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Measurement of stressful postures during daily activities: An observational study with older people

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ABSTRACT

This study measured the postures of older people during cooking and laundry. A sample of men and women aged 75+ years ($n = 27$) was recruited and observed in a home-like environment. Postures were recorded with a measurement system in an objective and detailed manner. The participants were videotaped to be able to see where 'critical' postures occurred, as defined by a trunk inclination of $\geq 60^{\circ}$. Analysis of data was facilitated by specially developed software. Critical postures accounted for 3% of cooking and 10% of laundry, occurring primarily during retrieving from and putting in lower cabinets, the refrigerator, laundry basket or washing machine as well as disposing into the waste bin. These tasks involve a great variation in postural changes and pose a particular risk to older people. The results suggest that the use of stressful postures may decrease efficiency and increase fatigue, eventually leading to difficulties with daily activities. The specific tasks identified during which critical postures occurred should be targeted by designers in order to improve the activities. A few examples are given of how better design can reduce or eliminate some of the postural constraints.

1. Introduction

The challenge of facilitating independent living in old age is shared by health researchers and those from other disciplines, such as engineering, product design and architecture [1]. Although evidence suggests that modifying the home environment can minimise disability-related outcomes [2], field studies are needed to help develop design guidelines. Two activities necessary for independent living in the community are preparing meals and doing laundry [3]. The ability to cook is highly valued by older people, particularly women [4], and regular hot meals contribute substantially to daily energy intake [5]. Being able to do laundry was found to be more strongly associated with self-rated health than, for example, using the telephone, shopping for groceries, doing housework and managing medication [6].

Cooking and laundry place demands on mobility, reaching, lifting, carrying and dexterity; however, not all of these functions are equally likely to cause difficulty. Most difficulties among a sample of older people in Great Britain were attributable to limitations in body postures, primarily bending/stooping (40–45%), whereas actions and hand function accounted for many fewer difficulties [7]. Thus, identifying the activity components associated with critical postures is important to design products and services that enhance independence. Only once we know which tasks cause such postures and how often these occur will it be possible to develop effective design solutions.

1.1. Objectives

This study's objective was to investigate the body postures assumed by older people during cooking and laundry. Postures that are considered to be critical were identified and quantified, including an assessment of factors that promote their occurrence and the tasks from which they arise.

1.2. Recording postures

To study the relationship between activities and postures and ultimately improve the design of the task environment, a measurement system is needed for recording postures on a continuous basis. For the system to be practical, it should be easy to learn and use, reliable and interfaced with a computer for data analysis and storage [8]. Systems for motion recording and analysis are commercially available, which have the advantage that

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multiple joint movements can be recorded simultaneously. While these systems possess the accuracy to record detailed postures, their use is limited due to their cost and complexity [9]. A variety of sensor systems can be found in the literature, ranging from single attached sensors to complex systems. Despite guaranteeing continuity, the systems available often only record single body angles [10] or limit the ability to move around freely [11]. To overcome these limitations, a measurement system has been developed that records an individual's pattern of movement under realistic conditions with minimised interference; data analysis is facilitated by special software and the data can be linked to specific tasks (see below).

2. Methods

2.1. Measurement system

The CUELA measurement system ('computer-assisted recording and long-term analysis of musculoskeletal loads') was developed by the German Institute for Occupational Safety and Health [12]. Fig. 1 shows the measurement system in use. Sensors are attached to the thoracic and lumbar spine as well as hip and knee joints. Each sensor has a sample rate of 50 Hz and, thus, even dynamic movements can be mapped. Movements are recorded in three planes: trunk inclination, lateral flexion and torsion. In addition, the angular positions of the hip and knee joints are measured. All system components are attached to the individual, allowing him or her to move freely about. CUELA has been demonstrated to have good validity and reliability in field studies [12].

2.2. Study centre

The Centre for Health and Building at the Royal Institute of Technology, Sweden, has created a home-like research apartment in which older people were observed during cooking and laundry.

2.3. Activity simulations

Activities were simulated based on a task analysis [13] and task descriptions from the Assessment of Motor and Process Skills [14]; full details can be obtained from the corresponding author. First, individuals were required to prepare a pancake and serve it with a topping. The pancake had to be cooked in a frying pan; the batter had to be prepared with dry ingredients, at least one liquid and one egg; and the topping had to be put on before serving. Unneeded items had to be returned to their original storage locations, dirty utensils placed in or beside the sink and waste discarded into a bin. Second, individuals were required to load laundry from a basket into a washing machine, measure and add detergent and set and start the machine. The type of washing machine used had to be familiar and, therefore, both front- and top-loaders were provided. After the washing cycle was finished, the laundry had to be removed from the machine and hung on a clothesline to dry. Another basket of laundry was available for folding. Prior to beginning, all individuals were completely familiarised with the kitchen environment and laundry area.

2.4. Data collection

At the start of the measurement, the individuals had to assume a standardised upright position with all body angles set at zero. This posture had to be adopted again at the end in order to see whether any sensors had been displaced. Participants' height and weight were measured to be able to reconstruct the movements more precisely. The movement data were saved on a storage unit and transferred to a computer after digitisation. Specially developed software was used to visualise and analyse the data. Participants were videotaped by cameras to be able to see where critical postures occurred. The videos were later synchronised with the movement data. For this to be possible, a synchronisation point was recorded at the start. A snapshot of the software's user interface showing the analysis of a video sequence can be found elsewhere [15]. Interviews were conducted to obtain information on age, gender, chronic conditions (hypertension, heart attack, stroke, diabetes, arthritis and hip fracture), capability limitations (vision, cognition, locomotion and reaching) and disability (cooking, housework, laundry, shopping and transportation) (Appendix 1).

Fig. 1. Measurement system in use during (A) cooking and (B) laundry.