Time-on-legs: Measuring Weight-bearing Activities and Postures in Older People Using a Pendant Sensor

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***Abstract*—Results are presented of a study on detecting weight-bearing activities and postures in older people using a pendant sensor device. Mean sensitivity and specificity were 84% and 94% in time-on-legs (TOL) detection in 21 older people in free moving. Discrepancy between total time of TOL estimated by the sensor and the video was on average 10%.**

I. Introduction

Weight-bearing activities and postures in daily life (e.g. walking and standing) are important in maintaining bone and muscle strength and reducing the risk of injuries[1]. Wearable sensors have gained popularity in unobtrusive and objective quantification of daily activities, which might be feasible to facilitate physical activity monitoring and intervention in a long-term free living environment[2]. In this article, we present the results of our study in measuring time-on-legs (TOL): time spent on weight-bearing activities and postures (walking and standing), in older people using a pendant sensor device.

II. Methods

Twenty-one older people (16 females, 5 males, age: 70-89) participated in two experiments: 1). subjects were instructed to perform activities following a standard protocol; 2). Subjects performed free movements as in their daily life for ca.30 minutes without guidance of a protocol. Both experiments were carried out in the subjects' homes. Subjects were allowed to use walkers or canes and perform with their comfort manners in both experiments. A video camera was used to record the activities.

A sensor device consisting of a 3D accelerometer (50Hz) and an air pressure sensor (25Hz) was worn with a necklace belt in front of the chest unrestrictedly[2]. The second-wise sensor output of walking, standing, sitting, lying and TOL was validated against the video recording. Discrepancy of TOL was computed as $|T_{\text{TOLsensor}} - T_{\text{TOLvideo}}| / T_{\text{TOLvideo}}$, in which $T_{\text{TOLsensor}}$ and T_{TOLvideo} are the total time of TOL estimated by the sensor and the video recording.

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III. Results

The length of video recording was 9.4±2.9 (mean±SD) minutes for the standard protocol and 28.4±3.4 minutes for the free moving. In Table 1, mean and standard deviation of the sensitivity and specificity of activity, posture, TOL detection and the discrepancy of the total time of TOL estimation are summarized.

TABLE I. Validation results of the pendant sensor output against the video recording.

	Standard Protocol		Free Moving	
	Sensitivity	***Specificity***	***Sensitivity***	***Specificity***
Walk	0.62±0.21	0.98±0.02	0.45±0.18	0.96±0.03
Stand	0.61±0.26	0.83±0.12	0.78±0.21	0.68±0.21
Sit	0.83±0.15	0.66±0.21	0.85±0.28	0.83±0.20
Lie	0.30±0.22	0.99±0.01	0.65±0.24	0.99±0.01
TOL	0.73±0.20	0.88±0.10	0.84±0.15	0.94±0.10
Discrepancy	0.11±0.08		0.10+0.10	

IV. Discussion

The pendant sensor detected walking with moderate sensitivity and good specificity. Walking with discontinuous irregular steps, which were observed frequently during free moving, could be misclassified as standing. Lying was not recognized by the sensor when subjects were lying for very short periods of time (only a few seconds during standard protocol). The moderate to good sensitivity and the good specificity in TOL detection indicated that the weight-bearing and non-weight-bearing activities and postures in general can be well discriminated by the pendant sensor. The total time of TOL might be a useful parameter in quantification of daily activity level in older people.

References

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