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Research Article

Reliability of Knee Kinematic Parameters during Drop Jump Landing in Healthy Male Subjects

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ABSTRACT

Introduction: Knee joint has the highest percentage of injuries among lower extremity joints especially in athletes and people with high activity levels. Therefore, analyzing of knee movements has an important area of research in the bioengineering and rehabilitation fields. Sharif human movement instrumentation system (SHARIF-HMIS) is a new inertial sensor designed for movement analysis. The purpose of this study was to determine the reliability of knee kinematic parameters using SHARIF-HMIS.
Material and Methods: A total of 25 healthy male subjects (aged 18-28 years) participated in this study. SHARIF-HMIS sensors were fixed with straps on dominant leg of the participants. Thereafter, they performed double leg drop jump landing from a box with a height of 30 cm. Linear acceleration and angular velocity were analyzed in initial contact phase. The test was performed 3 times at an interval of 1 hour. To assess the intra-rater reliability, intraclass correlation coefficient (ICC) and standard error of measurement (SEM) were calculated.
Results: ICC in X, Y and Z planes was 0.99, 0.80 and 0.97 for linear acceleration and 0.50, 0.79 and 0.74 for angular velocity, respectively. Furthermore, the SEM in X, Y and Z planes were 0.03, 0.19 and 0.14 for linear acceleration and 0.007, 0.009 and 0.01 for angular velocity, respectively.
Conclusion: This study showed good test-retest reliability of knee kinematic parameters during double leg drop jump landing. Hence, the use of SHARIF-HMIS as a new and portable device is suggested for assessing knee joint movements.
Keywords: Reliability; Knee kinematic; Sharif-Human movement instrumentation system; Acceleration; Angular velocity; Drop jump landing

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Introduction

The knee joint sustains the highest percentage of injuries, particularly among physically active individuals such as runners and military recruits (1, 2). There is a high relationship between knee injuries and osteoarthritis in young athletes especially in female athletes (3, 4). Since the most common ligament injuries occur in non-contact deceleration tasks (5), monitoring the knee joint movements during physical activity, is essential (6). There are various measurement tools for analyzing human movements. These tools can be used for early detection of disorders and/or for assessing the efficacy of therapeutic interventions. However, some of them such as gait analysis are expensive and could only be used in laboratory environments (7-9). Therefore, simple devices consisted of small electronic sensors including accelerometer and gyroscope were developed. Gyroscope is based on the concept of measuring the Coriolis force of vibrating devices (10). The angular orientation can then be obtained from integration of the gyroscopic signal. When a combined form of the gyroscope and accelerometer is used, movement can be measured accurately.

Recently, a new human movement measurement instrument was designed and manufactured in Sharif Industrial University (89 A 014589) named Sharif human movement instrumentation system (SHARIF-

HMIS). Inertial measurement units and a data logger have been used in this device to record acceleration, gyro rate, and magnetic field of human movements. It is a real-time, three dimensional (3D) motion analysis system which can be used easily during daily activities (11, 12). The aim of this study was to determine the reliability of knee kinematic parameters using SHARIF-HMIS during double leg drop jump landing in healthy male subjects.

Materials and methods

A total of 25 healthy male subjects, aged between 18 and 28 years were recruited for this study. All participants signed an informed consent. Furthermore, the study was approved by Ethics Committee of Tehran University of Medical Sciences. Demographic characteristic of the subjects is shown in table 1.

Table 1. Demographic characteristics (n = 25)

Demographic characteristics	Mean ± SD	Range
Age (year)	22.56 ± 3.11	18-28
Height (cm)	173.52 ± 7.30	16-186
Weight (kg)	70.82 ± 10.65	55-100

SD: Standard deviation

Subjects were excluded from the research if they were unable to perform and complete tests, or if they reported pain during the experiment. Before starting the experiment, the test procedure was explained for the participants. They were instructed how to drop down on the ground from a box with a height of 30 cm and perform immediately one maximum vertical jump. The subjects were asked to keep their arms in the "stop position" (shoulders abducted 45° and elbows flexed 90°) to reduce momentum from arm swing (Figure 1). Next, two SHARIF-HMIS inertial sensors were attached on femur and tibia of dominant leg of each subject. The femur sensor and the tibia sensor were attached on superior_lateral and inferior_medial side of the patella by straps (Figure 2).

Figure 1. Participant standing position

Figure 2. Femur and tibia sensors

Direction of one sensors axis adjusted with axis of knee joint movements (13). To minimize learning effects, two trials of the drop-jump task were allowed and then three main drop jumps were performed. A 10-second interval between trials was implemented to reduce fatigue (14).

Angular velocity and linear acceleration data were collected by gyroscope and accelerometer sensors, respectively.

Sampling rate of each sensor during movement was 50 Hz. Custom software written in MATLAB (Mathwork works MATLAB R2015a) was used to calculate 3D kinematic rotation angles of the knee. The data were filtered using a Butterworth filter (fourth-order, zero-lag, low-pass cut-off at 10 Hz). The best data were used for analyzing (15). Trials were excluded during processing if markers were missing at the beginning or ending of the landing phase. The procedure repeated again after 1 hour to determine the reliability (16, 17).

Knee joint accelerometer and angular velocity calculated in X, Y and Z planes (Figure 3). Data were entered into and analyzed with SPSS (Version 19; SPSS Inc., Chicago, IL, USA). Statistical significance was accepted at the level of 0.05. Intraclass correlation coefficient (ICC) and standard error of measurement (SEM) were used to estimate the relative and absolute reliability of kinematic parameters.

Results

Demographic characteristics of the subjects are shown in table 1. First of all, the Kolmogorov–Smirnov test was used and showed normal distribution of data ($P > 0.05$).

ICC and SEM obtained from knee kinematic data while landing on the ground in X, Y and Z planes were presented in table 2. $P < 0.05$ for all data.

Based on Munro's correlation descriptors, sensors kinematic parameters had moderate to high correlation (18). In addition, Pearson correlation was also calculated for all data. There was a positive correlation for each of the measures (0.99, 0.80, 0.97 for acceleration and 0.52, 0.79, 0.74 for velocity in X, Y, Z planes; respectively).

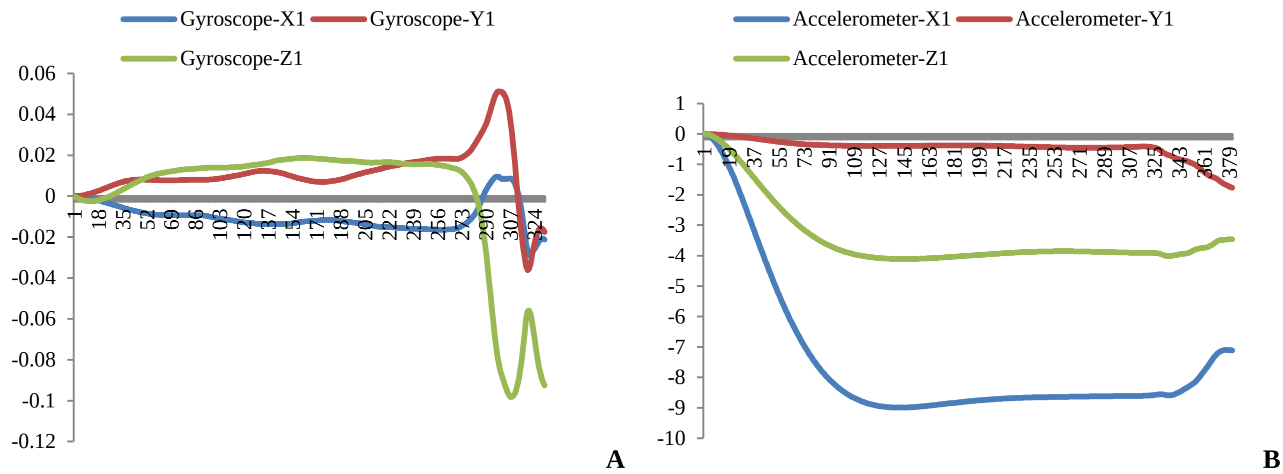

Figure 3. Sensors signal in three axis (X, Y and Z), (a) Gyroscope, (b) accelerometer

Table 2. Intra tester reliability of SHARIF-HMIS sensors data during double leg landing

Variable	ICC	SEM	95% CI
Linear acceleration (deg/s^2)			
X	0.99	0.03	0.99-0.99
Y	0.80	0.19	0.65-0.89
Z	0.97	0.14	0.95-0.98
Angular velocity (deg/s)			
X	0.50	0.007	0.21-0.71
Y	0.79	0.009	0.62-0.89
Z	0.74	0.01	0.55-0.86

$P < 0.05$. ICC: Intraclass correlation coefficient, SEM: Standard error of measurement, CI: Confidence interval, SHARIF-HMIS: Sharif human movement instrumentation system

Discussion

In this study, we investigated knee movements during double leg drop jump landing using SHARIF-HMIS sensors. These inertial sensors are part of a new instrument designed by a group of researches in Sharif University of Technology. Since this portable device can analyze 3D movements of human even during the functional activities, the reliability of its indices is necessary. We determined both relative and absolute reliability of linear acceleration and angular velocity of knee movements. Relative reliability was found high to very high for linear acceleration, and moderate to high for angular velocity. On the other hand, absolute reliability was obtained for all indices. These finding besides high relationship of the measures between two repetition sessions provide evidence for good reliability of the above indices using SHARIF-HMIS. These findings are in line with some reliability studies about kinematic parameters of the other parts of the body. For example, Duc et al. (16) reported good reliability (ICC: 0.63-0.99) of neck kinematic parameters by using different inertial sensors. Furthermore, Ronchi et al. (19) reported high reliability of their new hodograph sensor (named BSM) for spinal column kinematic studies.

Conclusion

To the best of our knowledge, this is the first study which investigated the reliability of knee kinematic parameters using SHARIF-HMIS sensors. We found good reliability of SHARIF-HMIS sensors in measuring knee joint kinematic parameters. Further research is recommended in this area to assess the reliability of these sensors during the other activities/functions of the knee joint.

Conflict of Interests

Authors have no conflict of interests.

Acknowledgement

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REFERENCES

1. Taunton JE, Ryan MB, Clement DB, McKenzie DC, Lloyd-Smith DR, Zumbo BD. A retrospective case-control analysis of 2002 running injuries. Br J Sports Med 2002; 36(2): 95-101.
2. Jordaan G, Schwellnus MP. The incidence of overuse injuries in military recruits during basic military training. Mil Med 1994; 159(6): 421-6.
3. Arendt E, Dick R. Knee injury patterns among men and women in collegiate basketball and soccer. NCAA data and review of literature. Am J Sports Med 1995; 23(6): 694-701.
4. Hewett TE, Myer GD. The mechanistic connection between the trunk, hip, knee, and anterior cruciate ligament injury. Exerc Sport Sci Rev 2011; 39(4): 161-6.
5. Kirkendall DT, Garrett WE, Jr. The anterior cruciate ligament enigma. Injury mechanisms and prevention. Clin Orthop Relat Res 2000; (372): 64-8.

6. Weissman S. Anthropometric photogrammetry. Photogrammetric Engineering 1968; 34(11): 1134-40.
7. Dawson EG, Kropf MA, Purcell G, Kabo JM, Kanim LE, Burt C. Optoelectronic evaluation of trunk deformity in scoliosis. Spine (Phila Pa 1976) 1993; 18(3): 326-31.
8. Robinson ME, O'Connor PD, Shirley FR, Mac MM. Intrasubject reliability of spinal range of motion and velocity determined by video motion analysis. Phys Ther 1993; 73(9): 626-31.
9. Hsiao H, Keyserling WM. A three-dimensional ultrasonic system for posture measurement. Ergonomics 1990; 33(9): 1089-114.
10. Tong K, Granat MH. A practical gait analysis system using gyroscopes. Med Eng Phys 1999; 21(2): 87-94.
11. Mokhlespour MI, Zobeiri O, Akbari A, Milani Y, Narimani R, Moshiri B, et al. Sharif-human movement instrumentation system (SHARIF-HMIS) for daily activities. Proceedings of 19th Iranian Conference of Biomedical Engineering (ICBME); 2012 Dec 20-21; Tehran, Iran.
12. Mokhlespour MI, Zobeiri O, Akbari A, Moshiri B, Parnianpour M. Wearable Human Movement Instrumentation System. Iran Biomed J 2014; 7(4): 361-9. [In Persian].
13. Favre J, Aissaoui R, Jolles BM, de Guise JA, Aminian K. Functional calibration procedure for 3D knee joint angle description using inertial sensors. J Biomech 2009; 42(14): 2330-5.
14. Ekegren CL, Miller WC, Celebrini RG, Eng JJ, Macintyre DL. Reliability and validity of observational risk screening in evaluating dynamic knee valgus. J Orthop Sports Phys Ther 2009; 39(9): 665-74.
15. Marras WS, Parnianpour M, Ferguson SA, Kim JY, Crowell RR, Bose S, et al. The classification of anatomic- and symptom-based low back disorders using motion measure models. Spine (Phila Pa 1976) 1995; 20(23): 2531-46.
16. Duc C, Salvia P, Lubansu A, Feipel V, Aminian K. A wearable inertial system to assess the cervical spine mobility: comparison with an optoelectronic-based motion capture evaluation. Med Eng Phys 2014; 36(1): 49-56.
17. MATLAB Lecture 7. Signal Processing in MATLAB. Introduction to Symbolic Computation [Online]. [cited 2007 Jan 23]; Available from: URL: http://homepages.math.uic.edu/~jan/mcs320s07/matlec7.pdf
18. Mathur S, Eng JJ, Macintyre DL. Reliability of surface EMG during sustained contractions of the quadriceps. J Electromyogr Kinesiol 2005; 15(1): 102-10.
19. Ronchi AJ, Lech M, Taylor NF, Cosic I. A reliability study of the new Back Strain Monitor based on clinical trials.Conf Proc IEEE Eng Med Biol Soc 2008; 2008: 693-6.