Upper extremity kinematics during the functional activities of a hair-blow-drying task

Three-dimensional studies of professional hairdressers.

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Abstract: For hairdressers, direct observation and sEMG studies have been widely used for the identification of risk factors associated with work-related upper limb disorder (WRULD). However, it is unknown what UE joint excursions are required to perform hair-blow-drying tasks since there have been no studies establishing a normative database of the 3D kinematic values of various hairdressing tasks. This study aims to examine the feasibility of 3D motion analysis for the study of the upper extremity (UE) kinematics during functional activities of the hair-blow-drying tasks, to make a contribution to the establishment of a normative database of 3D kinematic values during selected hair-blow-drying tasks and to enable future comparisons with pathologic movements. As a result, some of the composite graphs representing joint motions showed a small standard deviation at the beginning and end of the task. Thus, the same protocol is therefore recommended for implementation in various hairdressing tasks, such as hair-cutting and hair-perming. The next step is to propose and implement training intervention strategies for the functional improvement of various hairdressing tasks for these six professional hairdressers and to evaluate the effectiveness of these strategies by comparisons with the recorded pathologic movements.

Keywords: Upper extremity; 3D motion analysis; hairdressers; Musculoskeletal disorders (MSD)

1. Introduction

1.1 Background

Musculoskeletal disorder (MSD) is a term given to a group of conditions representing a wide range of illnesses that involve the nerves, tendons, muscles and supporting structures. Despite a hairdresser typically spending long hours working on various daily tasks, such as cutting, blow-drying, perming and washing hair, the amount of data and research effort to explore Work-related Musculoskeletal Disorders (WMSDs) during these daily tasks among hairdressers has been limited [1,2,4].

Prior to this research, various assessment tools had been chosen and implemented in order to expose the musculoskeletal disorders among professional hairdressers in Taiwan. The results showed that 91.7% of subjects reported shoulder discomfort as the most frequent problem (n=12). Furthermore, an EMG amplifier is commonly used for recording the electrical activity of the muscles of a participant's body regions during the working activities. However, the limitation of such a technique is that it requires specialists to place the inter-electrode on the surface of the appropriate muscle group in order to record electrode-to-electrode readings properly. Since there is a lack of 3D motion analysis dedicated to hairdressing tasks, an explorative study is required in order to validate its feasibility [1,2,4,5].

1.3. Aim and Objectives

This study aims to examine the feasibility of 3D motion analysis for the study of the upper extremity kinematics during the functional activities of a hair-blow-drying task and, in turn, to establish a normative database of 3D kinematic values during selected hair-blow-drying tasks, thereby enabling future comparisons with pathologic movements. In order to achieve the aim, the following objectives have been achieved:

1. To review literature on the related background information;
2. To choose functional activities of the hair-blow-drying task based on direct observation among invited professional hairdressers;
3. To conduct a trial protocol in order to record the body movement of the chosen functional activities of the hair-blow-drying task for the invited professional hairdressers;
4. To highlight the future work that may be required.

2. Literature Review

3D imaging techniques allow the clinician and ergonomists to measure the position of the extremity in space during the performance of a simulated functional task. The 3D imaging techniques also provide a way to document the multi-planar functional limitations in the UE. It was suggested that the 3D imaging techniques are a good basis for statistical comparison of normal and abnormal subjects, or for measuring outcomes during training intervention and treatment. The observations using the 3D imaging techniques show that these parameters are easy to detect and are a clinically useful measure for statistical comparison of populations. Furthermore, the data obtained from the 3D imaging techniques can lead to the development of a kinematic model for a transradial prosthesis or as a training guide for upper limb prosthetic use during the activities involved in various working tasks. Moreover, the 3D motion analysis offers the opportunity to reveal the relation between the extremity motion and the risk of experiencing work-related injuries. In fact, the relation between the range of upper extremity motions and the key risk factors for joint pain, as in handbike propulsion, was studied with the help of 3D movement analysis. As a result, it was revealed that the high amplitudes and fast angular joint accelerations of the upper extremity could result in overuse injuries. However, the 3D imaging techniques have not been routinely used for this purpose primarily due to a lack of standardized protocols stemming from the complex nature of UE motion. The problem using the 3D imaging techniques was omissions in the recorded camera data arising from tracking errors. Fortunately, current developments of the motion system have provided the filtering algorithm for the statistical smoothness characteristics of the camera data under the assumption that a human movement trajectory should not contain any sudden shifts [2,3,4,5,6].

3. Trial Protocol

3.1. Subject Selection

Six professional hairdressers (one male, five females, aged 21-26 years) completed the study under a protocol approved by the Tainan University of Technology Department of Styling and Cosmetology Institutional Review Board. Subjects had no orthopaedic or neurological conditions and no upper extremity limitations. They were asked to perform the four simulated tasks from the start position, and to return their arm to their side after achieving the desired movement. The experimental procedures were approved by the Review Board of the Department of Occupational Therapy, National Cheng Kung University, Taiwan. (Ref.: Fang200804).

3.2. Testing Apparatus

A six-camera, 3D, motion analysis system (Qualisys ProReflex-MCU240, Qualisys AB, Gothenburg, Sweden) was used to capture kinematic data at 100 Hz. Twenty retro-reflective markers (1”-diameter) were attached to the participant over pre-determined bony landmarks of the trunk and upper extremities where subcutaneous tissue was thin and relatively fixed to the underlying skeleton.

3.3. Experimental Procedure

At the beginning, twenty retro-reflective markers were attached to the participant. The motion system was calibrated. Subjects were asked to perform the four simulated hair-blow-drying tasks from the start position, and to return their arm to their side after achieving the desired movement. The transition from rest to activity was repeated for four blocks.

4. Selected Results and Analysis

4.1. Description of the Simulated Tasks

Prior to the study, a direct observation using digital video was conducted over ten subjects in order to define the hairdressing tasks. As a result, four simulated hair-blow-drying tasks are chosen and shown in Table 1 below. The outcome measures on the right limb were examined by using SPSS software (Ver. 15 for Windows, Chicago, IL).

Table 1. Description of simulate tasks

Task ID	Task name	Motion description
BD-over-head	Blow-drying over the head.	Hand to the front of the customer’s head.
BD-top-head	Blow-drying the top of the head.	Hand to the top of the customer’s head.
BD-back-head	Blow-drying on the back of the head.	Hand to the back of the customer’s head.
CR-over-head	Curling the hair roll over the head.	Wave the arm over the front of the customer’s head.

4.2. Motion Analysis

The positions of the UE during the activities of these four simulated hair-blow-drying tasks were expressed as the mean joint angles, as shown in Table 2. One-way ANOVA analysis indicated that the difference of each joint angle among the tasks was significant ($p<0.000$) [13].

Table 2. Motion analysis during four simulated hair-blow-drying tasks

Joint motion	BD-over-head	BD-top-head	BD-back-head	CR-over-head
Right shoulder flexion (^{o})	-24 (24)	-19 (21)	-12 (20)	-16 (27)
Right shoulder abduction (^{o})	33 (28)	29 (25)	22 (25)	24 (26)
Right shoulder external rotation (^{o})	-2 (58)	-7 (63)	-12 (59)	-29 (59)
Right elbow flexion (^{o})	-44 (61)	-26 (96)	-47 (80)	-20 (91)
Right elbow abduction (^{o})	-29 (40)	-27 (39)	-29 (49)	-22 (44)
Right forearm pronation (^{o})	-32 (71)	-28 (66)	-40 (57)	-40 (55)

Joint motion reported as mean value with standard deviation in parentheses. (n = 6)

5. Discussion

This study aims to examine the feasibility of 3D motion analysis for the study of the upper extremity kinematics during functional activities of a hair-blow-drying task and, in turn, to establish a normative database of 3D kinematic values during selected hair-blow-drying tasks, enabling future comparisons with pathologic movements. As a result, several unique characteristic curve patterns were identified in certain movement, and some of these representing joint motions showed a small standard deviation at the beginning and end of the task. This indicates the potential for implementing 3D motion analysis for the kinematic study of the tasks carried out by hairdressers, such as hair-cutting and hair-perming.

6. Future Work

The next step is to propose and implement training intervention strategies for functional improvement of various hairdressing tasks among these six professional hairdressers, and to evaluate the effectiveness of the training intervention strategies by comparison with these recorded pathologic movements.

7. References

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