Wrist range of motion during a gardening occupation using an ergonomically labeled trowel versus a standard-design trowel: an extension and replication

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

Title of Scholarly Project
Wrist Range of Motion During a Gardening Occupation
Using an Ergonomically Labeled Trowel versus a Standard-Design Trowel:
An Extension and Replication

Submitted by
Laurie Linton

(NAME)

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
Wrist Range of Motion during a Gardening Occupation Using an Ergonomically Labeled Trowel versus a Standard-Design Trowel: An Extension and Replication

Laurie B. Linton

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The purposes of this study were to investigate the difference in wrist range of motion between an ergonomically labeled trowel and a standard-design trowel and to determine whether participants perceived the two trowels differently in terms of ease of use and comfort. The study also proposed that the term “ergonomic” on a tool’s label would have no effect on the user’s perception for choice of trowel. Participants were 60 healthy women over age 55, right-hand dominant, and without any disability or disease in their right upper extremity that hindered their ability to carry out the task. Participants used both trowels to fill flowerpots with soil in a counterbalanced, repeated measures, randomized design. The wrists movements of ulnar and radial deviation, and palmar and dorsiflexion were measured with an electrogoniometer (Penny and Giles Biometrics Limited Goniometer XM65). Participants answered questions regarding their enjoyment in gardening, ease of use and comfort of each trowel and trowel preference. Two-tailed paired t-tests showed that the differences in the average amount of extreme movement used between the trowels were not significant for palmar flexion, ulnar deviation, or radial deviation, but the ergonomically labeled trowel required significantly less amounts of dorsiflexion than the standard-design trowel. Participants rated the standard-design trowel as significantly easier and more comfortable to use than the ergonomically labeled trowel. When asked to choose a trowel for home use, there was not a significant preference expressed for one trowel over the other. Occupational therapists should use caution when recommending a gardening trowel to clients based only on the “ergonomic” label. Matching a person with the right trowel involves analyzing characteristics of the individual and the tool. This study is an extension and a replication of a previous study by Tebben and Thomas (2004).
Millions of older adults enjoy tending their own flower or vegetable garden or indoor plants (Wells, 1997). Gardening is an occupation requiring the use of hand tools and hand and wrist movements. However, some gardeners experience discomfort or injury when gardening and using hand tools. The purpose of the present study is to investigate the differences in wrist range of motion between an ergonomically labeled garden trowel and a standard-design trowel. Furthermore, the prevalence, as well as the benefits of gardening as a leisure occupation will be discussed. Hand tool use in gardening and the effect these tools have on the musculoskeletal system related to cumulative trauma disorder (CTD) will be addressed. Additionally, ergonomic standards and tool design will be reviewed. The current literature on this topic will be summarized followed by the discussion of the present study.

Gardening is a popular leisure time occupation for the general population, but especially for older adults. Milligan, Gatrell, and Bingley (2004) state that data on social and leisure trends indicate a steady rise in adults participating in gardening and that as many as 61% of people aged 60-69 garden at least once a month. Horticulture has been identified as the number one leisure pursuit of older Americans (Wells, 1997).

For many older adults gardening is not just something they enjoy, but something they find beneficial, both physically and emotionally. Recreational gardening has been described as relaxing and stress relieving (Brown & Jameton, 2000) and it provides an opportunity for empowerment and increased competence (Myers, 1998). There are therapeutic effects of direct physical engagement with the environment and the aesthetic and therapeutic benefits of mentally engaging with the environment (Palka, 1999). For many people the experience of being close to nature and having the chance to see things grow from their own efforts is valuable. Milligan et al. (2004) studied participants aged 65 and over, and found the subjects expressed pleasure and
satisfaction in planting, seeing things grow and witnessing the results of their communal labors. Gardening benefits for older adults include stimulation of the senses through the use of natural materials, improvement in quality of life and self-concept, maintenance or improvement of function, and appreciation of nature in the immediate environment (Wells, 1997). Gardening also has been shown to help improve self-esteem and build self-image (Adil, 1994). As for physical benefits of gardening, Adil (1994) states that participating in gardening can help develop fine and gross motor skills, strength, coordination, stamina, flexibility, and hand-eye coordination.

Nearly every aspect of gardening requires the use of tools, most commonly hand tools. Hand tools are meant to assist the bare hands in doing work (Radwin, 1996). Standards of hand tool design are relevant to the field of ergonomics. The term ergonomic implies improved work efficiency, quality, and safety (Armstrong, 1986). Products that are available to the general public and are labeled as ergonomic imply that fatigue and musculoskeletal disorders can be avoided by choosing these tools over non-ergonomic labeled tools. However, customers should not assume ergonomically labeled tools decrease fatigue and the occurrence of musculoskeletal disorders. Ergonomic principles should guide the selection, installation and use of the right tool for the right application. The selection of a tool depends on the specific job being performed (Radwin, 1996). Furthermore, persons should realize that tools referred to as “ergonomic” may not have follow up studies that validate whether the tool has actually diminished the incidence of musculoskeletal problems (Cacha, 1999).

Standards for hand tool design have been developed to ensure that tools provide assistance to the individual without causing harm. One such standard is that the person should avoid unnatural postures. An “unnatural posture” includes any fixed or constrained body position not well suited for the human body; these are more stressful than those assumed voluntarily
Negative consequences of undesirable postures include (a) overload of the muscle and tendons, (b) loading of joints in an uneven or asymmetrical manner, or (c) involving a static load on musculature (Putz-Anderson, 1994). Armstrong (1986) states that movements of the wrist, flexion-extension, and radial-ulnar deviation cause the tendon to be displaced past and against the adjacent anatomic surfaces. Nerves can be stretched and compressed by exertion in certain postures as well. Stressful postures can often be controlled through tool design. Tools should be designed so the wrist is maintained in a neutral position, which is not excessively flexed, hyperextended, or turned side-to-side. According to the Ergonomics division of UCLA’s Office of Environment, Health, and Safety (UCLA Ergonomics, n.d.), the movement of the wrist should be kept within the “safe zone” of 15° in all directions. When force is applied at the hand, the wrist should be kept straight. All side-to-side deviations of the wrist should be avoided, as well as tools that require the wrist to be flexed and the arm pronated at the same time (Putz-Anderson, 1994). This motion stretches the wrist extensor tendons and may contribute to lateral epicondylitis (Putz-Anderson, 1994). Motions performed frequently should be kept well within the midranges of motion of the joint because movements at the extremes place extensive pressures on tendons as they cross the joints (Putz-Anderson, 1994).

The literature also recommends positioning of the wrist for maximum grip related to wrist torque. A study that explored the patterns of wrist positioning to find where concurrent maximal grip force and wrist torque occurred with a population of twenty-five young adult males, found the significant range was between 45° of flexion and 30° of extension (Jung & Hallbeck, 2002). Additionally, a study by O’Driscoll (1992), found that in order to generate maximal grip strength the wrist must be in 35° of extension and 7° of ulnar deviation.
Another standard of tool design is for the tool to provide an optimal grip. Hand tools should not require great hand strength to hold or use. Mechanical disadvantages occur when the fingers are excessively flexed around a small diameter handle or minimally flexed around a large diameter handle. These lead to excessive grip force requirements that lead to fatigue tendinitis and the hazard of accidentally dropping the tool (Cacha, 1999). Armstrong (1986) states that tools should be selected that distribute grip forces over as large an area as possible and avoid delicate nerve tissues. When a handle is too short not all of the fingers can grip around it resulting in the handle digging into the palm, pressing on nerves, and reducing blood flow. Putz-Anderson (1994) describes the optimal dimensions of a handle. The average palm length is 100 mm, so the recommended length of the handle should be 115-120mm. The diameter of the handle should be 30 to 45 mm to offer efficient grip and control. Properly designed tool handles should isolate the hand from contact with the tool surface, enhance tool control and stability, and serve to increase the mechanical advantage while reducing the amount of required exertion (Putz-Anderson, 1994). Tools should fit the grip comfortably and be light weight (Adil, 1994).

Ergonomic principles are applied to prevent cumulative trauma disorders. Repetitiveness, posture, forcefulness, mechanical stress, vibration, low temperatures and unaccustomed work activities are many factors that contribute to CTD (Armstrong, 1986). These factors that cause CTD are commonly present in gardening occupations. Given that musculoskeletal hand disorders have been associated with pruning, a study of six, healthy, experienced winegrowers was conducted that evaluated the musculoskeletal load on the hand and wrist during pruning (Roquelaure, Dano, Dusolier, Gunello, & Penneau-Fontbonne, 2002). They used surface electromyography to measure the activity of the right flexor digitorum superficialis muscle and wrist posture during pruning to show that the biomechanical strain on the hand and wrist is high
because it requires repetitive handgrips and wrist movements combined with static work of the upper extremity. The subjects coped with this by adopting strategies to reduce the occurrence of the extreme wrist positions combined with the high force exertion. The researchers added that ergonomic hand-powered pruning shears would also be needed to “lower the force exertion and reduce the frequency of awkward postures of the wrist during pruning,” (Roquelaure et al., 2002). Similarly, Pitt-Narin, Relf, & McDaniel (1992) reported the preference for four differently designed pruners by active people over the age of 50. They found that the preference for tools was affected by physical characteristics of hand length and grip strength.

Tebben and Thomas (2004) investigated the differences between using an ergonomically labeled trowel and a standard-design trowel in biomechanical measures of wrist ulnar and radial deviation, and palmar and dorsiflexion in women aged 20-50 years. The authors hypothesized that the ergonomically labeled garden trowel would promote better wrist positioning in a gardening occupation than a non-ergonomically labeled trowel. They concluded that while the trowels did not differ in extremes of dorsiflexion, the extremes for deviation and palmar flexion did not support the hypothesis. The ergonomically labeled trowel produced significantly greater amounts of deviation in the wrist.

It is essential to continue evaluating the effects of ergonomically labeled tools on the user as well as the user’s preferences for tools. The proposed study concentrated on the biomechanical measures of wrist ulnar and radial deviation, and palmar and dorsiflexion while using both an ergonomically labeled trowel and a standard-design trowel, like the Tebben and Thomas (2004) study; however, this study used a different population of healthy older adult women completing a gardening occupation. It was hypothesized that there will be no difference in the extremes of wrist deviation, and palmar and dorsiflexion with the use of the ergonomically
labeled trowel compared to the standard design trowel. It was also hypothesized that there will be no difference in the ratings of the ergonomically labeled trowel and the standard-design trowel in terms of comfort, ease to use. This study extended the Tebben and Thomas (2004) study by hypothesizing that the term “ergonomic” on a label will have no effect on the user’s preference for choice of trowel.

Method

Participants

The participants were 60 women age 55 and over. Similar to the Tebben and Thomas (2004), all participants were right-hand dominant and without any disability or disease in their right upper extremity that hindered their ability to carry out the task. Using participants of one gender helped to limit the anthropometric differences between a female’s hand and a male’s hand. Participants were recruited verbally and through bulletins and notices to local senior centers and volunteer groups at local garden clubs, hospitals, and churches.

Instruments and Apparatus

Like the Tebben and Thomas (2004) study, 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 participant’s left elbow, when flexed to approximately 90 degrees. The following items were placed on the table from the participant’s right to left: the ergonomically labeled trowel or the standard-design trowel, a 32 liter plastic tub filled with approximately 18 cm of Scotts Garden Soil, a standard 8-inch (23 cm) diameter, and a plastic flowerpot (see Figure 1).

The plastic tub was centered on the midline of the table, 13 cm from the front edge. The trowel laid 24 cm from the right edge of the tub and the end of the handle was 13 cm from the front edge of the table. A green dot was placed between the tub and trowel and 6 cm from the
front edge of the table to designate the starting hand placement. The flowerpot was 34 cm from the left edge of the table. A separate table held the computer, switches, and the Biometrics K100 Base Unit. It was on the adjacent wall, perpendicular to the planting table.

The ergonomically labeled trowel used in this study was labeled by the manufacturer as having an “ergonomically designed cushion grip handle.” It was manufactured by Hi-Point (North Bergen, NJ) and purchased at a local home improvement store. It is 35.5 cm long and weighs 333 g. The handle is 17 cm long and 13 cm at the widest part of the diameter. The standard-design trowel was manufactured by Ames Lawn and Garden Tools (Parkersburg, WV) and purchased at a local garden center. It is 28 cm long and weighs 155 g. The handle is 11.5 cm long and 8.5 cm at the widest part of the diameter (see Figure 2).

Tape was used to cover the drain holes on the bottom of the flowerpot. The flowerpot also had an inner ledge, which was approximately 13 cm from the bottom. The number of scoops required to fill the flowerpot to this ledge depended on the amount of soil scooped on each transfer. According to Tebben and Thomas’s (2004) study and pilot testing it was determined that 6 scoops were the minimum number required to fill the flowerpot.

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 degree measured over a range of 90 degrees. Its accuracy is ± 2 degrees measured over a range of 90 degrees. The elgon was aligned with the third metacarpal and the midline of the forearm as done in Tebben and Thomas (2004).

As in the Tebben and Thomas (2004) study, ordinal scale items on the Gardening Question and the Trowel Question were rated from 1 (“strongly disagree”) to 4 (“strongly
agree”). The Gardening Question asked participants to rate how much they enjoyed gardening on a scale of 1 (“dislike”) to 4 (“enjoy”). The Trowel Question contained two items. The first item asked participants how easy was this trowel to use from 1 (“very difficult”) to 4 (“very easy”). The second item asked how comfortable was this trowel to use from 1 (“very uncomfortable”) to 4 (“very comfortable”). There was an open-ended statement on the Trowel Question that sought comments from the participants about the trowel. (See Appendices A and B for the Gardening and Trowel questions).

The Preference Question asked the participants which trowel they would choose if they were going to use it to plant in their garden. They circled their choice, “gray handled” or “black handled” trowel, and wrote their reason(s) for choosing their preference, (See Appendix C for the Preference Question).

Modified from the Tebben and Thomas (2004) study, an Ergonomic Question was added. The participants were shown two transplanting trowels, different tools from those used in the previous trials. One trowel had a label attached describing it as “ergonomic” and the other was a standard-design transplanting trowel. The Ergonomic question asked the participants if they were going to purchase one of these tools, which would it be and why. (See Appendix D for the Ergonomic Question).

Design

This study was part of a larger study that included evaluation of the effects of an ergonomic labeled bulb planter on wrist movement. It was counterbalanced for which study was done first as well as a repeated measures for this study. Participants were first randomly assigned through a computer-generated number system to order of the studies and next to one of the two orders of the trowel use. For this study, order one was the use of the ergonomically labeled
trowel first, then the use of the standard-design trowel. Order two was reversed. Every participant had an individual way of scooping; therefore this design offered the advantage of comparing the participants with themselves.

Procedure

The Medical College of Ohio Institutional Review Board approved the study’s protocols and informed consent document. All participants were given informed consent prior to participation. They were asked to complete the Gardening Question. When they finished, the planting table was set and the procedure was explained in detail. The elgon was attached while a brief description was given of its components and how it was secured. The elgon was calibrated with the right elbow flexed at approximately 90 degrees and the forearm and hand in neutral position. The table was adjusted to the correct height. Participants were instructed to stand in front of the tub containing the potting soil at the center of the table.

The participant’s number and age was entered and the computer displayed which trowel was used first. The assigned trowel was placed according to the markings at the center of the table.

A practice period of four scoops was given to allow the participant to familiarize herself with the trowel. The soil in the flowerpot from the practice period was dumped back into the tub. The participant was instructed to fill the flowerpot to the designated inner ledge when prompted. The elgon was activated when she started scooping. A switch was pressed when the trowel touched the soil in the tub at the start of the second scoop, which marked the initiation of the data collection period. The switch was pressed again when the trowel touched the soil in the tub at the start of the fifth scoop, which inactivated the elgon. The participant continued filling the flowerpot to the inner ledge while the data were saved.
A chair was offered in the five-minute rest period while the planting table was reset and the area swept. The filled flowerpot was emptied back into the tub of soil, and the flowerpot along with the second trowel 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 trowel. When finished, the elgon was removed and the area swept. The second filled flowerpot and the tub were slid to the back of the table.

The first trowel the participant used was presented with the first Trowel Question. When she finished, those two items were removed and the second trowel with another Trowel Question was presented. The Preference Question was presented with both trowels: the ergonomically labeled (gray handled) on the left. Finally, a new set of transplanting trowels was presented with the Ergonomic Question. After the participant answered the questions, she was given a $10.00 gift certificate as a thank you for participating in the study.

Data Analysis

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

The ordinal scale data from the Gardening and Trowel Questions were analyzed via Wilcoxon signed ranks tests using the Statistical Package for the Social Sciences (SPSS). Chi square tests were used to compare responses to the Preference and Ergonomic questions. The Preference and Ergonomic Questions also allowed the participants to comment on their use and selection of the trowels. These comments were used to discuss participants’ preferences for the two trowel types.

**Results**

*Descriptive Statistics*

The data of one participant was not included due to a computer error; therefore, the sample size analyzed was 60. The wrist movement data from the Testpoint and Datalink were transferred into a Windows Excel program. The data were not skewed and t-tests revealed no order effects. The data were grouped according to trowel type. The mean of degrees of extreme movement used over the three scoops was calculated for each plane (ulnar and radial deviation; palmar and dorsiflexion). Descriptive data for palmar and dorsiflexion, and ulnar and radial deviation using the trowels were analyzed and can be seen in Table 1.

*T-Test Statistics*

Differences in the average amount of extreme movement used between the two trowels were not significant for palmar flexion ($t = 1.737$, $df = 59$, $p = .0877$), ulnar deviation ($t = 0.5655$, $df = 59$, $p = 0.5739$), radial deviation ($t = 1.506$, $df = 59$, $p = .1375$); however, there was a significant difference for dorsiflexion ($t = 2.772$, $df = 59$, $p = .0075$) with the ergonomically labeled trowel requiring less dorsiflexion than the standard-design trowel.
Wilcoxon Signed Ranks Test Statistics

The mean response for the Gardening Question, “how much do you enjoy gardening,” was a 3.2 (see table 2) with more than half of the participants ranking their enjoyment as a 4 (enjoy). Participants rated the standard design trowel as significantly easier ($Z = -2.216, p = .027$) and more comfortable ($Z = -3.131, p = .002$) to use compared to the ergonomically labeled trowel. The majority of the participants rated the standard design trowel as a 4 for ease (very easy) and for comfort (very comfortable) (see Table 2).

Chi Square Statistics

The responses to the Preference Question, “which trowel do you prefer,” were not significantly different (see Table 3) with 25 participants preferring the ergonomically labeled trowel and 34 participants preferring the standard design trowel. The responses to the ergonomic question were also not significantly different (see Table 4) with 37 participants choosing the ergonomically labeled tool and 22 choosing the standard design tool.

Comments by Participants

Fifty-seven participants (93.4%) commented on their choice of trowel. The participants’ comments were analyzed qualitatively. A majority (50.8%) of the participants who preferred the standard-design trowel stated they preferred it because it was “lighter,” “smaller,” “easier to use,” placed “less stress on hand,” and it was “easier to maneuver.” The participants who preferred the ergonomically labeled trowel (36.1%) stated that the “handle was comfortable,” they “liked the grip/grooves,” it was “bigger,” and preferred it because it “held more soil,” and they “liked the sharp pointed end” to dig with.

To answer the Ergonomic Question, participants were presented with a new set of transplanting trowels that they had not used to fill the flowerpots, one ergonomically labeled and
one standard-design. The participants were asked which they would purchase if they were going to buy a new trowel. Fifty-eight (95.1%) participants commented or made a choice on the Ergonomic question. Of those who commented on this question, 62.5% preferred the ergonomically labeled transplanting trowel, while 32.6% of the participants chose the standard-design trowel. A majority (47.5%) of the participants who chose the ergonomically labeled tool stated, “the grip was easier.” For the participants who preferred the non-ergonomically labeled tool, they chose the tool because “it was lighter”, “smaller”, and was “more comfortable.”

Discussion

This study concentrated on the biomechanical measures of wrist ulnar and radial deviation and palmar and dorsiflexion while using both an ergonomically labeled trowel and a standard-design trowel. It was hypothesized that there would be no difference in the extremes of wrist deviation, and palmar and dorsiflexion with the use of the ergonomically designed trowel compared to the standard design trowel. The results supported the hypothesis for palmar flexion, ulnar deviation, and radial deviation; however, results did not support the hypothesis for dorsiflexion. The range of extremes of dorsiflexion for the standard design trowel was significantly greater than the range of extremes of movement for the ergonomic trowel. Therefore, the ergonomically labeled trowel did not offer a benefit of reducing the degrees of movement the participants used for palmar flexion and ulnar and radial deviation, but the ergonomically labeled trowel significantly limited dorsiflexion when compared to the standard-design trowel.

The ergonomic literature suggests that individuals should avoid unnatural postures such as extreme flexion-extension and radial-ulnar deviation (Armstrong, 1986). It is recommended that wrist movement stay within 15° of all directions (UCLA, n.d.). In this study, the means of
the participants’ wrist range of motion were greater than 15° in all directions but radial deviation; concluding that both of the trowels exceeded the “safe zone” of positioning. Although this task required more wrist movement than is recommended, this occupation did not require the participants to move their wrists to the extremes of range, which can place extensive pressures on tendons as they cross the joints (Putz-Anderson, 1994). When comparing the results with the literature from Jung and Hallbeck (2002), the ranges of wrist positioning fell within the range for optimal grip strength of 45° of flexion and 30° degrees of extension. Furthermore the ranges of wrist movement did not exceed the recommendations by O’Driscoll (1992) of 35° degrees of extension, but did exceed the recommendation of 7° degrees of ulnar deviation for generating maximum grip strength. In terms of positioning, there was no benefit of one trowel over the other; both trowels performed similarly in terms of range of motion. It is also necessary to mention the standard deviations were quite large in all directions, which are similar to the findings of the Tebben and Thomas (2004) study. These large standard deviations show that there was a great amount of variability among participants in terms of how they moved when filling the flowerpots. Large standard deviations also make it difficult to find statistically significant differences.

It was also hypothesized that there will be no difference in the ratings of the ergonomically labeled trowel and the standard-design trowel in terms of comfort and ease of use. The results from the ordinal scales revealed that the participants rated the standard design trowel as significantly easier and more comfortable to use compared to the ergonomically labeled trowel. With this population of healthy older adult women, many preferred the standard-design trowel because it was “lighter and easier to use,” and “smaller and more comfortable to use.” Many women liked aspects of the ergonomically labeled trowel, such as the larger scoop and
ability to hold more dirt, but the handle was too heavy for their hands. One woman commented, “Although the gray handled (ergonomically labeled trowel) held more dirt I was more comfortable with the weight of the black (standard-design trowel). Another participant also stated she “liked the handle and the larger shovel head of the gray (ergonomically-labeled), but it was too heavy for a lot of gardening.” Older adult women appear to be most influenced by trowel weight and handle size when determining their preference for ease of use and comfort.

This study also hypothesized that the term “ergonomic” on a label will have no effect on user’s perception of the tool. To investigate this, the participants were presented with a new set of transplanting trowels, one ergonomically labeled, and one standard-design. The results supported the hypothesis showing there was no difference in the user’s preference of which transplanting trowel she would be more inclined to purchase when judging between the two trowels, one ergonomically labeled, and one standard-design. Although there was no significant difference by the set p value, the results came close to significance with 37 participants choosing the tool with the ergonomic label and 22 participants who chose the standard-design tool. Comments were mixed on this question. Those women who chose the ergonomically labeled tool stated it was “easier to grip,” they liked the “comfort of the handle,” and the “handle feels better or softer and less likely to cause a blister.” Participants who preferred the standard-design tool commented the tool was “lighter,” it was “more comfortable to hold,” it “fits better my hand better,” the handle was “smaller to grip.” One woman stated, “Initially I liked the blue (ergonomically labeled tool) but after experimenting, I liked the tan (standard-design) better. It was more comfortable for my hand and easier to use.” Another participant also stated she liked the blue handled trowel (ergonomically labeled) and “I would buy it if it were made smaller for my hand.”
The Ergonomic Question may not have elicited the response we were intending. By having the label still attached to the tool, the intention was that the participants would look at the label and their decision would be based on that label. Many of the participants did not appear to read the label and based their decision instead on physical attributes of the tool.

It was very interesting to note that in the first part of the study, when participants actually used and compared the ergonomically labeled trowel to the standard design trowel; more participants preferred the standard-design trowel. However for the second part of the study when participants were shown a new set of transplanting trowels and asked which they preferred, more participants chose the ergonomically labeled transplanting trowel. When answering the Ergonomic Question, participants might have been persuaded more by the appearance of the tool. One participant who asked if she could “try out” and practice using the tools commented, “Initially, I liked the blue (ergonomically labeled) but after experimenting liked the tan (standard-design). It was more comfortable for my hand and easier to use.” Another participant stated, “I was attracted to the blue handle (ergonomically labeled), but the tan (standard-design) handle felt better.” Participants would also be persuaded by price as in one woman’s response, “Price has always been my guide but the comfort of the handles would now help my decision.”

The results of this study differ somewhat from the results found in the Tebben and Thomas (2004) study. In the Tebben and Thomas (2004) study the participants used a significantly greater amount of wrist deviation with the ergonomically labeled trowel compared to the standard-design trowel. There also was no significant difference found in the participants’ ratings for comfort. The previous study did find a significant difference in how the participants rated the ease of use with the trowels, which is similar to the results of the current study. In both studies, the participants rated the standard design trowel as significantly easier to use than the
ergonomic trowel. In the Tebben and Thomas (2004) study, the population observed was adult females between the ages of 20 to 50. Both studies examined women, who generally have smaller hands than men. This could be one reason both of the studies found the standard-design trowel as significantly easier to use than the ergonomically labeled trowel. The comments on the ease and comfort of the trowels were very similar between the studies for both trowels. In both, individuals who preferred the ergonomically labeled trowel stated they liked the handle and the grip or positions for fingers and thumb. These results concur with a previous study by Pitt-Narin et al., (1992) that investigated the preference of differently designed pruners by active people aged 50 and over. Researchers found similar results to this study where the participants’ preference for tools was affected by physical characteristics of hand length and grip strength.

It seems that many of the participants liked some of the characteristics of the ergonomically labeled trowel such as grip or the scoop, but did not like the size or weight of the tool. If ergonomically labeled tools were made with ergonomic characteristics, such as the ergonomic grip, but were made smaller and lighter in weight, more people may perceive them more favorably.

When individuals are looking to buy a new tool, they should not base their decision solely on the label of a tool. As shown in this study and in the Tebben and Thomas (2004) study, the ergonomically labeled tool did not necessarily provide the better wrist positioning for the participants using the tool. If a gardener feels he/she needs to have better joint protection and wants to use an ergonomically labeled trowel, this study found the ergonomically labeled trowel would only benefit for dorisiflexion. It is important to remember that every person has his/her own preferences and what is best for one person may not be best for another person. Therefore, when purchasing a new tool, individuals should be sure to practice using the tool or at least hold
the tool in the position it would be used in. This can allow them the opportunity to see if the tool fits their hand and if it is comfortable to use.

**Implications for Occupational Therapy**

Occupational therapists are knowledgeable in implementing interventions that are focused on the client’s needs and wants. They are also in the position to recommend physical activity and occupations that are meaningful to their clients. When getting clients involved in occupations, occupational therapists need to be aware of proper biomechanics. This study concentrated on the biomechanical measures of the wrist in older adult women while using an ergonomically labeled trowel and a standard-design trowel. The findings of this study are relevant for occupational therapists to be aware of when making recommendations to clients about gardening tools. Due to the fact that gardening is a popular leisure time occupation for the general population, but especially for the older population it will be necessary for occupational therapists to possess the knowledge to make acceptable recommendations. This study found that the ergonomically labeled trowel would only benefit the movement of dorsiflexion. In terms of positioning, both of the trowels performed similarly. For this reason occupational therapists may want to use caution when recommending ergonomically labeled tools over standard-design tools.

Occupational therapy is a client-centered profession. Therapists make recommendations based on what is best for the individual. It is best to have the client try out different tools and see what works best for him/her and is preferred.

It is also concluded from the results of this study as well as those from the Tebben and Thomas (2004) study that in most cases smaller and lighter tools would be more beneficial when recommending tools for women, especially older adult women. Generally their hands are smaller
than men’s hands and the smaller tool allows for more comfort with use. This is also an important aspect for occupational therapists to keep in mind when treating this population.

**Limitations**

The environment in which the study took place was not naturalistic for gardening. This could have had an influence on the participants and the way they moved. Especially with the elgon attached to the individual’s hand and forearm and the transmitter box attached to her waist, this was not a typical form for gardening. In addition, the results of this study can only be applied to the trowels used. The results cannot be generalized to all ergonomically labeled tools.

This study only focused on the movements at the wrist; however other joints were equally used during this occupation such as the elbow and shoulder. Movements at these joints, such as shoulder abduction and forearm supination and pronation could have had an impact on the wrist movement and that was not investigated.

**Future research recommendations**

Future studies could be conducted to further investigate whether the “ergonomic” label on a tool has any impact on the user’s perception of the tool. To clarify, more questions that inquire about the decision making process could be asked. Researchers could use tools, one ergonomically labeled and one standard-design, which look similar and were the same colors. This would eliminate variability, allowing the researchers to more clearly understand what the decision making factors are. Another technique would be to present the trowels and ask the participants preference based on the appearances of the trowels. Next, the participants would use the trowels and then be asked the same questions again to see if their preference changed based on actually using the trowels.
Replications of this study using populations such as men, throughout the age range, or individuals with musculoskeletal disorders of the wrist are suggested. Other ergonomically labeled tools, gardening or other work related tools, such as screwdrivers or wrenches, could be compared to the standard-design tools.

Conclusion

This study focused on the wrist range of motion while using both an ergonomically labeled trowel and a standard-design trowel. The ergonomically labeled trowel required significantly less dorsiflexion than the standard-design trowel, but did not differ in the amount of movement in the other directions. Participants rated the standard-design trowel as significantly easier and more comfortable to use compared to the ergonomic trowel.

Occupational therapists should use caution when recommending a gardening trowel based only on the “ergonomic” label. Matching a person with the right trowel involves many factors based on the individual and the tool. Occupational therapists are qualified to fit the preferences and the needs of their clients with the tools they will most benefit from during their leisure occupations.

Acknowledgements

I greatly appreciate my advisor Julie Jepsen Thomas, Ph.D., OTR/L, FAOTA, for her endless support, encouragement, and guidance. I thank Dr. Martin S. Rice, Ph.D., OTR/L for his technical skills and support for this study. I thank Barbara Kopp Miller Ph.D., and Julie Jepsen Thomas, Ph.D., OTR/L, FAOTA, for their help in the recruitment of participants. I also thank the School of Allied Health/School of Nursing of the Medical College of Ohio for a Graduate Research Support Award for this study. Appreciation also goes to my classmate, Ann Mizen, who helped with many aspects of this study.
References


Palka, E. (1999). Accessible wilderness as a therapeutic landscape: Experiencing the nature of Denali National Park, Alaska. In a Williams (Ed.), *Therapeutic landscapes: The dynamic between place and wellness* (pp. 29-51). Maryland:


Gardening Question

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

(Dislike)  1  2  3  4  (Enjoy)
Appendix B

Trowel Questions

Please answer the following questions about this trowel by circling a number from 1 to 4.

How easy was this trowel to use?

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

How comfortable was this trowel to use?

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

Please offer any comments you may have about this trowel.
Appendix C

Preference Question

If you were going to use one of these trowels to plant in your garden, which one would you choose? (Circle your response)

Gray handled  Black handled

Why did you choose this one?
Appendix D

Ergonomic Question

If you were going to purchase one of these tools, which would it be and why? (Circle your response)

Blue handled    Tan handled

Why did you choose this one?
### Table 1.

Extremes of Wrist Movement in Degrees using the Two Trowel Types

<table>
<thead>
<tr>
<th></th>
<th>Palmar Flexion</th>
<th>Dorsiflexion</th>
<th>Ulnar Deviation</th>
<th>Radial Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ergonomic Trowel</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>21.10</td>
<td>24.47</td>
<td>27.76</td>
<td>2.76</td>
</tr>
<tr>
<td>SD</td>
<td>14.75</td>
<td>13.04</td>
<td>12.72</td>
<td>12.37</td>
</tr>
<tr>
<td>Range</td>
<td>0 – 57.42</td>
<td>0 – 48.07</td>
<td>2.98 – 82.78</td>
<td>0 – 28.45</td>
</tr>
<tr>
<td><strong>Standard-Design Trowel</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>18.14</td>
<td>28.10</td>
<td>27.20</td>
<td>4.45</td>
</tr>
<tr>
<td>SD</td>
<td>15.17</td>
<td>13.35</td>
<td>9.49</td>
<td>11.92</td>
</tr>
<tr>
<td>Range</td>
<td>0 – 50.27</td>
<td>0 – 57.15</td>
<td>7.18 – 48.69</td>
<td>0 – 15.84</td>
</tr>
</tbody>
</table>

n = 60
Table 2.

Frequency and Percentage of Responses Indicating the Degree to which Participants Enjoyed Gardening, and Perceptions of Ease of Use and Comfort of Trowels

<table>
<thead>
<tr>
<th>Gardening Question</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7 (11.5%)</td>
<td>5 (8.2%)</td>
<td>15 (24.6%)</td>
<td>34 (55.7%)</td>
</tr>
</tbody>
</table>

Ergonomic Trowel

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ease</td>
<td>0 (0%)</td>
<td>4 (6.6%)</td>
<td>10 (16.4%)</td>
<td>47 (77%)</td>
</tr>
<tr>
<td>Comfort</td>
<td>1 (1.6%)</td>
<td>5 (8.2%)</td>
<td>22 (36.1%)</td>
<td>33 (54.1%)</td>
</tr>
</tbody>
</table>

Standard-Design Trowel

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ease</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>6 (9.8%)</td>
<td>55 (90.2%)</td>
</tr>
<tr>
<td>Comfort</td>
<td>0 (0%)</td>
<td>3 (4.9%)</td>
<td>5 (8.2%)</td>
<td>53 (86.9%)</td>
</tr>
</tbody>
</table>

n = 60
Table 3.

Chi Square Statistics for the Preference Question

<table>
<thead>
<tr>
<th></th>
<th>Observed</th>
<th>Expected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ergonomic Trowel</td>
<td>25</td>
<td>29.5</td>
</tr>
<tr>
<td>Standard-Design Trowel</td>
<td>34</td>
<td>29.5</td>
</tr>
</tbody>
</table>

Note: Chi Square = 1.373, df = 1, p = .241
Table 4.

Chi Square Statistics for the Ergonomic Question

<table>
<thead>
<tr>
<th></th>
<th>Observed</th>
<th>Expected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ergonomic Trowel</td>
<td>37</td>
<td>29.5</td>
</tr>
<tr>
<td>Standard-Design Trowel</td>
<td>22</td>
<td>29.5</td>
</tr>
</tbody>
</table>

Note: Chi Square = 3.814, df = 1, p = .051
Figure 1. The set up of the planting table according to the markings placed on the table. From the participant’s right to left: ergonomically labeled trowel or standard-design trowel, the tub of soil, and the flowerpot.
Figure 2. The ergonomically labeled trowel is on the left and the standard-design trowel is on the right.