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The Relationship Between Hand Strength and the Forces Used to Access Containers by Elderly
Women with Arthritis

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May 2013

This scholarly project reflects individualized, original research conducted in partial fulfillment of the requirements for the Occupational Therapy Doctorate Program, The University of Toledo

Abstract

This study is an extension of previous work of Rice, Leonard, and Carter (1998) and Rahman, Thomas, and Rice (2002). It examined the relationship between grip and pinch strengths and the forces exerted while accessing common containers in older adult women with arthritis. Fifty-eight women 55 years of age and older were recruited from local senior centers and were assigned randomly to orders of tasks using a counterbalanced, repeated-measures design. Grip strength and pinch strength were measured via dynamometer and pinch meter. Force sensing resistors were applied to six common household containers. Data analysis included Spearman rho's correlation coefficient between the sensor forces and the pinch and grip strength measurements. A moderate relationship was found between grip and pinch strength and the amount of force exerted to open three containers. Negligible to low relationships were found between grip and pinch strength and the ability to open the remaining two containers. No order effects were found. Strong relationships did not exist between the grip and pinch strength and the amount of force the older adult women with arthritis exerted to open the containers, which is similar to the previous studies. The participants appeared to use a greater proportion of their available strength when accessing the containers than did the healthy older adult women in Rahman et al. (2002) and the younger persons previously studied. Further research is needed to explore the strength necessary to open or operate other common containers used for occupations of daily living.

The Relationship between Hand Strength and the Forces Used to Access Containers by Elderly Women with Arthritis

Arthritis is a common disease that affects one's hand function. Our daily occupations such as self-care, work, and leisure interests rely heavily on the ability to use one's hands. Grip strength is an important component for occupational therapists in gathering information about general hand function. There has been minimal research conducted regarding functional clinical testing of hand strength with grip and pinch meters applied to occupations of daily living such as opening containers. Previous research examined grip strength and force required to open common containers in healthy populations. This research will investigate the hand forces needed to open common containers in elderly women who have arthritis.

Aging and Limitations of Hand Function

In the next couple of decades the number of older adults will dramatically increase. *Morbidity and Mortality Weekly Report* (2003) estimated that the population of the aged 65 years and older will increase from approximately 35 million in 2000, to an estimated 71 million in 2030.

Arthritis affects many adults as they age and some of the most common symptoms individuals experience include pain, aching, stiffness and swelling in and around the joints (Center for Disease Control, 2011). According to the Center for Disease Control (2011), over 21 million U.S. adults report activity limitations because of arthritis. Occupational therapists must understand the aging population and limitations and challenges older adults may face. Grabiner and Enoka (1995) reported that a 15% loss in strength per decade occurs in 50-70 year old individuals. Hand function is essential for one to be independent in performing a wide variety of

daily occupations ranging from dressing and eating, to making a living and carrying out one's leisure interests.

Occupational Therapists and Grip Strength

Dellhag and Bjelle (1999) describe hand function as the ability to use the hands to perform daily activities. Occupational therapists take baseline hand grip and pinch strength measurements as part of the evaluation of hand function (Mathiowetz, Weber, Volland, & Kashman, 1984). Therapists use dynamometers and pinch meters to measure patients' hand strength. Strength measures combined with dexterity evaluations provide a picture of hand function for the therapist (McPhee, 1987). Although these measurements can be obtained as a baseline, it is hard to determine the patient's level of function without observing the person perform a wide variety of functional daily tasks. Agnew and Maas (1982) stated that an evaluation of a person's performance in activities of daily living provides more useful information about the person's abilities than does grip strength alone. However, due to time constraints in the clinic, assessing each individual occupation of daily living and evaluating patients' performance level wouldn't be realistic. Many occupational therapists use a combination of strength tests, self-report questionnaires and a sampling of occupations of daily living to assess functional ability for occupations of daily living. Self-report questionnaires are typically completed by the patient and reviewed with the occupational therapist. "The ability to grip and manipulate an object may be the most important function of the hand, and any deterioration in this ability can lead to impaired ability to perform activities of daily living" (Ranganathan et al., 2001). Little research guides occupational therapists with regard to the amount of forces needed to accomplish a broad range of daily living occupations.

Occupations of Daily Living and Grip Strength

A person's ability to use his or her hands effectively in daily tasks depends on anatomical integrity, mobility, muscle strength, sensation, coordination, and motivation (McPhee, 1987). Grip and pinch strength are important factors for accessing common containers used for occupations of daily living. Nalebuff and Philips (1990) stated that grip strength of at least 20 pounds and pinch strengths of five to seven pounds are required to perform most occupations of daily living. However, they did not specify the basis for these guidelines. Due to the progression of arthritis and the associated symptoms, individuals will experience a deterioration of the anatomical structures of the hand. This alteration will affect their performance in their daily occupations. Previous research examined hand function by focusing on grip strength and pinch strength. While some strictly researched hand strength related to prehension patterns, others expanded the research and studied more functional occupations related to hand strength such as opening containers.

Grip Force and Opening Containers

Shiffman (1992) studied strength and prehension patterns in adults of differing ages and found that as age increased, hand strength decreased for all prehension patterns and performance time increased. However, there were limitations in this study such as small sample size.

Keram and Williams (1998) compared the amount of time persons 60 years of age and older used to open fifteen different types of medication containers. Participants could open all the non-child-resistant containers but not all of the child-resistant containers. Differences in their ability to open the non-child-resistant containers versus all the child-resistant containers were reflected in the amount of time required opening the containers, the proportion of participants able to open each container, and participants' own ratings of the ease of use of various

containers. The speed at which an individual can open containers may be important in some cases; however speed in opening containers is often not an important factor for independence. Therefore our research will focus on the force needed to open containers independent of speed.

Two studies have compared grip and pinch strength and performance on a specific daily living occupation (Rice, Leonard, & Carter, 1998; Rahman, Thomas, & Rice, 2002). Rice, Leonard, and Carter (1998) investigated younger adults grip strength and the amount of force used to access a sample of household containers. Both studies used the same six containers which consisted of small prescription bottle, dual pinch bottle, pop-off bottle, large prescription bottle, trigger pump spray, and aerosol spray. They found little to no relationship between the total amount of grip strength participants possessed and the amount of force they used to access the household containers. The participants lowest grip strength performance was 40 pounds and the lowest pinch strength performance was six pounds. Researchers found that the lowest force recorded was the trigger pump spray bottle at 2.31 pounds. The maximum force recorded by the sensors ranged from 25.38 pounds on the bottle with the pop-off lid to 48.59 pounds on the aerosol spray can. However, the mean forces for all the containers were below 20 pounds. Therefore, the researchers concluded that an amount of 20 pounds of grip strength would be sufficient in opening all the containers tested. Individuals with arthritis may have difficulty reaching the 20 pounds of grip strength without experiencing pain.

An extension of Rice et al. (1998) study was completed by Rahman, Thomas, and Rice (2002). Rice et al. (1998) participants were young healthy adults and Rahman et al. (2002) had older adults and they examined the relationship between grip and pinch strengths and forces used to access common household containers. Rahman et al. (2002) predicted that no relationship would be found between the grip and pinch strengths and forces exerted to operate or open

common containers in the healthy, elderly population. Their results indicated that four of the six containers showed low to no relationship between grip strength and the forces used to open the containers and a moderate relationship between grip strength and the forces used to access the large prescription bottle and the aerosol spray can. Three of the six containers had low to no relationship between pinch strength and the forces used to access the containers. The results found that elderly persons tend to use more force to access the containers than the younger adults studied in Rice et al. (1998). The younger female adults in Rice's study averaged 75 pounds of grip strength and an average of 15-17 pounds for all pinch measurements compared to Rahman et al. (2002) older female adults grip strength average of 51.92 pounds and pinch averages ranging from 9-13 pounds for all pinch measurements. However, the older women's overall amounts of grip and pinch strengths were less than the younger adults in the Rice et al. (1998) study. This suggests that more of the available force in older individuals is used to access containers. Patients with impaired hand strength would require a higher proportion of their maximum strength to open common containers.

The next step in this line of research would be to examine the grip strength and forces used by elderly women with arthritis to open common containers. This study is an extension of the two previous studies (Rice et al. 1998 and Rahman et al. 2002). The purpose of this study is to examine the relationship between grip, lateral pinch, tip-to-tip pinch and three jaw chuck pinch performance and the force produced to open common household containers in elderly women with arthritis. Another purpose is to describe the amount of force women with arthritis use to open and/or operate common containers. The results from this study will help provide occupational therapists guidelines to follow when working with women with arthritis. The amount of force required to open common containers can be used as a goal in therapy for the

client to work towards. The following primary null hypothesis is based on previous research (Rice et al., 1998 and Rahman et al., 2002); no relationship will be found between strength measurements and forces used to access common containers.

Methods

Participants

Females over the age of 55 were recruited for the study. These individuals had a diagnosis of arthritis affecting the hands and/or wrists. All participants were English speaking. Participants had no other orthopedic or neuromuscular conditions affecting their upper extremities that would compromise their performances. They were recruited from local northwest Ohio arthritis support groups, The University of Toledo Center for Successful Aging, and local Toledo, OH senior centers after permission was obtained from the facilities. Participants were recruited by flyers and word of mouth. To describe our sample, we recorded demographic information from participants including age, hand dominance, and ethnicity.

Instruments

A standard Baseline© Digital Dynamometer was used to collect baseline grip strengths among participants. A standard Baseline© Digital Pinch Dynamometer was used to determine baseline pinch strength in participants. Both the grip and pinch dynamometers were calibrated prior to obtaining measurements. Six common household containers were used in the study and are shown in Figure 1, the containers include:

1. Dual-pinch safety squeeze bottle.
2. Small prescription medicine bottle that required pushing down on a tab with thumb and twisting the cap or lid.

3. Large prescription medicine bottle that required pushing down on a tab with thumb and twisting the cap or lid.
4. Over-the-counter medicine bottle that requires an alignment and pop-off motion for the lid.
5. Aerosol can of air freshener that typically requires a single-handed operation (power grip combined with depression of a button by thumb or index finger).
6. Trigger pump spray bottle that typically requires a single-handed operation (power grip with one or more fingers used for the depression of the trigger).

Force sensing resistors (FSRs) were affixed to each container to record the amount of force exerted while opening them. These FSRs were placed on areas where force is used to open containers. The FSRs were calibrated and placed on containers before data were obtained in the study. Data obtained by FSRs were interfaced with a custom computer data collection program.

Design

A counterbalanced, repeated-measures design was used for this study. Participants were randomly assigned to an order in a counterbalanced design to measure the force utilized to open and operate six different types of household containers. This study was part of a larger study that also investigated the effect of a wrist orthosis versus the free hand on the force used to open and operate the containers. This study focused on the performance of the free (non-splinted) condition. Each person was assigned an order and opened and operated each of the six containers three times. The grip and pinch strengths measurements were counterbalanced and recorded after the participants opened the containers. Each participant experienced the following grip and pinch strength conditions: power grasp, tip-to-tip pinch, lateral pinch, and the three-jaw chuck pinch.

Procedure

The University of Toledo Institutional Review Board approval was obtained before the study began. The researcher obtained both written and verbally expressed informed consent from subjects prior to participating in research. The researcher obtained demographic information after informed consent which included hand dominance, ethnicity, and history of splint use.

Patients sat with their feet flat on the floor in a chair that was 18-20" from the floor and approximately one foot away from a 32" high table upon which the containers were placed. Each container was numbered. The participant received the following verbal instructions: "I want you to pick up the container marked (number of container) and open or operate the mechanism on the container. After the first time, please repeat twice more, for a total of three times". Participants opened or operated each container three times with and without the orthosis, for a total of six trials.

In order to obtain grip and pinch strength measurements, standardized procedures of the American Society of Hand Therapists were used, as described in Mathiowetz et al. (1985). Three trials of each grip and type of pinch were obtained. Participants had a 30 second rest period between each grip and pinch trial.

Data Analysis

One measurement was obtained for each grip and pinch strength pattern and the forces exerted to open and operate the six containers, by calculating an average from the three trials of each measure. These averages were used for the data analysis.

Descriptive data (central tendency, range, and standard deviation) were calculated for demographic variables, grip and pinch strength measures, and force data on the containers. Order

effects for the strength measurements and for the container forces were assessed through analysis of variance. The data were tested for normal distribution by the Gaussian test for normalcy.

Results

The participants included in the sample were 60 older adult women who reported having a diagnosis of arthritis. Two participants were removed due to computer malfunction and loss of data. The remaining fifty-eight participants ranged in age from 55 to 90 years old. The mean age of the sample was 71.72 years ($SD = 9.28$). In regards to hand dominance, the sample was primary right-handed (93.1%), and four (6.7%) were left-handed. Three ethnicities were represented in the sample. Forty-six self-identified as Caucasian (79.3%), eleven identified as African American (19%), and one participant identified as Asian (1.7%).

All data regarding the dual pinch safety squeeze container were eliminated due to computer and/or sensor error. Once the outliers were eliminated, order effects for order of containers and for order of grip and pinch strength measurements were assessed through analysis of variance. No significant order of presentation effects were found within the containers, or within the grip and pinch measurements.

The data were tested for normal distribution by the Gaussian test for normalcy and some of the data were found to be non-normally distributed. Therefore, non-parametric Spearman's rho correlation coefficients were used to examine the relationships between the grip and pinch strength measurements and the forces exerted to open and/or operate the containers.

Descriptive statistics for grip and pinch measurements, displayed in Table 1, showed the averages for our sample of older adult women with arthritis. All but one participant was right handed. Their average gross grip strength in the right hand was 46.67 pounds ($SD = 13.64$) with

mean pinch strength measurements for the right hand ranging from 8.39 pounds (SD= 3.21) to 11.06 pounds (SD= 3.43).

The mean forces exerted on the containers, displayed in Table 2, ranged from 7.74 (SD=8.58) pounds of force for operating the trigger pump spray to 24.41(SD= 11.69) pounds of force for operating the pop-off lid container. The maximum forces exerted ranged from 23.71 pounds of force for operating the large prescription bottle to 48.20 pounds of force for operating the pop-off lid container. The minimum amount of force used to access the containers ranged from 0.42 pounds of force for the trigger pump spray bottle to 6.84 pounds for the pop-off lid bottle.

The Spearman rho's correlation coefficients were calculated on the data between the sensor forces and the pinch and grip strength measurements. As displayed in Table 3, significant correlations were found for three out of the five containers and participants' grip and pinch strength measurements. There were significant correlations between the trigger pump spray and left gross grasp, left three jaw chuck, left lateral pinch, and left tip pinch. All p values for the relationships between the aerosol spray can, large prescription bottle and pinch and grip strength measurements were significant.

The correlations between the grip and pinch measurements and the forces used to operate the containers were analyzed for the strength of their relationships. The interpretation of the correlation coefficient is the strength of the relationship (Kielhofner, p. 263, 2006). The values for correlations that are 0-.20 suggest a negligible correlation, 0.20-.40 suggests a low correlation, 0.40-.60 suggests a moderate correlation, 0.60-.80 suggests a high correlation, and 0.80-1.00 suggests a very high correlation. (Kielhofner, pp. 263-264, 2006). Of the relationships that were statistically significant, all but four correlations should be interpreted as having

negligible to very low correlations between the forces used on the containers and the women's strength measurements. However, eight moderate relationships (0.40-.60) were found. There were moderate relationships between the trigger pump spray and left tip pinch (0.41), trigger pump spray and left three jaw chuck (0.40), aerosol and left gross grasp (0.40), aerosol and left lateral pinch (0.51), aerosol and left three jaw chuck (.46), aerosol and left tip pinch (.40), large prescription bottle and right lateral pinch (0.43), and large prescription bottle right three jaw chuck pinch (0.48).

Discussion

The purpose of this study was to replicate and extend Rahman et al. (2002) examination of the relationship between grip and pinch strengths and the forces used to access common household containers in older adult women with arthritis. Rice et al. (1998) and Rahman et al. (2002) found no to low relationships between grip and pinch strengths and forces generated in accessing the majority of containers. Rice et al. (1998) and Rahman et al. (2002) used dual-pinch safety squeeze bottle, small prescription bottle, pop-off bottle, aerosol can, and trigger pump spray which were very similar to the containers used in the present study. Rice et al. (1998) found moderate relationships between pinch strengths and the ability to open the bottle with pop-off lid, the small prescription medicine bottle, and the large prescription medicine bottle. Rahman et al. (2002) reported a moderate relationship between pinch and grip strength measurements and the ability to open the bottle with the dual-pinch lid, the large prescription medicine bottle, and the aerosol spray can. These researchers concluded that greater hand strength did not afford better performance in opening and accessing selected containers.

Based on Rahman et al. (2002) and Rice et al. (1998) findings, we predicted that no relationship would be found between the grip and pinch strength measurements and the forces

exerted to operate or open common household containers in older adult women with arthritis. Our results indicated that two of the five containers (pop-off lid and small prescription bottle), had no to negligible relationships between grip strength and pinch measurements and the forces used to open the containers successfully. A moderate relationship was found between grip strength and pinch measurements and the forces used to open the large prescription medicine bottle, and to operate the trigger pump spray bottle and aerosol can. The aerosol container had moderate relationships for all right hand strength and pinch measurements and the forces used to operate the container.

The highest correlations in this study were between the lateral, three-jaw chuck, and tip-to-tip pinch strength measurements and the force to operate the aerosol can and open the large prescription bottle. These somewhat stronger relationships may result from the similarity of these pinches to those required to open and operate these types of containers. These types of containers isolated the thumb or index finger which are the primary digits used when collecting pinch measurements. The required positions of the thumb and index finger to operate the aerosol can and the large prescription bottle supports the stronger relationships between the pinches and containers.

Many of the studies cited previously found that decreases in hand strength with normal aging and age-related changes were related to decreased functional performance in occupations requiring strength or dexterity or both. Older adult women with arthritis in our study displayed decreased grip and pinch strengths compared to the healthy older adult women in Rahman et al. (2002) study and the healthy young adult women in Rice et al. (1998) study. The older adult women with arthritis in our study had average grip strengths of 46.67 pounds (SD= 13.64) compared to the healthy older adult women in Rahman et al. (2002) who had average grip

strengths of 51.92 (SD= 10.37) pounds, despite the fact that they were very similar in average ages. The average grip strengths for the women with arthritis are much lower than the average grip strength in the younger, healthy adult women in Rice et al. (1998) study who had average grip strengths of 75 pounds. In addition, the older adult women with arthritis in our study had average pinch strength measurements ranging from 7.20 to 11.06 pounds compared to the healthy older adult women in Rahman et al. (2002) who had a range of 8.6 to 13.4 pounds, and the younger, healthy adult women in Rice et al. (1998) who had estimated averages ranging from 10 pounds to 15 pounds. The older adult women with arthritis in our study had less overall average grip and pinch strength measurements compared to those in previous studies. The standard deviations for the grip and pinch averages amongst the older women with arthritis are all larger than the standard deviations for the younger and well elderly women which indicates greater individual variability in the women with arthritis. This trend of decreased grip and pinch strength measurements was evident in our sample of older women with the diagnosis of arthritis. These findings were similar to the results of Shiffman (1992) who found that there was a trend in the aging population to have a decrease in grip and pinch strength. However, the amount of forces exerted to operate the containers differed among the populations.

The older adult women with arthritis in our study had lower levels of available strength and therefore exerted more of their available force to operate or open all the containers except for the trigger pump spray bottle, compared to the healthy younger adult women in Rice et al. (1998). The healthy older adult women had a greater amount of grip and pinch strength compared to the older adult women with arthritis in our study and the healthy older adult women exerted a lower amount of force to operate the containers. For example, the older adult women with arthritis in our study exerted an average of 12.13 pounds (SD= 5.45) of force when

operating the aerosol can. Their minimum amount of force used on the aerosol can was 2.12 pounds and their maximum force used on the aerosol can was 26.11 pounds. Their maximum effort was well above the average force used to operate the aerosol container. Compared to Rahman et al. (2002), these forces were greater than what the healthy older adult women exerted to operate the same type of container. The healthy older adult women in Rahman et al. (2002) had an average of 5.22 pounds (SD= 2.90) of force and a minimum of 1.16 pounds and maximum of 12.00 pounds to operate the aerosol spray. These findings differed from previous studies where Rahman et al. (2002) found that healthy older adult women had a consistently lower force to operate containers compared to Rice et al. (1998) healthy young adult participants. However, the maximum forces recorded by all older women with arthritis in this study ranged from 23.71 pounds on the large prescription medicine bottle to 49.19 pounds on the small prescription bottle—well over the minimum forces used to open the containers. These high force efforts can be attributed to the available slack capacity. The average force exerted to operate the containers was higher compared to their healthy counterparts and suggests that due to impaired hand strength and function, the women with arthritis required a higher proportion of their available strength to open the containers.

Kinoshita and Francis (1996) reported that the use of slack capacity is similar to the use of a greater “safety margin” of grip force by older adults versus younger adults. As stated previously, individuals between the ages of 50-70 years old experience a 15% loss in strength per decade (Grabiner & Enoka, 1995). If older women with arthritis are exerting more force to compensate for the decrease in grip and pinch strength, these excessive forces during movement could result in unhealthy strain on their vulnerable joints and an increase in pain when opening and/or accessing common containers.

Limitations

Several limitations were present within this study. The sensors used to detect force were placed in the most optimal position to measure the individual forces required to access the container, but additional forces may have been used as well. For example, when accessing the small and large prescription bottles, participants pressed a small tab on the side of the lid to release a twist off lid. When measuring the force, the sensor was placed on the tab and not the lid, so the force of pressing the tab was recorded, but the force used when twisting the lid off was not recorded. Due to technical difficulties, some data were lost and should be considered a limitation of the study.

Lastly, a wide range of forces was used to access containers. For example, participants operating the trigger pump-spray bottle exhibited forces ranging from 0.42 pounds to 45.25 pounds, showing a large difference of 44.83 pounds. In addition, the standard deviations for each container were large. This suggests that individual differences may produce significant differences in hand force used. This may be a limitation because the population selected for data collection had self-identified their arthritis diagnosis. The participants could have been at different stages in the progression of the disease therefore varying in their strength and ability to access the containers for the study. The level of impairment would vary based on age, severity of symptoms and pain experienced.

Implications for Occupational Therapy Practice

Based on the data, occupational therapists can recommend certain types of containers to their clients for easier use in the home. For example, the mean force used to open the large prescription container was 8.98 pounds (SD= 5.61) compared to the pop-off lid medicine container at 24.41 pounds (SD=11.69). Occupational therapists can make recommendations to

transfer medication stored within a pop-off lid container into a re-labeled empty large prescription bottle to make access to medication easier. The occupational therapist can recommend that when shopping, participants purchase containers that have a trigger pump-spray mechanism over aerosol containers as the pump-spray container required less force to operate than did the aerosol container.

In addition, occupational therapists can work with older adult clients on improving their pinch and grip strengths in the clinic in order to facilitate independence with daily living occupations. Occupational therapists can incorporate occupations that facilitate an increase in grip and pinch strength. The findings of our study concluded that there were negligible to moderate relationships between grip and pinch measurements and the forces used to open and operate the containers. The minimum forces exerted to open the containers ranged from 0.42 pounds to operate the trigger pump spray (SD= 8.58) and 6.84 pounds to open the pop-off lid container (SD= 11.69). Occupational therapists can use these numbers as guidelines for the amount of strength to work toward for older adult women with arthritis so that they can be successful in opening and operating common containers. By increasing one's strength, one may not need to exert as much force as the women in our study demonstrated. In addition, occupational therapists can observe their clients to see if any modifications to the client's approach should be recommended to decrease fatigue and pain associated with exerting force in opening containers. Occupational therapists should teach clients who have vulnerable joints alternate methods for opening containers in order to protect and prevent further deterioration of the joints. Joint protection and energy conservation are important interventions when working with individuals with hand conditions. If the individuals are over-exerting and putting repetitious strain on their joints, they will have an increase in pain. The overall goals when working with

individuals with arthritis would be to increase their level of independence and prevent joint injury or strain.

Directions for Future Research

Future research needs to examine the amount of average strength required to complete other common daily living occupations. For example, research should investigate the amount of force exerted to open food containers or access containers used for bathing such as shampoo bottles or toothpaste containers. Future research should explore the relationship between strength and functional use of the hand, including the minimum grip and pinch forces needed for functional hand use and the efficiency of various prehension strategies. Studies could include subjective measures of ease of opening the containers. It would be beneficial to extend this study to investigate the grip and pinch strength measurements and forces exerted amongst men with arthritis to see if they have the same trends as older adult women with arthritis.

Conclusions

The purpose of this study was to explore the relationships between grip and pinch strengths and the forces used to open and operate common household containers in older adult women with arthritis. On average, the participants did not demonstrate strong relationships between grip and pinch strength measurements and the forces used to open and operate the containers. The older adult women with arthritis in this study used greater force than the healthy young adults in Rice et al. (1998) and the healthy older adult women in Rahman et al. (2002) to operate the containers, despite having less available grip and pinch strength. These results support the trend that elderly persons use a greater proportion of their available strength during these tasks compared with the younger participants and healthy older adults in previous studies.

Future decrements in strength from aging or from the progression of arthritis may pose problems in successfully opening and operating common types of containers.

Acknowledgements

This study was made possible by grant funding from the Northwest Ohio Arthritis Association. A special thank you to the Margaret Hunt Senior Center in Toledo, OH for providing a site for participant recruitment and allowing data collection at their facility. Special thanks to Dr. Julie Thomas for providing guidance, support and knowledge throughout the research process and Dr. Martin Rice for being a technical genius and helping with the force sensing resistors when needed. Finally, thanks to Chase Majewski for being a loyal research partner and confidant throughout this experience.

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Figure 1. Containers with sensor placements

Table 1
Grip and Pinch Strength Measurements

Dynamometry	<i>M</i>	<i>SD</i>	Min	Max	Range
<i>Right hand</i>					
Grip	46.67	13.64	9.00	80.33	71.33
Lateral	11.06	3.43	2.00	20.33	18.33
Three-jaw chuck	9.48	3.22	1.00	18.67	17.67
Tip-to-tip	8.39	3.21	1.00	17.33	16.33
<i>Left hand</i>					
Grip	46.26	11.77	18.67	84.33	65.67
Lateral	10.05	2.81	5.33	15.67	10.34
Three-jaw chuck	8.91	2.89	4.00	17.33	13.33
Tip-to-tip	7.20	2.57	2.67	15.67	13.00

Note: N= 58; Units in pounds

Table 2
Forces Applied on the Force Sensing Resistors

	N	<i>M</i>	SD	Min	Max	Range
Aerosol	58	12.13	5.45	2.12	26.11	24.00
Pop-off lid	44	24.41	11.69	6.85	48.20	41.35
Small prescription	57	11.23	10.25	1.39	49.19	47.80
Large prescription	57	8.98	5.61	0.46	23.71	23.25
Trigger pump spray	57	7.74	8.58	0.42	45.25	44.83

Note: Units in pounds

Table 3

Spearman's Rho Correlations Between Grip and Pinch Strengths and Container Sensors

Containers	<u>Gross Grasp</u>		<u>Lateral Pinch</u>		<u>Three Jaw Chuck</u>		<u>Tip-to-Tip</u>	
	Right	Left	Right	Left	Right	Left	Right	Left
Trigger Pump Spray	0.17	0.38**	0.11	0.33*	0.26	0.40**	0.26	0.41**
Aerosol	0.38**	0.40**	0.38**	0.51**	0.37**	0.46**	0.37**	0.40**
Small Prescription	0.13	0.06	0.04	0.13	0.18	0.18	0.12	0.18
Pop- off	0.01	0.05	0.14	0.07	0.07	0.01	0.18	-0.05
Large prescription	0.28*	0.33*	0.43**	0.31*	0.48**	0.32*	0.38**	0.32*

***. Correlation is significant at the 0.01 level (2-tailed).*

**. Correlation is significant at the 0.05 level (2-tailed).*