Bulb planters labeled ergonomic versus standard design: preferences and effects on wrist range of motion during a gardening occupation

Ann E. Mizen
Medical College of Ohio

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FINAL APPROVAL OF SCHOLARLY PROJECT
For the Degree of
Master of Occupational Therapy

Title of Scholarly Project: Bulb Planters Labeled Ergonomic Versus Standard
Design: Preferences and Effects on Wrist Range of Motion During a Gardening Occupation

Submitted by:
Ann Mizen

In partial fulfillment of the requirements for the degree Master of Occupational Therapy

APPROVED

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Attachment: Abstract

Final Approval of SP MOT
Bulb Planters Labeled Ergonomic Versus Standard Design: Preferences and Effects on Wrist Range of Motion During a Gardening Occupation

Ann E. Mizen

Department of Occupational Therapy

Medical College of Ohio at Toledo
Abstract

OBJECTIVE. This study compared the wrist range of motion used with an ergonomic-labeled bulb planter and a standard design bulb planter during a gardening occupation. It also compared the comfort, ease of use, and overall preferences of participants for the two bulb planters.

METHOD. Sixty-one right-handed females, 50 years of age and older, with no known disease or disability impairing their dominant upper extremity were recruited. Each participant used both bulb planters to dig five holes in a flowerbox containing soil in a randomized repeated measures counterbalanced design. The wrist movements of palmar and dorsiflexion, and ulnar and radial deviation were measured with a Penny and Giles Biometrics Limited Goniometer XM65 (elgon). Participants also completed questions regarding their interest in gardening, use and comfort of each bulb planter, and preference.

RESULTS. There were no significant differences between the two planters for extremes of range of motion. Participants rated the ergonomic-labeled bulb planter significantly more comfortable to use than the standard design bulb planter. There was not a significant difference in the participants’ perceptions of ease of use for the two bulb planters. A majority of participants preferred the ergonomic-labeled bulb planter rather than the standard design bulb planter.

CONCLUSION. Occupational therapists should be cautious when recommending a gardening tool solely based on it being labeled “ergonomic.” Many factors influence the right fit between a person and a tool.
Occupational therapists are concerned with leisure pursuits because of the meanings and purposes that clients attach to them. As therapists strive to build on those occupations that motivate their clients, they need to carefully analyze all aspects of the occupational form in order to achieve the optimal occupational synthesis in facilitating the client’s goals. Gardening is one of the most popular leisure pursuits of Americans. According to Butterfield (1992), 75% of Americans participate in some type of gardening occupation. A review of the literature shows numerous references to a wide array of benefits that can be derived from gardening. The main occupational forms involved in this leisure occupation are the gardening tools. While people rely on tools to aid them in the performance of many tasks, research shows that the design of a tool can also have an effect on the person. Ergonomics is an area of science involved in the research and design of tools to promote efficiency while preventing negative impacts for the user (Boyles, Yearout, & Rys, 2003; Boyles, Yearout, Rys, & Neimken, 2001; Li, 2002). The literature shows that many ergonomic studies have investigated musculoskeletal disorders such as carpal tunnel syndrome that may be associated with tools used in industrial settings. A problem exists though in that the available literature does not show many studies that have been conducted in the area of ergonomics as it applies to gardening tools. As the tools used for gardening have not been well researched, it is essential that therapists use caution regarding the tools used in the synthesis of a gardening occupation to avoid the possibility of musculoskeletal stress or injury. The purpose of this study was to compare an ergonomic and a standard-design bulb planting gardening tool in terms of the amount of range required by the wrist and comfort level and ease of use as rated by older adult women.
Literature Review

Leisure

As the pursuit of leisure has grown in recent generations, researchers have begun to focus on studying this aspect of our lives. One of the challenges, however, in studying the various aspects of leisure is arriving at a consensus for a definition of the term “leisure” (Brightbill & Mobley, 1977; Gunter, Stanley, & St. Clair, 1985; Iso-Aloha, 1980). Although a concise definition that captures the wide variety of leisure activities and the meanings and purposes people attach to leisure may be difficult to achieve, there is agreement on some of the characteristics of leisure. Leisure involves that time that individuals have available to them in which they are free to do those things of interest (Brightbill & Mobley, 1977; Kelly, 1982). The motivations for how people decide to use their leisure time vary as much as the possible choices for leisure occupations. Kelly (1982) provided guidance regarding this aspect. “People find in leisure: self-expression, satisfaction, integration of mind and body or wholeness, physical health…rest and relaxation… [fulfillment of the desire] to get in touch with nature (p. 11).”

Gardening

One leisure occupation that ranks as one of the most popular outdoor pursuits among Americans is gardening (Kaplan, 1992; Butterfield, 1992). The benefits cited by gardeners who pursue this as a leisure occupation are enhancement of the quality of life; gaining a sense of self-sufficiency, personal satisfaction, and enjoyment; and additional opportunities for social interaction (Patel, 1992). The position of importance that plants have in our lives is evident in the number of occasions throughout life, from the birth of a child up to and including the death of a loved one, in which we convey our feelings
through flowers. The psychological benefits derived by simply viewing a well-
landscaped scene are reported in all ages from college students, to workers, to the elderly.

In Ulrich’s (1979) study of college students under stress from an exam, views of plants increased positive feelings and reduced fear and anger. The results of a study of people who worked in an office environment showed that those workers with a view of trees and flowers experienced less job pressure, were more satisfied with their jobs, and reported fewer ailments and headaches than those workers who had no outside view (Kaplan, Talbot & Kaplan’s study as cited in Kaplan, 1992). In a study conducted through questionnaires and semi-structured interviews of 60-94 year-old residents of sheltered housing complexes, Stoneham and Jones (1997) concluded that the elderly believe an attractive landscape is important for the image of their home and for providing them with an interest and concern for the future. Adil (1994) restates many of the same emotional and psychological benefits for those who participate in gardening. He said that gardening is a means of building self-image, reducing stress, providing a healthy outlet for anger, and a way to build feelings of enthusiasm, interest and concern for the future.

Adil (1994) elaborates on some of the ways that gardening may benefit the social aspect of a person’s life by pointing out that with an estimated 75% of the population interested in gardening, it is relatively easy to find someone who shares that same interest. This topic is a great icebreaker among neighbors who are more likely to engage in conversation while outside working in their garden. This same author also states the intellectual benefits that may be gained through gardening. He believes that gardening is an occupation that can sharpen your powers of observation, heighten your sense of curiosity, and improve your abilities to problem-solve and make decisions (Adil, 1994).
In addition to the psychological, social, and intellectual benefits, many authors cite the physical benefits of gardening (Adil, 1994; Davis, 1994; Mattson, 1992; Simson & Straus, 1998; Woy, 1997). The pursuit of gardening, regardless of ability or disability, can enhance one’s physical condition (Davis, 1994). Besides maintaining the physical abilities of healthy people, gardening also offers a way to harness the healing power of nature (Milligan, Gatrell, & Bingley, 2004).

Although most people living today have more time beyond that which is required for existence than preceding generations did, the pace of life and the variety of the demands on our time have escalated in ways that increase the value of the time one is able to devote to the pursuit of personal interests. This may be why, according to a 1989 national Gallup Poll survey of attitudes towards plants and gardens, people cited one of the most satisfying aspects of gardening as being the peace and tranquility it brings (Butterfield, 1992). When considering the many benefits of gardening and its widespread popularity, it is distressing to realize that a growing number of gardeners suffer from repetitive motion injuries such as carpal tunnel syndrome, tendonitis, and trigger finger (Appleton, 1999; Carroll, 2001). Ergonomically designed garden tools may be one solution to this problem.

_Gardening and Ergonomics_

Ergonomics is an evolving inexact science, which aims in part to prevent cumulative trauma disorders (Bittner, 2001). Cumulative trauma disorders (CTD) is a category that includes several disorders that occur as the result of repeated stresses or microtraumas to a body part over time such as carpal tunnel syndrome (CTS) and
tendonitis (Putz-Anderson, 1994). As these types of injuries have escalated, several studies have addressed these concerns particularly in relation to females.

In a study conducted by Arvidsson, Akesson, and Hansson (2003) of twelve female operators 26-58 years old in an industrial work setting, the frequency of musculoskeletal disorders was highly correlated to repetitive and high-velocity movements. Wu and Hsieh (2002) investigated repetitive bent-wrist motions associated with the use of the spatula, one of the most common cooking tools in Asia. This study, which included eight female participants 18-25 years old, focused on the angle and length of the handle to minimize the risk of injury to the hand and wrist. The results of this study indicated that a spatula with a handle length of 20 cm and an angle of 15° was the most efficient for frying and turning food, while a spatula with a length of 25 cm and an angle of 25° was the most efficient for “food-shoveling”. The authors used the term food-shoveling to refer to the task of removing the food from the pan. Coury, Porcatti, Alem, and Oishi (2002) compared the incidence of work-related musculoskeletal disorders between nineteen male and eighty-four female workers 18-54 years of age performing the same repetitive industrial tasks. The number of symptoms of musculoskeletal disorders was significantly higher ($p=0.02$) for women than for men.

Nordin, Andersson, and Pope (1997) state that the amount of force used in gripping a tool during repetitive or sustained tasks is a predictor of the risk for tendonitis and CTS. Pheasant (1991) further defined the risk factors associated with CTD, “The worst problems are often associated with repeated forceful gripping and turning actions executed with the wrist in a deviated position (p. 261).”
The literature strongly supports a neutral wrist position when using hand tools in order to decrease the incidence of CTD (Bittner, 2001; Boyles, Yearout, & Rys, 2003; Cacha, 1999; Fox, Longo, Siffer, VerWoert, & Dutta, 2001; Li, 2002). According to the Ergonomics Division of the University of California at Los Angeles’ (UCLA) Office of Environmental Health and Safety (n.d.), “Keep wrists as neutral as possible. Avoid extreme motions. There is a safe zone of movement for your wrist. This zone is about 15° in all directions.” The literature also offers some guidance regarding the position of the wrist for maximum grip force in relation to wrist torque. In a study of twenty-five young adult male students investigating the effects of wrist position, force exertion direction, and angular velocity to find the patterns of wrist positions where maximal forces occur on simultaneous grip force and wrist torque, Jung and Hallbeck (2002) found the significant range fell between 45° of flexion and 30° of extension. O’Driscoll (1992) identified 35° of extension and 7° of ulnar deviation as the wrist position to generate maximum grip strength.

To achieve a mechanical advantage in grip force, an ergonomic tool should be designed so that the fingers are not maximally flexed around the handle (Cacha, 1999). The shape of the handle should be either round or oval (Bittner, 2001; Cacha, 1999). Due to the proportional variations in hand sizes and finger length, the literature does not offer a consensus regarding the diameter of the handle. Some suggestions for diameter include 3.75 cm [1.476 inches] (Bittner, 2001), 1.25 to 1.75 inches [3.18-4.45 cm] (Cacha, 1999), and 5 to 6 cm [1.97-2.36 inches] (Mital & Kilbom, 1992). The handle should be long enough to accommodate the fingers and covered in a material that provides some cushion
for the fingers, such as plastic or rubber, to maintain good circulation (Bittner, 2001; Cacha, 1999).

There may be confusion on the part of the consumer as to what constitutes an ergonomically designed tool. Indeed, the literature indicates that there is an ongoing discussion within the discipline to provide a precise definition of the term. In addition to the goal of preventing cumulative trauma disorders as stated by Bittner (2001), Wilson (2000) states that the field of ergonomics is devoted to understanding people and their characteristics in relation to design. Cacha (1999) suggests that the term ergonomic on a tool may be misapplied unless studies have been conducted to prove that, “the tool has actually diminished the incidence of musculoskeletal disease.” The concern for accurate use of the term is perhaps best reflected in popular literature. An article in a contractor’s journal regarding ergonomic tools states that the term ergonomics, “is used so much and applied so broadly that you can ask a dozen different people what ergonomics is, and easily get a dozen different answers (Spaulding, 2001).” However, this same author also states, “ergonomics is one of the top considerations people have when making a tool purchase.” Authors of articles related to home and gardens address this issue by advising consumers to consider carefully their purchases of ergonomic tools (Eckstein, 2003; Carroll, 2001; Halverson, 1998).

Although tools labeled ergonomic or ergonomically oriented are found in most stores that sell hand tools, the need to verify the benefits of these tools in reducing the incidence of musculoskeletal injuries is clear. An earlier study using a randomized, repeated measures, counterbalanced design conducted by Tebben and Thomas (2004), investigated the use of a garden trowel labeled ergonomic versus a standard garden
trowel in terms of wrist positioning when planting. The participants were sixty-four females, ages 20-50 years, with no self-reported deficits or disabilities of their upper extremities. The authors proposed two directional hypotheses: (1) the extremes of wrist deviations, and palmar and dorsiflexion would be less with the use of a trowel labeled ergonomic than with the use of a standard-design trowel, and (2) participants would rate the trowel labeled ergonomic as more comfortable and easier to use than the standard-design trowel. Their analyses showed that these hypotheses could not be supported, and concluded that the ergonomically labeled trowel offered no benefits in terms of wrist positioning over the standard-design trowel. However, the authors encouraged further research in this area. The suggestions from that study that formed the basis for this study relate to a different population and another gardening tool labeled as ergonomic.

The Present Study

It is important to consider both the preferences of the ergonomic tool user and the effects of the ergonomic design of the tool on the user. Extending the Tebben and Thomas study to investigate a different tool as well as a different population, this study focused on biomechanical measures of wrist ulnar and radial deviation and palmar and dorsiflexion while using both an ergonomic-labeled bulb planter and a standard-design bulb planter to complete a gardening occupation. Since the goal of ergonomic tool designers would be to decrease extremes of wrist motion and finger flexion while increasing the grip force, the first hypothesis was that there would be a difference in the degree of wrist deviations, palmar and dorsiflexion between an ergonomic-labeled bulb planter and a standard-design bulb planter. A second hypothesis was that there would be a difference in the comfort level and ease of use between the ergonomic-labeled bulb
planter and the standard-design bulb planter as rated by the older adult women participants.

Method

Participants

Extending the Tebben and Thomas (2004) study, this study focused on the older adult female population. The participants were 60 adult females over the age of 55. Following similar procedures as the Tebben and Thomas study, the participants were right-hand dominant and were without disease or disability in their dominant upper extremity to the extent that it would impede full participation in the research task. Using participants of one gender helped limit the anthropometric differences between a female’s hand and a male’s hand. Participants were recruited verbally and through notices posted at three local colleges, a local botanical garden, local gardening clubs, churches and senior centers.

Instruments and Apparatus

A 66 by 48-inch (167.64 cm x 121.92 cm) adjustable height table was used as the planting table. The height of the table was adjusted for each participant to 15 cm below the participants’ left elbows, which were flexed at approximately 90° (Kroemer & Grandjean, 1997). The following items were placed on the table from the participant’s right to left: the ergonomic-labeled bulb planter or the standard-design bulb planter, a 29 x 7 x 6 inch plastic flower box filled with approximately 18 cm of EarthGro Topsoil™, and a 4-cell pack of bulbs. A plastic tub to hold the soil removed from digging was placed behind the flower box (see Figure 1).
The plastic flower box was centered on the midline of the table, 13 cm from the front edge. The bulb planter was laid 24 cm from the right edge of the tub and the handle was 13 cm from the front edge of the table. A green dot was placed between the tub and bulb planter and 6 cm from the front edge of the table to designate the starting hand placement. The cell pack of bulbs was placed on another green dot 24 cm beyond the flower box. A separate table held the computer, switches, and the Biometrics K100 Base Unit. It was on the adjacent wall, perpendicular to the planting table.

A bulb planter is a garden tool used when planting flowers that grow from bulbs. The user presses the tool into the ground while turning the tool. After the gardener delves the implement into the dirt to the desired depth, she then pulls upward which brings the soil within the cylinder out of the ground thus forming a hole into which she is able to place a bulb. A general description of both tools used in this study from the top down includes the following: a solid, cylindrical, horizontal handle; a metal support for the handle attached at each end of the handle; the handle supports tapered slightly inward for approximately 4 inches; the metal handle supports were continuous with a hollow metal oblique cylinder 3.75 to 4 inches in height; the oblique cylinder had three embossed markings denoting inches on the exterior surface; the bottom of this cylinder was cut in a wavy pattern larger than but similar to the serrated edge of a knife. The bulb planter referred to as ergonomic in this study was labeled by the manufacturer as having an “ergonomically designed comfort grip” handle. It was manufactured by Home Gardener (Atlanta, GA) and purchased at a local home improvement store. It stood 22.8 cm tall and weighed 310g. The standard-design bulb planter was manufactured by Bond Manufacturing Company (Bay Point, CA) and purchased at a local home and garden
store. It was 22.3 cm tall and weighed 280g. The handle of the ergonomic bulb planter was wrapped with an orange rubber-like material and was 11 cm wide. The handle of the standard-design bulb planter was composed of wood and was 10 cm wide.

To measure the amount of wrist movement during the occupation, participants wore a Penny and Giles Limited Goniometer XM65 (Cwmfelinfach Gwent NP1 7HZ, United Kingdom; referred to as elgon) on the dorsum of their right wrists. The manufacturer reports repeatability of the elgon is better than ± 1° measured over a range of 90°. Its accuracy is ± 2° measured over a range of 90°. The elgon was aligned with the third metacarpal and the midline of the forearm, as suggested by Carlson and Trombly (1983).

Similar to the Tebben and Thomas (2004) study, an ordinal scale was used for the Gardening Question and the Bulb Planter Question and was rated from 1 (“strongly disagree”) to 4 (“strongly agree”) (Rosenthal & Rosnow, 1991). The Gardening Question asked participants to rate how much they enjoy gardening on a scale of 1 (“dislike”) to 4 (“enjoy”). The Bulb Planter Question forms contained two items. The first item asked participants how easy was this bulb planter to use on a scale from 1 (“very difficult”) to 4 (“very easy”). The second item asked how comfortable was this bulb planter to use on a scale from 1 (“very uncomfortable”) to 4 (“very comfortable”). There was an open-ended statement on the Bulb Planter Question soliciting comments from participants about the bulb planter (see Appendices A & B for the forms).

Also similar to the Tebben and Thomas (2004) study, a Preference Question asked participants which bulb planter they would choose if they were going to use it to plant in their garden. They were asked to circle their choice, “orange handled” or “wood
handled”, and to write their reason(s) for choosing their preference (see Appendix C for this form).

*Design*

The study design was a randomized repeated measures counterbalanced design. As this study was part of a larger study also investigating ergonomically labeled and standard designed trowels, it was randomized as to which study was done first. Participants were randomly assigned through a computer-generated number system to one of two orders of bulb planter use. Order one was the use of the ergonomic-labeled bulb planter first, then the use of the standard-design bulb planter. Order two was reversed. As every participant may have an individual way of performing the movements, this design offered the advantage of comparing participants with themselves.

*Procedure*

The soil in each of the three flowerboxes, one for practice and one for each condition, was prepared prior to each participant’s arrival. A board covered the surface of the soil and two 5-pound weights were placed on top of the board to compact the soil in order to simulate as closely as possible the natural conditions of the garden prior to planting.

The study protocol, forms, and informed consent document were approved by the Medical College of Ohio Institutional Review Board. All participants gave informed consent prior to participation. As in the Brown Tebben and Thomas study, they then were asked the Gardening Question. When finished, the planting table was set and the task was explained in detail. While the elgon was being attached, a brief description was given of its components. The elgon was calibrated with the right elbow flexed at
approximately 90° and the forearm and hand in neutral position. The table was then
adjusted accordingly. Participants were instructed to stand in front of the flower box
containing the potting soil at the center of the table.

The participant’s number and age were entered, and the computer displayed
which bulb planter was to be used first. The assigned bulb planter was placed according
to the markings on the planting table.

The total movement involved in this task involved pressing the tool into the soil
while turning it at the same time and then lifting the tool upward until it had been
completely removed and was no longer in contact with the soil. Hereafter, this total
movement unit will be referred to as ‘dig(s)’ or ‘digging’. A practice period of two digs
was given to allow the participant to familiarize herself with the bulb planter. The soil
was then emptied from the tub back into the flowerbox. This flowerbox was then
removed and replaced with a second flowerbox with compacted soil. The participant was
instructed to press and twist the bulb planter into the soil up to the 3-inch line then lift the
bulb planter out of the soil and empty the soil into the tub. The elgon was activated when
she touched the bulb planter to the soil. A switch was pressed when the bulb planter
touched the soil in the flower box at the start of the second dig, which marked the
initiation of the data collection period. Another switch was pressed when the bulb planter
touched the surface of the soil at the start of the fourth dig, which inactivated the elgon.
The participant completed the dig while the data were being saved. Once the participant
had completed the preparations for planting, she was reminded that she could plant the
bulbs if she wished.
A chair was offered in the five-minute rest period while the planting table was reset and the area swept. The flower box with or without the bulbs in it was slid to the back of the table, along with the tub used to hold the soil. The cell pack of bulbs remained on their marking to be used in the next condition. Another identical flower box with the same amount of soil, another empty tub to hold the soil that had been removed, and the second bulb planter was placed in their designated positions on the table. The computer was reset for the next condition.

After the five-minute rest period, the participant repeated the above procedure with the second bulb planter. When finished, the elgon was removed and the area swept. The third flower box, the tub, and the bulbs were slid to the back of the table.

The first bulb planter the participant used was presented with the first Bulb Planter Question. When she finished, those two items were removed and the second bulb planter with another set of Bulb Planter Questions was presented. Finally, the Preference Question was presented with both bulb planters.

Data Analysis

The elgon recorded the degrees of wrist ulnar and radial deviation, and palmar and dorsiflexion. The elgon interfaced with a 200 MHz Gateway Pentium P5-200 desktop computer. Data were sampled at 100 Hz and 100 times a second using KPCMCIA-16At analogue to digital acquisition card (Keithly; Cleveland, OH) with Testpoint data acquisition Software version 3.2B (Capital Equipment Corp.; Bellerica, MA). Analyses were conducted on the data compiled at the start of the second dig until the start of the fourth dig for each of the bulb planters. Two-tailed paired t-tests were used to analyze the wrist movement data. GraphPad Prism Version 2.0 (San Diego, CA)
was used to analyze the two-tailed paired t-tests. An alpha value of $p \leq .05$ was set to determine the significance of the data analyses.

The ordinal scale data from the Gardening and Bulb Planter Questions were analyzed via Wilcoxon signed ranks test. The Statistical Package for the Social Sciences (SPSS) was used to analyze the Wilcoxon signed ranks test. The Bulb Planter and Preference Questions also allowed the participants to comment on their use of the bulb planters. These comments were used to discuss participants’ preferences for the two bulb planter types.

The analyses tested for order effects and examined the descriptive data for normalcy and outliers.

Results

The data from all participants were included, thus the analyzed sample size was 61. The age range of the participants was 55 years to 95 years of age with a median age of 69 years. The mean age was 68.6 years and the standard deviation was 9.2 years.

Data were smoothed with a 2$^{nd}$ order dual pass Butterworth filter using a 5 Hz cutoff frequency. The smoothed data were reduced into the dependent variables using a custom software program. The data were not skewed and an analysis of variance across the orders of presentation for the movement data variables revealed no order effects.

Extremes for participants’ range of motion, the mean of participants’ extremes of degrees for range of motion, and standard deviation were calculated for palmar flexion, dorsiflexion, ulnar deviation, and radial deviation for the ergonomic-labeled bulb planter and the standard-design bulb planter. Refer to Table 1 for these data.

The two-tailed $t$-tests showed that there were not significant differences in the
amount of palmar flexion \( (t=.8524, df=60, p=.3974) \), dorsiflexion \( (t=1.751, df=60, p=.0850) \), ulnar deviation \( (t=.05402, df=60, p=.9571) \), or radial deviation \( (t=.3063, df=60, p=.7605) \) used between the two types of bulb planters.

Using four point ordinal scales, all participants \( (n=61) \) responded to questions spaced throughout the course of each trial. Fifty-eight participants responded to the Preference Question \( (n=58) \) at the conclusion of the trial (see Appendices A, B, & C).

Frequency distributions of responses from the Garden Question and the two questions from the Bulb Planter Question are shown in Table 2. The ordinal data from the gardening and bulb planter questions were analyzed via Wilcoxon Signed Ranks tests to determine if there was a difference in the ratings of ease of use and comfort between the ergonomic-labeled bulb planter and the standard-design bulb planter. The results showed that there was a significant difference in perceptions of comfort \( (Z= -2.781, p= .005) \) with participants rating the ergonomic-labeled bulb planter as more comfortable to use than the standard-design bulb planter. There was not a significant difference in perceptions of ease of use \( (Z= -1.888, p=.059) \). A Chi square test was used to compare responses on the preference question. Three participants (4.9%) chose not to complete this question, 43 (70.5%) preferred the ergonomic-labeled bulb planter, and 15 (24.6%) preferred the standard-design (non-ergonomic) bulb planter. Please see Table 3 for the results of the Chi square tests.

Participants were invited to write their thoughts and comments on the Bulb Planter and Preference Question forms. After using the ergonomic-labeled bulb planter, 18 of the 61 participants wrote comments. Eight of the responses were comments related to the handle and all of these were interpreted as positive responses with comments such
as, “The grip was good,” and “The padded handle made it more comfortable.” After using the standard-design bulb planter, 24 of the 61 participants wrote comments with 10 of these mentioning the handle. Seven comments were interpreted as negative responses. Examples of some of the typical negative responses were, “More friction in the handle,” and “It didn’t feel as flexible.” Three of the responses were interpreted as positive with comments such as, “Easy to grip.”

Discussion

This study compared the movements of palmar flexion and dorsiflexion, and ulnar deviation and radial deviation while using an ergonomic-labeled bulb planter and a standard-design bulb planter during a gardening occupation. It was hypothesized that there would be a difference in the degree of wrist movements used for the ergonomic-labeled bulb planter and the standard-design bulb planter. The results did not support this hypothesis. The participants used a somewhat greater average amount of extreme palmar flexion and dorsiflexion with the ergonomic-labeled bulb planter, than was used with the standard-design bulb planter, but the amount of difference between the two types of bulb planters did not reach the level of significance. The participants used the same average amount of extreme ulnar deviation for both types of bulb planters, and nearly the same average amount of extreme radial deviation for the ergonomic-labeled and standard-design bulb planters. Thus, the ergonomic-labeled bulb planter did not seem to afford significantly better positioning than did the standard-design bulb planter.

The literature on ergonomics advocates that tools constructed using ergonomic principles should promote a neutral wrist position when using hand tools (Bittner, 2001; Boyles, et al., 2003; Cacha, 1999; Fox, et al., 2001; Li, 2002). According to the
ergonomics division of University of California at Los Angeles (n.d.), a neutral wrist position is “about 15° in all directions.” According to the present study, it appears that the ergonomic-labeled bulb planter did not offer any positioning benefits over the standard-design bulb planter.

This study was also designed to collect participants’ reactions to using the two types of bulb planters. It was hypothesized that there would be differences in participants’ perceptions of the comfort level and ease of use between the ergonomic-labeled and standard-design bulb planter. Results from the ordinal scales showed that there was not a significant difference in how participants rated the ease of use of the bulb planters, but they did rate the ergonomic bulb planter as significantly more comfortable than the standard-design bulb planter. The majority of participants offered comments on their Bulb Planter and Preference Question forms, which were used to support their ratings of bulb planter comfort and ease of use.

Comments for the standard-design bulb planter indicate a somewhat mixed reaction regarding the participants’ perceptions of its comfort and ease of use. Some participants liked the “shorter handle” and thought it was “easy to grip”. Other participants indicated their preference for the smaller circumference of the non-ergonomic handle with comments such as it was “easy to grip” and “more comfortable to use [because of the] smaller grip.” Other participants thought the smaller circumference handle of the standard-design bulb planter made that tool “more uncomfortable” and some did not like the unpadded handle because they felt there was “more friction in [the] handle.” All of the comments that related to the handle of the ergonomic-labeled bulb
planter written by the participants indicated that they thought the “handle [was] a little more comfortable” and the padding gave them “a better grip.”

Participants’ comments also supported their ratings for preference between the two bulb planters. The majority preferred the ergonomic bulb planter as they thought it was “more comfortable to use” because the padded handle made it “softer on the hand [and] easier [to] grip.” Although fewer people preferred the standard-design bulb planter over the ergonomic bulb planter, those who did prefer it cited similar sorts of reasons for their preference, “[the] handle was smaller, easier to grip.”

The mixed responses reflect the individuality in the participants’ preferences. As Kroemer and Grandjean (1997) pointed out “people come in a variety of sizes…thus, fitting equipment to the body requires careful consideration; design for statistical average will not do.” The results of the Preference Question justify these concerns. While the majority preferred the ergonomic bulb planter, the percentage of those who preferred the standard-design bulb planter is too great to dismiss without consideration.

*Implications for Occupational Therapy Practice*

Because gardening is an occupation of interest to such a large segment of the population, therapists view the synthesis of gardening occupations as one means of achieving clients’ goals due to the many benefits that can be derived from performance of these occupations as reported in the literature (Patel, 1992). Occupational therapists are concerned with the occupational forms used in the therapeutic process and the impact they can have on the developmental structure. It is essential that these occupational forms do not have a negative impact that could serve to undermine the desired outcomes.

When a person uses a bulb planter to plant bulbs, the fingers are tightly flexed
around the handle of the tool and downward pressure is exerted on the handle while turning the wrist back and forth from ulnar to radial deviation in order to push the tool into the soil. After pushing the bulb planter into the soil to the desired depth, a hole is created by removing the bulb planter from the soil using a pulling motion that also frequently involves turning the tool back and forth in order to extricate the dirt-filled bulb planter from the earth. When planting a small number of bulbs, these motions may have minimal impact on the user. When the goal is to plant a greater quantity of bulbs, the repeated forceful gripping and turning actions executed with the wrist in a deviated position are factors that are associated with an increased risk of musculoskeletal disorders such as tendonitis and carpal tunnel syndrome according to Nordin, et al., (1997), and Pheasant (1991). Therefore, therapists are advised to use caution when recommending which type of bulb planter to use for this occupation. Both bulb planters maintained the wrist extremes for palmar flexion movements well within Jung and Hallbeck (2002) and O’Driscoll (1992) positioning recommendations for maximum gripping and torque production. However, both planters exceeded their recommendations for range of extremes for dorsiflexion and ulnar deviation. The motions involved in bulb planting, particularly dorsiflexion and ulnar deviation place the wrist in vulnerable positions and positions where grasp and torque production are sub-optimal. Occupational therapists should caution persons with wrist problems and those at risk for developing wrist problems to avoid prolonged use of bulb planters. They could also recommend patients take other protective measures such as frequent rest breaks and stretching the wrist and fingers while planting.
As this study demonstrated, a tool that is labeled as ergonomic does not necessarily mean that all of the recommended ergonomic guidelines for finger and wrist positions as well as the guidelines for the recommended range of wrist movements will be achieved for every older adult woman. Although they tested a different tool (trowels), Tebben and Thomas (2004) also found that the ergonomic-labeled trowel afforded no wrist positioning advantage over a standard-design trowel. It appears that ergonomic labels may influence perceptions of comfort or ease of use, and may influence preferences. However, these studies do not support advantages of ergonomic-labeled trowels and bulb planters in terms of better wrist positioning.

Limitations

The bulb planters in this study were chosen for specific reasons. The ergonomic-labeled bulb planter was the only one found in the area that was labeled as such and the standard-design bulb planter was the most similar in comparison. Other bulb planters labeled as “ergonomic” may have been available in other areas or by other means to use in this study. Results cannot be generalized to other bulb planters labeled as “ergonomic.” Because the participants in this study were a sample of convenience, the posted signs and verbal recruitment may have drawn people who were particularly interested in gardening. The frequency distribution of the gardening question shows a broad range of responses from “dislike” to “enjoy” gardening, so a fairly diverse sample was recruited.

The procedure of this study tried to replicate an outdoor gardening occupation by using a product labeled as topsoil that was then compacted to simulate the condition of the earth as it might be during the fall bulb planting season, a flowerbox to simulate a row
in a garden, and real flower bulbs, however some aspects were not naturalistic. The attachment of the elgon to the wrist and its transmitter box to the waist was an unnatural aspect of the occupational form. Effort was made to decrease the participants’ awareness of the elgon by instructing them to “move as normally as possible with it on,” taping back its cords, and providing the practice scoops. It was also difficult to maintain a uniform amount of density for the soil, which the authors did not anticipate prior to performing the study. In order to make it possible for the participants to be able dig in the soil, it was necessary to keep the soil somewhat moist. Therefore, at the completion of each trial the flowerboxes were covered with plastic as a means of preventing the moisture in the soil from evaporating. However, this technique was not always successful and it became necessary periodically to sprinkle the soil with water. As this situation arose unexpectedly during the course of gathering data, no standardized methods of achieving a uniform density to the soil were operationalized. In addition, the participants performed this gardening occupation while standing in front of a flowerbox that was placed on top of a table. While the procedure for adjusting the height of the table for each participant, the top of the table was set at 15 cm. from each participant’s elbow at 90° of flexion, was operationalized, the typical position for a person performing this occupation in an outdoor setting would be kneeling or sitting and the elbow would be extended downward to the ground rather that flexed forward toward a flowerbox on a table. While these are differences from the usual conditions for performing this occupation, they should be a small influence when comparing how the two types of tools may affect clients, as the conditions were identical in each trial.
This study measured only the wrist movements during the occupation, excluding elbow and shoulder movements that may have been equally important in completing the task. The lack of significant differences in palmar flexion, dorsiflexion, radial deviation, and ulnar deviation may be due to the use of shoulder abduction, shoulder flexion, elbow flexion, pronation and supination while digging in the soil and while shaking the dirt out of the bulb planter.

**Suggestions for Future Research**

The gardening occupation used in this study involved movement at other joints. Along with wrist movement, pronation, supination, and shoulder movements, especially abduction, adduction, and flexion were used to load the soil into the tool and to unload the soil from the tool. Future studies could compare how the two bulb planter designs affect the amount of movement at these other joints.

The soil used in this study was chosen for a specific reason. In pilot testing it was determined that a purchased product labeled as potting soil was too lightweight in texture and was insufficient for removing the soil with a bulb planter in order to create a hole in the dirt. Initially, the second type of soil purchased seemed adequate for the task. However, the authors were unaware of how the conditions of this soil would change over time. It is recommended that future studies that are designed to replicate this one should conduct pilot studies testing different types of soil or testing different strategies to operationalize a way of maintaining a uniform soil density.

The gardening occupation in this study was performed indoors in a standing position. Future studies could compare how the two bulb planter designs affect movement when performing this occupation in a naturalistic setting.
This study used participant comments to support the quantitative data. Future studies could systematically evaluate the factors contributing to perceptions of the bulb planters’ comfort and ease of use to further understand participant preferences.

Replication of this study using special populations such as individuals with wrist conditions, a younger population, and men is recommended. Also, other bulb planters or gardening tools labeled as “ergonomic” could be available and compared to standard-design models.

Conclusion

This study compared the wrist movements used during a gardening occupation with a standard-design bulb planter versus a bulb planter labeled “ergonomic.” There were not significant differences in the extremes of movement for palmar flexion, dorsiflexion, ulnar deviation, and radial deviation used between the two types of bulb planters. Additionally, there were not significant differences in the participants’ ratings for ease of use between the two types of bulb planters. However, participants rated the ergonomic-labeled bulb planter as significantly more comfortable to use. There was a significant difference on the Preference Question with a greater number of participants preferring the ergonomic-labeled bulb planter.

Occupational therapists should be cautious when recommending a gardening tool for a client solely based on it being labeled “ergonomic.” Many factors influence the right fit between a person and a tool. It is within the unique qualifications of an occupational therapist to match the abilities and needs of people to the tools they use in their leisure occupations.

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References


Appendix A

Gardening Question

Please rate how much you enjoy gardening by circling a number from 1 to 4

(Dislike) 1  2  3  4  (Enjoy)
Bulb Planter Questions

Please answer the following questions about this bulb planter by **circling a number from 1 to 4**

How **easy** was this bulb planter to use?

(Very difficult) 1  2  3  4 (Very easy)

How **comfortable** was this bulb planter to use?

(Very uncomfortable) 1  2  3  4 (Very comfortable)

Please offer any comments you may have about this bulb planter.
If you were going to use one of these bulb planters to plant in your garden, which one would you choose? (Circle your response)

Orange handled               Tan handled

Why did you choose this one?
Table 1

*Descriptive Statistics for Extremes of Movement with the Ergonomic-labeled and Standard-design Bulb Planters.*

<table>
<thead>
<tr>
<th>Type of Planter</th>
<th>Mean of Extreme</th>
<th>Standard Deviation</th>
<th>Range of Extremes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Plane of Movement</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Ergonomic bulb planter</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Palmer flexion</td>
<td>8.4°</td>
<td>13.31°</td>
<td>0° – 49.2°</td>
</tr>
<tr>
<td>Dorsiflexion</td>
<td>49.1°</td>
<td>13.44°</td>
<td>0° – 87.0°</td>
</tr>
<tr>
<td>Ulnar deviation</td>
<td>27.5°</td>
<td>10.96°</td>
<td>0° – 57.8°</td>
</tr>
<tr>
<td>Radial deviation</td>
<td>14.2°</td>
<td>10.38°</td>
<td>0° – 45.9°</td>
</tr>
<tr>
<td><strong>Standard design bulb planter</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Palmar flexion</td>
<td>7.2°</td>
<td>12.16°</td>
<td>0° – 35.6°</td>
</tr>
<tr>
<td>Dorsiflexion</td>
<td>47.3°</td>
<td>13.79°</td>
<td>0° – 79.5°</td>
</tr>
<tr>
<td>Ulnar deviation</td>
<td>27.5°</td>
<td>10.59°</td>
<td>0° – 65.6°</td>
</tr>
<tr>
<td>Radial deviation</td>
<td>14.5°</td>
<td>10.96°</td>
<td>0° – 40.3°</td>
</tr>
</tbody>
</table>

n=61
Table 2

*Frequency Distribution of Responses to the Gardening and Bulb Planter Questions*

<table>
<thead>
<tr>
<th></th>
<th>Frequency (Percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td><strong>Gardening</strong></td>
<td></td>
</tr>
<tr>
<td>Ergo Bulb Planter</td>
<td></td>
</tr>
<tr>
<td>Ease of use</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Comfort</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Non-Ergo Bulb Planter</td>
<td></td>
</tr>
<tr>
<td>Ease of use</td>
<td>2 (3.3)</td>
</tr>
<tr>
<td>Comfort</td>
<td>3 (4.9)</td>
</tr>
</tbody>
</table>

n=61
Table 3

*Chi square statistic for Preference of Bulb Planters*

<table>
<thead>
<tr>
<th></th>
<th>Observed Frequency</th>
<th>Expected Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ergonomic Bulb Planter</td>
<td>43</td>
<td>29</td>
</tr>
<tr>
<td>Standard Bulb Planter</td>
<td>15</td>
<td>29</td>
</tr>
</tbody>
</table>

Note: Chi square=13.52, df=1, $p=.000$
Figure 1. The set-up of the planting table according to markings placed on the table. From the participant’s right to left: the ergonomic-labeled or standard design bulb planter, the green dot (covered by right hand), the flowerbox with soil, the plastic tub (for soil removed from flowerbox), and cell pack of bulbs (not seen in this view).
Figure 2. Participant digging in soil with ergonomic-labeled bulb planter.