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RELIABILITY STUDY

A reliability study of the new sensors for movement analysis (SHARIF—HMIS)

Mohen Abedi, PT, PhD [a,1], **Farideh Dehghan Manshadi, PT, PhD** [a,*,2], **Minoo Khalkhali Zavieh, PT, PhD** [a], **Sajad Ashouri, M.Sc** [b,3], **Hadi Azimi, PhD** [c,4], **Mohamad Parnanpour, PhD** [d,5]

[a] *Physiotherapy Department, School of Rehabilitation Sciences, Shahid Beheshti University of Medical Sciences, Tehran, Iran*
[b] *School of Mechanical Engineering, Sharif University of Technology, Tehran, Iran*
[c] *Department of English Language Teaching, School of Medicine, Shahid Beheshti University of Medical Sciences, Tehran, Iran*
[d] *Department of Industrial Engineering & Manufacturing, University of Wisconsin Milwaukee, WI, USA*

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Summary *Aim:* SHARIF—HMIS is a new inertial sensor designed for movement analysis. The aim of the present study was to assess the inter-tester and intra-tester reliability of some kinematic parameters in different lumbar motions making use of this sensor.
Materials and methods: 24 healthy persons and 28 patients with low back pain participated in the current reliability study. The test was performed in five different lumbar motions consisting of lumbar flexion in 0, 15, and 30° in the right and left directions. For measuring inter-tester reliability, all the tests were carried out twice on the same day separately by two physiotherapists. Intra-tester reliability was assessed by reproducing the tests after 3 days by the same physiotherapist.
Findings: The present study revealed satisfactory inter- and intra-tester reliability indices in different positions. ICCs for intra-tester reliability ranged from 0.65 to 0.98 and 0.59 to 0.81 for healthy and patient participants, respectively. Also, ICCs for inter-tester reliability ranged from 0.65 to 0.92 for the healthy and 0.65 to 0.87 for patient participants.

* Corresponding author. School of Rehabilitation Faculty, Shahid Beheshti University of Medical Sciences, Damavand Ave., Imam Hussein SQ., Tehran, P.O. Box: 1616913111, Iran. Tel.: +98 21 77548496; fax: +98 21 77591807.
E-mail addresses: manshadi@sbmu.ac.ir, farideh4351@gmail.com (F.D. Manshadi).
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Conclusion: In general, it can be inferred from the results that measuring the kinematic parameters in lumbar movements using inertial sensors enjoys acceptable reliability.

Introduction

Wearable measuring systems have extensively been used in biomedical engineering (Wong et al., 2007). This technology has many diverse applications (Patel et al., 2012), including usage as a home rehabilitation device, assessment of the outcomes of different therapeutic interventions, and early detection of certain disorders (Bonato, 2010). Also, these systems enjoy many benefits as they are compact and easy to use, and bring about no negative effect on the daily activities (Bergmann and Mcgregor, 2011). Inertial sensors are composed of accelerometers, gyroscopes, and magnetic sensors (Fong and Chan, 2010). Among many interesting applications of these sensors is angle estimation, for example, in knee flexion/extension movements (Fong and Chan, 2010).

During the past decade, some researchers have made efforts to combine accelerometer, gyroscope, and magnetic sensors by Kalman filter (Wong et al., 2007). This filter is typically applied to fuse the output of these sensors for many assessment methods such as gait analysis and kinematics measurements (Greene et al., 2010; Favre et al., 2008). X Sense and Biosyn companies produced full human movement systems in 2010 (Patel et al., 2012). Despite the recent developments in human movement measuring systems by making use of the IMUs (Inertial Measurement Units), these systems are expensive and cannot be utilized for a long time (Williams et al., 2013).

In 2012, a new device was developed to record acceleration, rate of the gyro, and magnetic field of human movements with Euler angles by the direction cosine matrix method. This system enjoys several advantages in comparison with the relevant commercial devices. First, it uses lower price IMUs. Second, comparatively, it weighs less. Next, it is non-invasive. Fourth, it does not impede with daily routine, and finally, its three-dimensional instrumentation of human body movements makes the system advantageous over the other existing systems.

This system is composed of ten IMU sensors and a data logger, attached on stretchable clothing. The system is named SHARIF—HMIS (Sharif—Human Movement Instrumentation System). The aim of the present study was to assess the inter- and intra-tester reliability indices of the Sharif—HMIS for measuring lumbar motions in five positions in two groups of participants with and without low back pain.

Methods

Equipment

The Sharif—HMIS is a recently-developed electronic device. This sensor can be used by healthy people and patients to monitor their movements. Real-time feedback is beneficial for the patients because it helps them to immediately correct their body postures or to stop the physical activities that may bring about a higher risk of injury. This system consists of two parts: the sensor that attaches to the body, and the software that saves the data.

Participants

The sample comprised of two groups. The first group included 24 healthy male participants with no history of low back pain in the previous year. They were staffs of a hospital in Tehran, Iran. Participants in the second group included 28 male patients with low back pain who had referred to the physiotherapy clinic in a hospital in Tehran, Iran. The inclusion criterion for these participants was having low back pain at least during the previous three months without any identified underlying pathology. The age of the first group ranged between 25 and 45 years (average 35) and the patient participants ranged from 30 to 50 years old (average 40). The Ethics committee of Shahid Beheshti University of Medical Sciences, Tehran, Iran, approved the study and, in addition, the participants were recruited on a voluntary basis and were asked for their permission to participate in the study by signing a consent form. Some demographic characteristics of the participants are given in Table 1.

Set up

Two Sharif—HMIS sensors were utilized in the present study. For better attachment of the sensors, the patients were

Table 1 Demographic characteristics of the participants (n = 52).

Variables	Healthy subjects (n = 24)	LBP Patients (n = 28)	t-test (p value)
Age (year)	35 (6.8)	40 (4.1)	0.12
Height (cm)	170 (9.3)	174 (7.1)	0.09
Weight (kg)	73.3 (8.8)	70.4 (8.10)	0.10
BMI (kg/m^2)	25.3 (5.6)	23.3 (4.3)	0.22