Comparison of Grip Force at the Hand–Handle Interface during the Use of Hotel Housekeeping Spray Bottles

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1. Background

In the United States, the maid and housekeeping cleaning occupation in the hospitality sector employed about 795,590 workers in 2020, representing 23% of the total employment in this industry. This occupation has been reported to have one of the highest rates of musculoskeletal disorders especially in the upper extremities in this industry. Housekeepers often use their hands in forceful gripping and pinching motions to complete their tasks including making beds, replenishing linens, cleaning, vacuuming, and dusting. As a result, they face a higher risk of developing carpal tunnel syndrome (CTS). The purpose of this study was to compare grip forces during the manipulations of three commonly used spray bottles during hotel housekeeping tasks. The study evaluated the effect of the spray bottle features on eights areas of the hand. It also evaluated participants' perception on the ease of use and comfort for each one of the spray bottles studied.

2. Methods

2.1 Participants

Twenty participants (5 females and 15 males) performed a common spray task in a laboratory setting. The average age of the participants was 30.6 years (SD = 10.2). The primary inclusion criteria required participants be free from any type of musculoskeletal, degenerative, or neurological disorders and to have had no history of upper extremities, neck, back, and shoulder injury or notable pain. Prior to data collection, participants were asked to sign the approved consent.

2.2 Data collection

The grip force was collected from the five fingers, anterior and posterior dorsal interosseous muscles (DIA & DIP), and abductor digiti minimi (ADM) using a Wireless ergoPAK Portable Analysis Kit and Force Sensing Resistor (FSR) Kit.

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Additionally, participants were asked to rate the spray bottles for the following characteristics: ease of use and comfort level using a 5-point Likert scale with 1 being strongly disagree and 5 being strongly agree. Data was collected using three different spray bottles: traditional with a trigger sprayer, motorized, and hand-held pressure pump. The traditional bottle is the most common spray bottle used by hotel housekeepers (1 Liter size). The motorized spray bottle is battery operated (4 AA battery), can be clipped to the waist and is connected by a long hose to the hand-held sprayer (1 Liter size). The hand-held pressure pump requires the users to generate a pressure inside the bottle by repeatedly pushing and pulling the pumping handle (stroking) (2 Liter size).

2.3 Experimental procedure

After collecting participants' demographic data, they were asked to spray a table (65″x 30″) surface using each of the spray bottles starting from the top-left side, moving to the right, then to the bottom-right side, and continuing left to return to the starting point. Participants were given five minutes rest period between trials. The order of the bottles was randomized among participants to eliminate the carryover impact from one bottle to the other. At the end of each trial, participants were asked to rate each spray bottle based on the ease of use and comfort level. All spray bottles were filled with one liter of water as the spray liquid to standardize the quantity/volume between battles since the pump spray bottle has 2 Liter capacity.

2.4 Data analysis

Data was analyzed using IBM's SPSS software version 27. Independent variables were the spray bottle type (three) and the sensor location (eight). The dependent variables were the accumulative grip force (CGF) in pounds (lbf) and perceived ratings using Likert scale. Results were considered significant using an alpha level of .05.

3. Findings

The motorized spray bottle was found to have the lowest cumulative grip force for all areas of the hand except for the index finger. The index finger was found to be the greatest contributor to the CGF for both the motorized and traditional spray bottles while the thumb was the prominent contributor for the pump spray bottle. Participants perceived the motorized spray bottle as the most comfortable and easiest to use. Overall, the motorized spray bottle was perceived as the most preferred spray bottle.

4. Discussion and Implication

Overall, the motorized spray was found experimentally to produce the lowest overall grip forces on the hand area compared to the traditional and pump spray bottles. This was in agreement with the findings from the subjective data (participants' perception). Utilizing the motorized spray bottle in the workplace for general housekeeping tasks or similar tasks that require the use of spray bottles, like maintenance tasks, is expected to reduce exposure to occupational risk factors related to hand injury such as carpel tunnel syndrome. Despite these results, it is critical to note that each of the three bottles has different grip force mapping and therefore each spray bottle impacts the hand regions differently. For example, the index finger was the greatest contributor to the CGF for both the motorized and traditional spray bottles while the thumb was the prominent contributor for the pump spray bottle. Even though the motorized bottle was the best option, it has a substantial negative impact on the index finger due to the how the motorized bottle operates (constant static pressure by the index figure) and the short trigger mechanism available on the brand and model evaluated in this study. Spray bottle features should also be considered when evaluating these bottles. The traditional spray bottle is the simplest of the three and work on the principle of pulse trigger (push and release). The motorized spray bottle is battery operated, so the flowrate is a function of the battery life (flowrate decreases with use). There is also the hassle of battery replacement and availability. On the positive side, the load stress from the weight of liquid is not on the hand since the bottle can be hung on the waist with a clip. The pump spray bottle is dependent on the stroke mechanism, so the more strokes, the more pressure generated inside the bottle and consequently the more liquid sprayed. The strokes can be generated by the palm of the hand, reducing the pressure/forces on the fingers except for the thumb, which is needed to push the trigger that is located on the top of the bottle. Lastly, the spray bottles should be tested in workplace settings for an extended period, as this study was conducted in a simulated laboratory and utilized the university student population.