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Ergonomic evaluation of an alternative tool for cake decorating

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ABSTRACT

Aim: Cake decorating involves several hand intensive steps with high grip force during the application of icing. The purpose of this laboratory study was to evaluate forearm muscle activity, discomfort, productivity, and usability of an alternative tool for cake decorating compared to decorating with the traditional piping bag.
Methods: Participants (n = 17) performed 2 h of cake decorating tasks using the two tools. Subjective hand and arm fatigue, usability, upper extremity posture, and muscle activity from three forearm muscles were assessed for each tool. Outcome measures were evaluated using the Wilcoxon Signed Rank test and the paired *t*-test.
Results: Less fatigue was reported in the dominant hand ($p = 0.001$), forearm ($p = 0.003$) and shoulder ($p = 0.02$) for the alternative tool when compared to the piping bag. Average median (APDF 50%) and peak (APDF 90%) muscle activity was significantly less for the alternative tool across all three forearm muscles. The alternative tool significantly reduced grip force, an important risk factor for distal upper extremity pain and disorders. Participants rated usability of the alternative tool superior for refill and comfort but the traditional method was rated better for accuracy, stability, positioning and control.
Conclusions: The alternative tool was associated with less dominant arm fatigue, muscle activity, and grip force when compared with the piping bag. However, the alternative tool did not receive the best overall usability rating due to problems with accuracy and overflow, especially with smaller decorating tips. Recommendations were made for addressing these problems with the alternative tool.

1. Introduction

The task of decorating edible items such as baked goods, candy, and ice cream cakes is a hand intensive task that is associated with high rates of hand and arm musculoskeletal disorders, including carpal tunnel syndrome (Osorio et al., 1994). Cake decorators (COC code 688 - food batchmakers) had the second highest rate of carpal tunnel syndrome of any occupation (310/100,000 workers compared to overall rate across all occupations of 36/100,000) (unpublished, Dr. Robert Harrison) and risk factor reduction is addressed in the OSHA draft guidelines for Retail Grocery Stores (OSHA, 2006). There are approximately 165,270 bakers in the U.S. in 2013 (BLS, 2013).

Workplace epidemiological studies have demonstrated an association between upper extremity musculoskeletal disorders, such as carpal tunnel syndrome, wrist tendonitis, and epicondylitis, and several biomechanical factors such as high grip or pinch force, sustained awkward wrist postures, and high repetition of hand and finger motions (NRC, 2001; Bernard, 1997). The risks are much greater when a worker is exposed to several risk factors simultaneously (Silverstein et al., 1986; Harris-Adamson et al., 2015). Reducing exposure to risk factors in jobs with high rates of distal upper extremity musculoskeletal disorders, such as cake decorating work, should reduce the severity of disability and prevent new cases.

Cake decorating traditionally involves several hand intensive steps including coating the cake with a thin layer of icing, then applying a decorative pattern of icing to the top and sides of the

Abbreviations: APDF, Amplitude Probability Distribution Function; APL, Abductor Pollicis Longus; ED, Extensor Digitorum; FDS, Flexor Digitorum Superficialis; MVC, Maximum Voluntary Contraction; RMS, Root Mean Square; RPE, Rate of Perceived Exertion.

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cake with a piping bag (a cloth or paper cone) filled with icing and squeezed with one hand to expel icing through a dispenser/decorative tip. The other hand typically turns the cake or holds the item being decorated. The process involves applying a high magnitude of grip force to the bag while decorating with precision. The task may require sustained awkward wrist, shoulder, and neck postures. The grip force required is influenced by a number of factors such as bag size, "stiffness" of icing (primarily a function of temperature and ingredients), and dispenser tip size.

The purpose of this laboratory study was to compare an alternative cake decorating tool to the traditional method. The alternative tool was designed to decrease the grip force and awkward postures associated with cake decorating. The study evaluated forearm muscle activity, wrist and shoulder postures, discomfort, productivity and usability among experienced cake decorators while they used each tool for 1 h.

2. Material & methodsv

2.1. Participants

Participants (N = 17) were a sample of convenience recruited from local bakeries and ice cream cake stores. Participants were required to be 18 years or older, have more than one year of experience as a paid cake decorator, and could not have any severe pain or diagnosed musculoskeletal disorder of the upper extremity. Participants completed a brief questionnaire that collected data on age, current upper body pain, and cake decorating experience. The study was approved by the University of California Committee on Human Research.

2.2. Cake decorating tools

Participants performed cake decorating using two tools, the traditional piping bag (12″ or 14″) (Fig. 1) and the alternative tool (Fig. 2). The alternative tool (Easy Piper, Dittmar Development, Coeur d'Alene, Idaho) utilized a pump to transfer icing from an 8-quart disposable bag into an elastic tube, 'charging' and inflating the tube with icing under pressure. The tube was detached from the pump then, at the other end of the tube, a hand-held applicator trigger was attached and held for dispensing icing. Participants were required to use their dominant hand to dispense the icing and could use their non-dominant hand to guide the tool. Both tools weighed approximately the same (612 g) when fully loaded with icing, however, the alternative tool could dispense 396 g of icing and the traditional piping bag could dispense 41% more (559 g). When empty, the alternative tool weighed 217 g and the traditional piping bag weighed 55 g. To compare the forces required to dispense icing from each tool, a force was applied to the piping bag (via a small block of wood to mimic palmar surface area) or the alternative tool switch using a digital force dynamometer to achieve a flow rate typical for decorating (approximately 5 g icing/6 s). Prior to testing, participants were instructed on how to refill and change the tip of the alternative tool and were allowed 30 min of practice time.

Fig. 1. Cake decorating using the traditional piping bag.

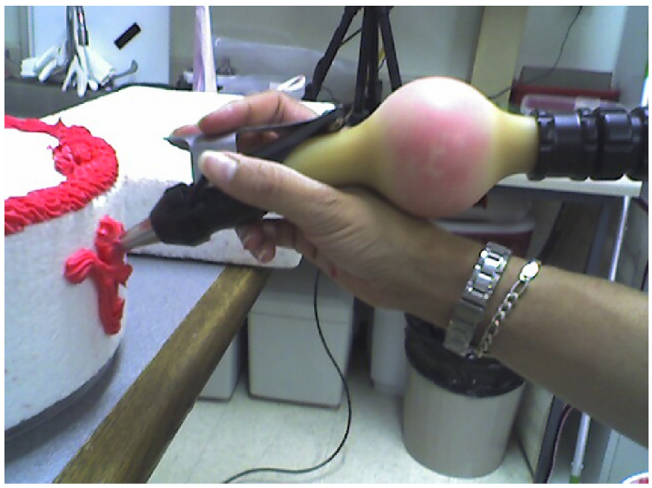

Fig. 2. Cake decorating using the alternative cake décor tool.

2.3. Tasks

Participants performed a 1-h trial of cake decorating with each tool. The order of tool testing was block randomized. Cake decorating was performed on round or rectangular Styrofoam blocks that are used for cake décor training. Two professional cake decorators, excluded from participation, identified three cake designs requiring easy (basic borders and décor), medium (swags and writing), and difficult (basket weave) decorative techniques that required a range of dispenser tips. The smallest tip was round, with a 1.5 mm diameter opening. Participants decorated in the order of easy, medium, and hard and repeated the order until 60 min had passed. The icing was a standard butter cream icing (BakeMark, Los Angeles, California) maintained at room temperature (20 °C). The work surface height was set to 88 cm but the participants could place the cake on top of a 10 cm high round Styrofoam block, if preferred. Cake decorating was done while sitting except for the basket weave and writing which were completed while standing. Participants rested for approximately 20 min between trials which served as a washout period before beginning the next condition.

2.4. Electromyography, video recording, and usability evaluation

Bipolar surface electromyography electrodes were placed over the extensor digitorum (ED), abductor pollicis longus (APL), and the flexor digitorum superficialis (FDS) muscles of the dominant forearm using recommended anatomical placement (Perotto, 2005). Circular Ag/AgCl electrodes with an active diameter of 8 mm and a center-to-center distance of 21 mm were used. Data was recorded using a 4 channel amplifier and data logger (Telemyo 2400T,