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Reliability of optoelectronics motion capture analysis in hip range of motion

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Abstract

Purpose: The purpose of this study was to determine the reliability of optoelectronic motion capture analysis to determine the hip range of motion.

Materials and Methods: Fifteen recreationally active male participants (age 26.67 + 4.84 years). Measurement values were got by performing the optoelectronic motion capture analysis on subjects with sensors attached to their bodies. The Root mean square error (RMSE) was used to determine the accuracy of optoelectronic motion capture analysis values got by the assessors and it was compared with the standard hip range of motion.

Results: The Root mean square error of optoelectronic measurements of the hip range of motion was calculated in reference to standard values. The left sided external rotation showed the highest deviation from the standard values (26.57). Hip adduction measurements using optoelectronic motion capture analysis were least deviated from standards (right – 29.70 and left – 29.70).

Conclusion: The optoelectronic motion capture analysis is a reliable tool to calculate the hip range of motion. But, further well designed studies need to be done in order to eliminate the limitations found in our study.

Keywords: Optoelectronics, Hip, Range of Motion, Reliability.

Introduction

Sports is the part of many peoples life; not only the athletes performing at competitive sports, but also the common man for the purpose of fitness, leisure and entertainment. Over time, each sport places specific demands on musculoskeletal system, which may result in tissue adaptation or overuse injuries. As a result, many individuals who participate in sports experience injuries that relate to their participation.(1,2) Hip disorders leading to chronic pain have been significantly noticed in many sports like football, hockey, soccer, rugby, martial arts and tennis.(3,4)

The pathology may arise either due to congenital malformations of the femur and acetabular rim or excess shear loads on the joints due to the demands of the sport.(5,6) These factors reduce the ability to participate in athletic exercises. Keogh & Batt (2008) found out that hip injuries are suggested to account for 5–6% of all adult athletic injuries and are a noteworthy cause of morbidity in athletes.(7) Although they are most commonly related to extra-articular muscular strains or sprains, intra-articular lesions affecting the acetabular labrum, articular cartilage, and capsular and ligamentous structures are frequently the cause of intractable hip pain that may be difficult to diagnose accurately.(8)

The range of motion (ROM) can be calculated by various devices and techniques like Goniometry, Radiography, Fluoroscopy, Isokinetic Machines, Optoelectronics Motion Capture System, Digital photography, and High-speed Camera.There are many studies on the reliability, Validity of Goniometry and other devices but there are very few on Optoelectronic Motion Capture system especially for measurement of hip ROM from the view of clinical application.To fill up this Gap in the Literature this study was conducted to determine the reliability of optoelectronic motion capture analysis in measurement of the hip range of motion.

The Hip range of motion (ROM) is an important clinical parameter which is measured, calculated and required in the following clinical conditions and other fields:

1. Early diagnosis of hip Impingement (FAI) especially in sports like Soccer, Rugby or for that matter most of the sports.
2. To know the perfect ROM for Sports activities in sorts like Gymnastics, Ball dancing, high and long jump and many more
3. In Orthopaedic Clinical, and Rehabilitation especially of elite athletes and sports persons.
4. For Biomechanical studies
5. Gait analysis in Neurosciences and /or Paediatrics or even Orthopaedics.
6. In Orthotics and Prosthetics design and research.

Optoelectronic Motion Capture system is used in the following fields:

1. Sports
   a. Technique Analysis
   b. Technique Correction
   c. Performance Analysis
   d. Performance Enhancement
2. Medical Sciences
   a. Posture, Balance and Motor control
   b. Gait Analysis
   c. Psychology
3. Human Biomechanics
4. Endo-prosthetics – THR and TKR

5. Engineering
6. Robotics
7. Entertainment and Gaming
8. Animation
9. Animal Biomechanics
10. Sound and Motion – Music

Hence both Optoelectronic Motion capture system and Hip Range of Motion both are important in view of its application in various fields and hence this study becomes important as it has a practical application or translational value.

For a measurement technique to be agreeable there must be a high degree of reliability and validity. A reliable clinical instrument allows for measurement outcomes that are consistent, accurate, precise and predictable.[9] Over the past recent years, many developments have occurred in measuring ROM; from advanced goniometers to high speed cinematography. Sports scientist and kinesiologists have relied on optoelectronic motion capture systems and digital photography to perform analysis of movement and sports performance in general.[10,11]

Adrian Lees and Moura, 2005, Fukashiro et al., 2005 found high reliability when conducting experiments using Optoelectronics system when performing gait analysis and joint kinematics in laboratory and field settings.[12,13] But, the evidence of the reliability of the optoelectronic motion capture systems in determining the hip range of motion in supine position are rare in literature.

Thus, the purpose of our study was to establish the role and reliability of optoelectronic motion capture analysis for measuring the hip range of motion in supine patients.

Materials and Methods

This study was done on 15 recreationally active male participants. This study was given ethical clearance by the Ethics committee of the institution after submission of ethical and laboratory risk assessment forms.

Study Design: Cross-Sectional, Observational study.
Inclusion Criteria:

1. 18-40 year old healthy young male.
2. Willingness to participate in the study.
3. Physiotherapists interested in carrying out the assessments.

Exclusion Criteria:

1. Hip pain
2. Past or present hip injury
3. Skin diseases

Participants: The mean age of participants was 26.67 ± 4.84 years and the mean height was 173.7 ± 10.68 cm. The mean weight of the participants was 79.41 ± 12.45 kg. All the participants including the physiotherapists were selected by public notice.

Setting: Written consent forms were obtained from all participants before the study began. 15 participants and 5 physiotherapists were selected. The measurements were carried out in the following order: Hip flexion, abduction, adduction, extension, internal rotation and external rotation for the ease of participants. The participants were asked to wear only a pair of shorts to facilitate the identification of anatomical surface markings on participants.

Motions capture system: Opto- electronics system was used to collect data from every participant. Data from this system was analysed using visual 3 D software. Six high speed Qualysis (Oqus, Sweden) cameras were also used. Their frequency was 175 Hz. The cameras were mounted on 3 way pan-tilt head tripods.

Marker Placements: twenty two retro- reflective markers were strategically attached on the skin at anatomical land marks at the following sites bilaterally. (Fig. 1)

1. Anterior Superior iliac spine (ASIS)
2. Posterior superior iliac spine (PSIS)
3. Highest point of iliac crest(IC)
4. Greater trochanter (GT)
5. A cluster plate of 4 markers on mid-thigh antero-lateral to mid-shaft of femur(right side: RT1, RT2, RT3,RT4;left side: LT1,LT2,LT3,LT4)
6. Lateral condyle of knee (LK)
7. Medial condyle of knee(MK)
8. Tibial tuberosity (TT)

Figure 1: marker placement on participant; anterior view, anterior view close up, left lateral view and posterior view

The ASIS, PSIS and IC markers were used to create the hip.GT was used to create the head and neck of femur. The mid shaft femur plate and LK an MK were used to create the femur. For purpose of modelling, a static and dynamic trial was conducted .The participant stood still in static trial. In the dynamic trial, the participant circled each leg 5 times so that the software could determine the hip joint centre of rotation which would be applicable during modelling.

Experimental set up: Six cameras were placed around the treatment couch at variable distances such that each marker could be identified by a minimum of 3 cameras (Fig. 2). This position of cameras was determined by performing a pilot study as mentioned earlier. Before recording data using Optoelectronics system, the system was calibrated. The first step of calibration was marking the required area using marker tapes. This area then was calibrated using a calibration wand (wand length was 750.7 mm). The wand was waved in all the 3 axes for 25 seconds each (Fig. 3, 4). All the data was then analysed using Qualysis track manager software in real time and 3 dimensional models were created.

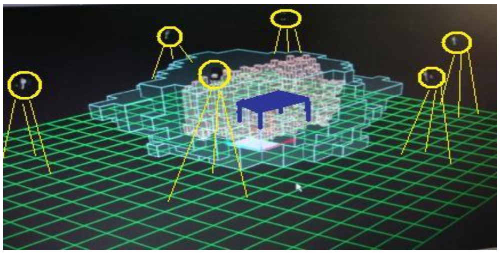

Figure 2: placement of motion capture cameras around the calibrated volume

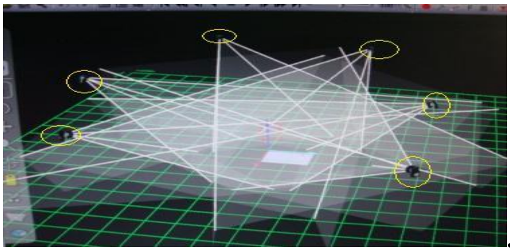

Figure 3: cameras showing field of vision

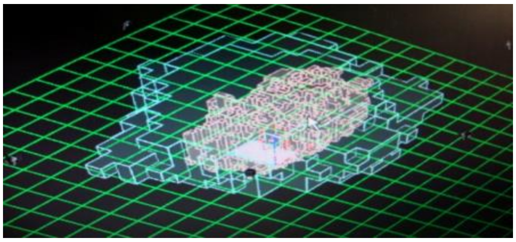

Figure 4: recorded volume (outer volume) and calibrated volume (inner volume)

The hip range of movement measurements by the optoelectronic motion capture camera was performed once for each movement of the participants.

The SPSS software was used to perform all statistics in this study (version 11.0). Root mean square error was calculated for each hip range of movement after comparing with standard values for the hip range of motion(14) and reliability assessed.

Results

To determine the reliability of optoelectronic motion capture analysis and deviation from the standard ROM, we compared the measurements with the standard universally accepted clinical ROM for each hip movement.(14) Table 1 shows RMSE for optoelectronic motion capture analysismeasurements in reference with standard values (RMSE 3-32). The left sided external rotation shows the highest deviation from the standard values. Hip adduction measurements using optoelectronic motion capture analysisare least deviated from standards.

Table 1: Validating goniometric and optoelectronic ROM measurements against standard clinically accepted ROM measurements for various hip movements(14)

Hip movement	Known standard measurements (in degrees)(14)	Optoelectronics measurement (in degrees) for right side	Optoelectronics measurement (in degrees) for left side
Flexion	110-120	124.2 ± 2.80	124.08 ± 2.81
Extension	0-30	27.58 ± 2.32	27.65 ± 2.10
Abduction	45	43.61 ± 1.75	43.80 ± 1.71
Adduction	30	29.70 ± 1.37	29.70 ± 1.46
Internal rotation	35	28.13 ± 0.84	28.09 ± 0.87
External rotation	35	26.52 ± 0.74	26.57 ± 0.75

Discussion

The goal of any clinical method of assessment is to produce accurate and reliable results.(15) This would ensure that measurements taken with a particular instrument would reflect true changes within the patient, rather than measurement error. If the measurement device is not accurate and reliable, it is not possible be confident in the results of repeated measures.

Apart from pain, reduction in functional range of motion is a symptom of underlying hip pathology. As severity of the pathology increases, the ROM of hip becomes more restricted and affects not only in athletic activities, but also affects activities of daily living. Measurement of hip function is important to detect any underlying hip pathology or assessing the outcomes of surgery and therapy. The validity of Motion capture system (optoelectronics) was performed on the participants in a laboratory. The participants were assessed by the assessors and Measurement protocol (position of participant) was kept same for all range of motions.

Optoelectronics system is considered as gold standard in our study. When we compared the measurement values of optoelectronics with universal standard hip range of motion values,[14] a large variation in data was observed (table 1). Most varied data was obtained for internal and external rotation. This variation was due to faulty measurement technique used while measuring ROM using optoelectronics. For optoelectronics, the markers were placed on the iliac crest, anterior superior iliac spine, and posterior superior iliac spine. For the thigh, greater trochanter, medial and lateral condyles of knee and a thigh plate placed antero-laterally on mid thigh. The Visual 3 d calculated the rotations using the thigh plate as a reference for movement. However, when the rotations were performed in sitting position, the posterior thigh was stabilized by the weight of the participant on the treatment couch. Although the movement of internal rotation and external rotation occurred, the soft tissues remained unmoved. As the marker thigh plate was attached to the skin, it did not move along the bone segment as assumed. Hence the rotation values showed vast variation. This could have been improvised by attaching retro reflective markers on participants mid shin. This would have allowed the visual 3 d software to calculate another rigid segment using reference points from lateral and medial condyles of knee and mid shin segment. It would have lead to accurate results.

Comparison was performed between standard known hip ROM[14] and optoelectronics system measurements (Table 1). Also, while performing measurements, researchers have neglected the effect of stabilization of pelvis, thus allowing compensatory movement to occur and increase in range of motion. This is one of the reasons why many clinicians prefer prone lying with knee bend technique to prevent hip movements while measuring hip rotations. But in this study, patient position for motion capture system was supine as in prone position, the retro reflective markers would not be seen and modelling using visual 3d would be difficult.

Much variability is also seen in hip flexion. During hip flexion, the pelvis needs to be stabilized. If the pelvis is not stabilized, additional ROM is acquired by Lumbo-pelvic rhythm. The lumbo–pelvic rhythm is a compensatory mechanism which occurs in hip flexion and abduction in both lumbar spine and pelvis, where the segment moves or tilts to produce a concomitant movement.

Conclusion

The optoelectronic motion capture analysis is a reliable tool to calculate the hip range of motion. The technique was most reliable for measuring adduction and least for measuring internal and external rotations of the hip. But, further well-designed studies need to be done in order to eliminate the limitations found in our study.

Limitations

One limitation was the number of participants available for the study. Experience and expertise of the assessor is an important aspect while performing this method to achieve accurate, precise and reproducible results.

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