechanisms are crucial. Traditional screw-top lids should be replaced with options requiring minimal force and single-handed operation. This could include push buttons, levers, sliders, magnetic closures, or spring-loaded lids. Clear visual and tactile cues should guide users on how to operate the chosen mechanism. ii) ***Lid and Jar Design***: The lid and jar should be optimized for secure grip and stability. A larger lid diameter with an ergonomic shape and textured surface can improve grip, especially for users with limited dexterity. A wide, stable base will prevent accidental tipping during opening and closing. ***iii) Pill Access and Retrieval***: Easy access to the pills is essential. A wide mouth opening allows for easier retrieval, and internal organization with compartments or trays can help separate medications. Specialized tools like small scoops or tweezers can further assist users with limited dexterity in picking up individual pills. ***iv) Materials and Texture***: The choice of materials is crucial for both functionality and comfort. Non-slip materials on the jar and lid prevent slippage during use. Soft-touch surfaces provide a comfortable grip and reduce pressure on sensitive joints. The jar should be made from durable materials to withstand repeated use and accidental drops. ***v) Visual and Cognitive Aids***: Clear labeling with large, high-contrast text is essential for medication names and dosage instructions. Color-coding can differentiate medications or times of day. Tactile markings or Braille can aid visually impaired users. Additionally, incorporating technology like reminders or dosage tracking can further enhance user experience and medication adherence. ***vi) Additional Considerations***: Child-resistant features should be considered for households with children. The design should be compact and lightweight for portability. Sustainable and recyclable materials should be prioritized [8]. Finally, an aesthetically pleasing design can encourage use and improve user experience.

### 2.7. Exploration of Mock-Ups

With the knowledge about the deterioration in the push strength, pinch and grip strength of the elderly, form exploration was carried out to understand the optimal hand posture. The following Table 3 depicts the mock-ups of the three ideas.

Table 3. Difference in the operations of the three ideas.

| |  a |  b |  c |
|---|---|---|---|
| | The design features a smoothly contoured structure optimized for one-handed use. Its rounded shape provides a stable resting surface for the palm, allowing the finger s and thumb to be comfortably positioned. This eliminates the need for pinch or grip force, enhancing overall ease of use | The design accommodates both one-handed and two-handed operation. By shaking the container, the pill moves into the lower chamber, which can be easily accessed using a push-button mechanism similar to those found in kitchen cabinets. This ensures convenient and effortless use | The design features a pill jar with a textured top, allowing for one-handed operation. By applying downward pressure, the user can effortlessly dispense a pill |
| Push force | Required | None | Required |
| Grip force | None | Required | None |
| Pinch force | None | None | None |

The assistive devices presented in the image offer several key improvements over traditional pill containers by prioritizing user-centered design to address ergonomic shortcomings. Notably, devices a and c minimize or eliminate the need for pinch force, relying instead on pushing actions that engage larger, stronger muscles in the hand and palm, thereby reducing stress on the fingers. Device a further aims to eliminate grip force by relying solely on a pushing motion, while device b, although requiring grip force for shaking, simplifies dispensing with a push-button mechanism, potentially reducing the sustained grip and twisting of traditional lids. Overall, the designs simplify movements, as pushing or shaking and pushing can be easier for those with motor impairments compared to the precise coordination of twisting and pushing child-resistant caps require. Ergonomic considerations are evident in device a's contoured shape for comfortable palm support, device b's push-button mechanism inspired by easy-to-use kitchen cabinet designs, and device c's textured top to enhance grip during pushing. In summary, these innovations aim to decrease the risk of fatigue and strain, improve ease of use for individuals with limitations, and promote better adherence to medication regimens. Options a and c streamline operation to a single push, making them more intuitive and requiring less fine motor skill compared to traditional child-safe lids. This simplicity is particularly advantageous for users with cognitive or motor impairments. Due to the benefits offered by option c, a mock-up of this design was chosen for a RULA assessment to evaluate the advantages of the improved design.

## 2.8. RULA Assessment of the Hand Posture in Opening New Pill Jars

The following **Figure 6** illustrates the areas where improvements are observed in opening pill jars with new mechanism. The Upper Arm and Lower Arm positions yielded a combined score of 2, indicating a neutral to slightly raised arm posture, with no significant deviation or support dependency. The Wrist posture was found to be in a neutral position, with minimal twist, resulting in a wrist score of 0—suggesting no immediate risk from wrist movement or position during the task.

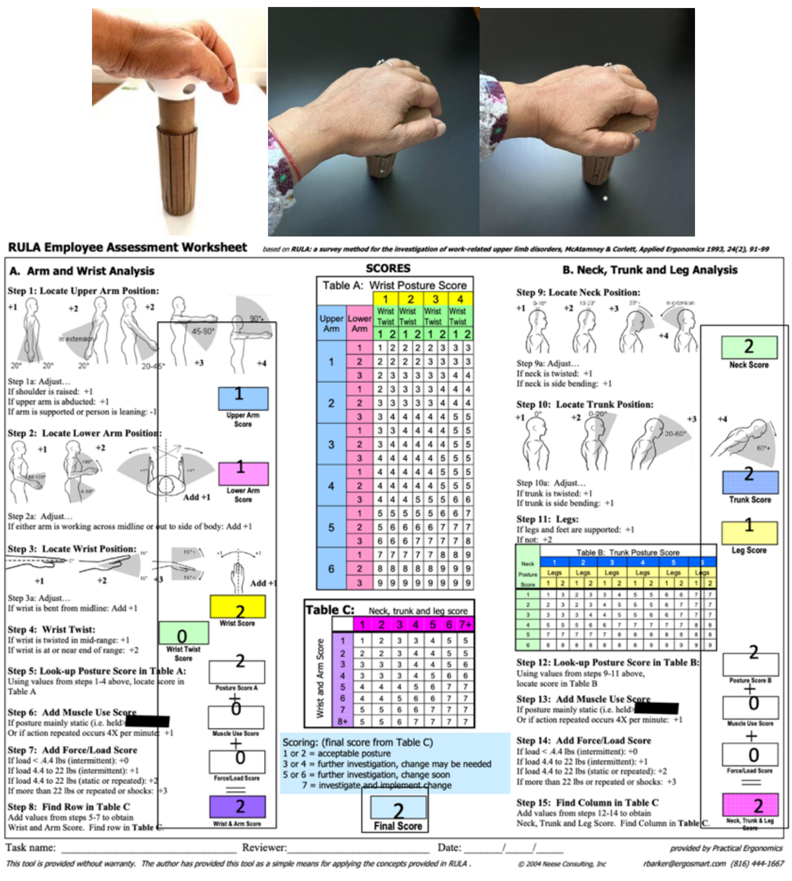



**Figure 6.** Rapid upper limb assessment while opening the improved pill jar design.

The Neck and Trunk positions scored 2 each, which reflects slight bending or forward inclination, common during close-hand tasks such as gripping and twisting. His leg Score was marked as 1, as the task was likely performed in a seated or stable standing position. Both Muscle Use and Force/Load scores were 0, indicating that the task involved neither static or repetitive exertion nor significant force application beyond routine effort. Final RULA Score: 2 This score falls within the "acceptable posture" category, meaning the physical demands of opening the new pill jars do not pose any immediate musculoskeletal risk. The design appears to support ergonomically sound movement, allowing the task to be performed without undue strain. While no immediate changes are required, continued user testing across varied demographics (e.g., elderly users, individuals with reduced grip strength) is recommended to ensure universal accessibility and ease of use.

## 3. Result

The improved design resulted in a notable reduction in RULA scores, with values ranging from 3 to 4. Participants showed more neutral wrist, elbow, and shoulder postures, with reduced muscle loading. This suggests that the new design significantly lowered the risk of musculoskeletal strain and may be considered acceptable without immediate intervention. Overall, the improved pill jar design demonstrated a marked ergonomic benefit, reducing upper limb stress and improving task comfort and safety compared to traditional pill jar designs. The findings of this study demonstrate that both null hypotheses are false, confirming the critical role of ergonomic design in pill jar usability for older adults. Hypothesis A is supported, as older adults indeed experience high RULA (Rapid Upper Limb Assessment) scores when opening standard pill jars, reflecting a heightened risk of musculoskeletal discomfort or injury. This risk is especially pronounced among individuals with pre-existing conditions such as arthritis. Similarly, Hypothesis B is validated, showing that ergonomically redesigned pill jars—engineered to require lower torque, grip strength, and compression force—are associated with significantly reduced RULA scores. This indicates enhanced biomechanical efficiency and substantially decreased physical strain during use. These results underline the importance of user-centered design approaches in addressing the physical limitations experienced by aging populations. The study reinforces the urgent need for thoughtful innovations in container designs that accommodate variations in grip strength, wrist-twisting ability, and gender-related differences to create truly accessible and user-friendly packaging solutions [26].

## 4. Discussion

Administering oral medication presents significant difficulties for elderly individuals. Age-related conditions like rheumatoid arthritis and osteoarthritis make everyday tasks tedious, as does opening pill containers. Pill organisers, while intended to help, have not proven as effective as hoped [8], and many users discontinue their use for various reasons. Furthermore, the limited capacity of these organisers often cannot accommodate the multiple prescriptions many elderly individuals require, and some medications must be shielded from light. Light exposure can degrade certain medications, reducing their effectiveness and, in some cases, forming harmful by-products. Elderly patients may lose interest and become reluctant to consistently take their prescribed medications. Some older couples adopt makeshift arrangements [27], grouping their prescription pill jars and placing them in different locations around the house to align with their daily routines. This method relies on mutual reminders and encouragement to ensure they take their medications on time. The demanding and tedious routine of self-medication can contribute to a decline in their health, often leading to physiological distress in the forearm and fingers. Further research is needed to collect quantitative data on the loss of power-grip strength when holding pill jars repeatedly for an extended time, the key-pinch strength required to press protruding locks, and the pinch strength needed to lift lids multiple times over a prolonged duration. Another area of study is evaluating how factors such as age, dexterity, and health conditions affect the time required to open pill jars. Grip strength is related to haemoglobin and alkaline phosphatase levels [28], which decline with age. Medications such as antibiotics and certain health conditions can influence alkaline phosphatase levels in the body, and these levels may fluctuate throughout the day [29]. Many people notice variations in their grip strength, finding it easier to hold objects in the afternoon. Factors like diet, hydration, and overall health contribute to these changes. As a result, elderly individuals may experience differences in their ability to grip objects, such as pill jars, at different times of the day. The study highlighted that among the various parts of the hand, older people experience higher strain in the thumb, knuckles, and fingers. The thumb, particularly at the base and tip, is under strain due to gripping and twisting actions on the pill jar lid. The flexor pollicis longus, abductor pollicis, and extensor pollicis muscles, as well as tendons such as the flexor carpi ulnaris, are involved in this strain. The knuckles, especially when swollen and stiff, experience significant strain due to limited finger curling. This affects muscles such as the flexor digitorum profundus and the dorsal digital expansion in the fingers. The index and middle fingers experience strain at the knuckles and fingertips because of repetitive gripping actions and the pressure applied to the lid. This leads to stress on the extensor digitorum and flexor digitorum profundus tendons, as well as the dorsal digital expansion.

Overall, the thumb, knuckles, and fingers—especially the index and middle fingers—are the primary areas of strain in the described activity. A future longitudinal study investigating changes in the difficulty of opening pill jars could reveal additional challenges and inform the design of a better pill-retrieval experience that accommodates users' varying needs throughout the day. Assessing the psychological effects of this arduous process may also offer valuable insights into why health improvements sometimes lag despite appropriate treatments and prescriptions. Therefore, the mock-ups should be developed into prototypes for testing by elderly users. Their feedback, combined with motion analysis, will provide essential data to further refine and enhance the system or product for oral medicine administration.

## 5. Conclusion

To address the challenges faced by users with limited hand strength and dexterity, pill jar design should prioritize reducing the force required for opening. This can be achieved by incorporating mechanisms that minimize excessive force—such as levers, push-buttons, or sliding closures—while also reducing twisting motions that strain the wrist and thumb. Additionally, enhancing grip surfaces and reducing pinching requirements is crucial. For users with arthritis, larger, easier-to-grasp lid edges, soft and cushioned materials, and the avoidance of small, intricate mechanisms can significantly improve usability. Ergonomic considerations should include designing jars with comfortable shapes and sizes that are easy to handle and do not require precision-based movements. Incorporating handles or grips that demand minimal flexion can further reduce strain. Simplifying opening mechanisms by exploring alternatives to traditional twist-off caps—such as snap-on lids, sliding mechanisms, or push-button releases—can enhance accessibility without relying on gripping and pinching actions. Optimizing surface textures and materials to improve friction can also help lower the required force, thereby improving the overall medication administration experience. By incorporating these design considerations, pill jars can become more accessible and user-friendly, particularly for elderly individuals and those with limited hand and finger strength. This research would provide valuable data for pharmacies and manufacturers to evaluate the accessibility of their current pill jar designs and make improvements to better serve their older customers.

## Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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## Appendix A

Grip force, pinch forces (index finger, middle finger, ring finger and little finger) and the wrist turning torque of 65 and 85 older male and female adults respectively curated from the study conducted by Nayak and Queiroga, 2004.

Grip, pinch strength and torque (wrist twisting) strength of older people (males) aged between 55 - 85 years.

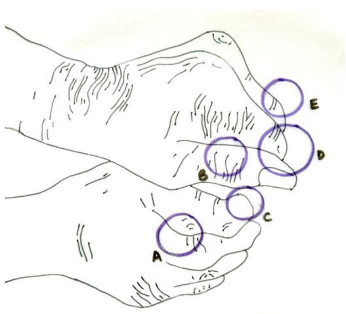
| Variable | Mean | SD | 5th %ile | 50th %ile | 95th %ile |
|---|---|---|---|---|---|
| Age (years) | 73.14 | 6.62 | 62.30 | 73.00 | 82.00 |
| Weight (kg) | 79.64 | 12.37 | 61.90 | 77.00 | 102.61 |
| Height (m) | 1.74 | 0.075 | 1.62 | 1.72 | 1.87 |
| BMI ($kg/m^2$) | 26.29 | 3.26 | 21.30 | 26.10 | 33.07 |
| Key grip (N) | 94.40 | 19.66 | 63.76 | 98.10 | 130.96 |
| Pinch II (N) | 60.97 | 16.70 | 39.24 | 58.86 | 96.63 |
| Pinch III (N) | 54.26 | 14.70 | 34.34 | 53.95 | 85.35 |
| Pinch IV (N) | 35.77 | 12.00 | 19.62 | 34.33 | 57.39 |
| Pinch V (N) | 23.17 | 8.60 | 14.71 | 24.52 | 34.34 |
| Torque (Nm) | 3.68 | 0.92 | 1.94 | 3.79 | 5.07 |

Grip, pinch strength and torque (wrist twisting) strength of older people (females) aged between 55 - 85 years.

| Variable | Mean | SD | 5th %ile | 50th %ile | 95th %ile |
|---|---|---|---|---|---|
| Age (years) | 70.18 | 8.00 | 58.3 | 68.0 | 83.0 |
| Weight (kg) | 67.47 | 10.83 | 53.3 | 67.2 | 92.85 |
| Height (m) | 1.59 | 0.066 | 1.49 | 1.59 | 1.72 |
| BMI ($kg/m^2$) | 26.47 | 3.61 | 20.45 | 26.29 | 33.04 |
| Key grip (N) | 62.67 | 13.12 | 44.15 | 63.76 | 88.29 |
| Pinch II (N) | 40.39 | 10.12 | 24.53 | 39.24 | 58.86 |
| Pinch III (N) | 37.28 | 9.34 | 24.52 | 34.33 | 53.95 |
| Pinch IV (N) | 24.53 | 7.86 | 14.7 | 24.52 | 42.67 |
| Pinch V (N) | 15.55 | 5.30 | 9.8 | 14.71 | 24.5 |
| Torque (Nm) | 2.37 | 0.79 | 1.32 | 2.20 | 3.8 |

## Appendix B

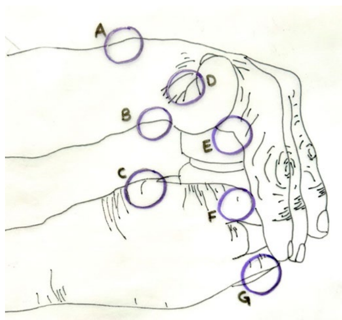
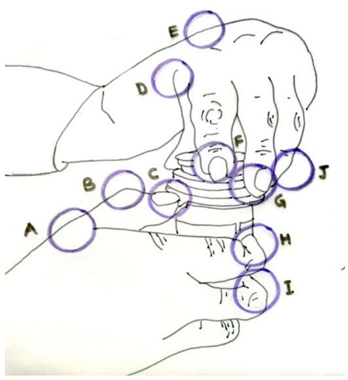
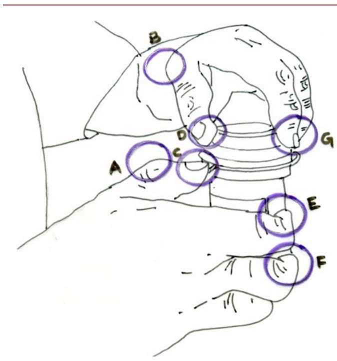
Posture analysis of the muscles and ligaments in the hand experiencing strain.



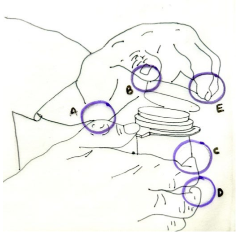
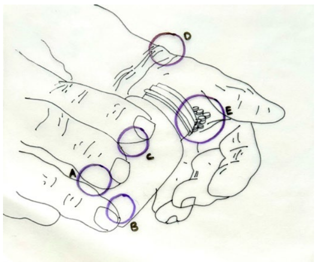
Posture 1.

| | |
|---|---|
| A | flexor digitorum superficialis under strain<br>First dorsal interosseous muscle under strain |
| B | flexor digitorum superficialis under strain<br>extensor pollicis brevis tendon under strain |
| C | Dorsal digital expansion |
| D | flexor digitorum profundus under strain<br>Dorsal digital expansion |
| E | flexor digitorum profundus under strain<br>Dorsal digital expansion |

**Continued**

| | | |
|---|---|---|
|  Posture 2. | A | extensor digitorum tendon under strain<br>extensor pollicis brevis tendon under strain |
| | B | Flexor carpi ulnaris tendon under strain |
| | C | First dorsal interosseous tendon under strain<br>First dorsal interosseous muscle under strain<br>extensor pollicis brevis tendon under strain |
| | D | flexor digitorum profundus under strain<br>First dorsal interosseous muscle under strain |
| | E | lumbrical muscle under stress |
| | F | flexor digitorum profundus under strain<br>Dorsal digital expansion |
| | G | flexor digitorum profundus under strain<br>Dorsal digital expansion |
|  Posture 3. | A | First dorsal interosseous tendon under strain<br>First dorsal interosseous muscle under strain<br>extensor policis longus under strain<br>extensor pollicis brevis tendon under strain |
| | B | Flexor pollicis longus under strain |
| | C | flexor digitorum profundus under strain,<br>Dorsal digital expansion |
| | D | Abductor pollicis muscle under strain |
| | E | extensor digitorum tendon under strain |
| | F | Dorsal digital expansion |
| | G | Dorsal digital expansion |
| | H | flexor digitorum profundus under strain<br>Dorsal digital expansion |
| | I | flexor digitorum profundus under strain<br>Dorsal digital expansion |
|  Posture 4. | A | Flexor pollicis longus under strain |
| | B | First dorsal interosseous tendon under strain<br>Flexor pollicis longus under strain<br>extensor policis longus under strain |
| | C | flexor digitorum profundus under strain<br>Dorsal digital expansion |
| | D | Dorsal digital expansion |
| | E | flexor digitorum profundus under strain |
| | F | flexor digitorum profundus under strain |
| | G | flexor digitorum profundus under strain<br>Dorsal digital expansion |

**Continued**

| | | |
|---|---|---|
|  | A | flexor digitorum profundus under strain<br>Flexor pollicis longus under strain |
| | B | Dorsal digital expansion |
| | C | flexor digitorum profundus under strain |
| | D | flexor digitorum profundus under strain |
| Posture 5. | E | flexor digitorum profundus under strain<br>Dorsal digital expansion |
|  | A | flexor digitorum profundus under strain |
| | B | flexor digitorum profundus under strain |
| | C | flexor digitorum profundus under strain |
| | D | extensor policis longus under strain<br>Flexor pollicis longus under strain |
| Posture 6. | E | Bunch of pills come out, out which the user puts back all leaving one for administration. |