

Proceeding Paper

# Kinematic Characteristics of National and College Level Weightlifters during Snatch Technique Using Wearable Inertial Sensors <sup>†</sup>

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**Abstract:** Weightlifting performance is strongly dependent on technique, explosive strength, and flexibility. There are two major lifts involved in competition: the snatch and the clean and jerk, where the snatch is the most technical component of the weightlifting competition. Most of the technical analyses have been done using either video analysis or conventional optical camera systems. However, few studies have investigated the kinematic characteristics of the weightlifters using the inertial measurement unit (IMU) sensors. In this study, we investigated the joints kinematics of the trunk, shoulder, elbow, hip, and knee as well as the main phases during the snatch technique for national and college level weightlifters using multiple IMU sensors. Seven female Mongolian weightlifters (3-national level and 4-college level) participated. Each participant performed three snatch attempts at 70% of one-repetition maximum. The joints angles were calculated using 3-axis acceleration and 3-axis gyroscope data from the IMU sensors. The six main phases of the snatch technique were defined based on knee flexion. All parameters were compared between the national and college level weightlifters. The national team showed a higher elbow range of motion and a greater extension of the hip and knee joints at the second pull than college-level athletes. In addition, the college team does not exhibit the transition phase and the proportion of the turnover phase was larger. This study provides a kinematic difference between the two different level weightlifters, which may help coaches and athletes to improve training strategy and weightlifting performance.

**Keywords:** weightlifting; snatch; kinematics; inertial sensors

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## 1. Introduction

Weightlifting is a sporting event that requires high technique, explosive strength, and flexibility [1]. There are two major lifts involved in competition: the snatch and the clean and jerk, where the snatch is the most technical component of weightlifting competition, involves both upper and lower extremity movement to lift a maximal weight [2].

Most of the studies have focused on the difference between different weight categories, barbell weight, and genders. Campos et al. [3] studied kinematic differences of the snatch technique between different categories. Gourgoulis et al. [1] compared the kinematics of the snatch technique between the male and female weightlifters. Harbili et al. [4] investigated the relationship between the barbell mass and power output during the lifts. Also, differences in snatch performances of elite female weightlifters were reported [5]. However, there are few studies have studied the kinematic difference between different skill level weightlifters. It was hypothesized that lifters would exhibit similar joint angle profiles and different phases for different skilled lifters.

## 2. Materials and Methods

In this study, seven female Mongolian weightlifters (three national-level (NL) and four college-level (CL)) participated. The trunk, shoulder, elbow, hip and knee motion data were recorded using the inertial measurement unit (IMU) sensors, which were attached to the chest, waist, arm, forearm, thigh and shank using the straps (Wearnotch, Notch Interface Inc.). Before the experiment, each participant was asked to perform several times of lifts as a warm-up at 50% of the repetition maximum (RM). Then, each participant performed three snatch lifts at 70% of the RM for each athlete under supervision by the coach. The extension angles of the trunk, shoulder, elbow, hip and knee were calculated from the sensor's raw data using the Madgwick filtering algorithm developed in Matlab® [6,7] (Figure 1). **In our previous study [7], the accuracy of the IMU sensors was compared against the optical motion capture system. The results showed that joint angles were strongly correlated between IMU sensors and optical motion capture system with  $\leq 5.8\%$  and correlation of  $r \leq 0.99$ .**

After calculating the joint angles, the six main phases of the snatch were defined based on knee angle according to the previous study [1]. Each lift includes the first pull, transition, second pull, turnover, catch and recovery phases. For each individual, joint angle data for all lifts were averaged. The averaged data of each participant were averaged again for NL and CL groups, respectively. Then, we compared the joint angles for these two groups.

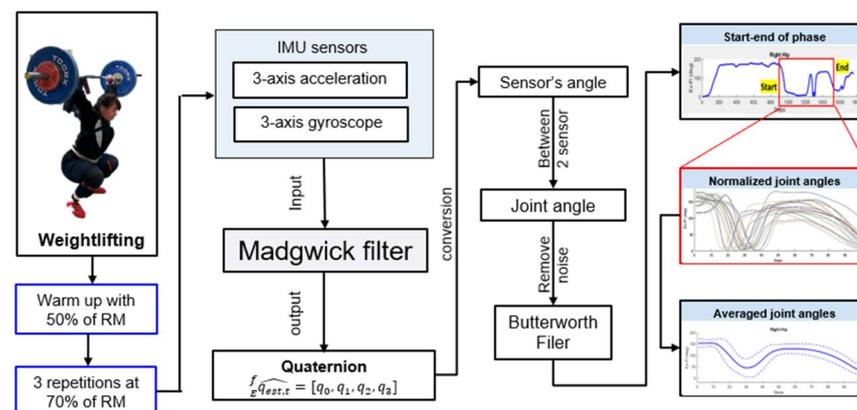


Figure 1. The experiment protocol and data processing.

## 3. Results

The maximum shoulder, elbow, trunk, hip and knee extension angles for NL/CL weightlifters were 167°/165°, 190°/186°, 166°/160°, 164°/136° and 153°/134°, respectively (Figure 2). The proportion of the phases were different between the two groups (Figure 1b). The CL group did not exhibit the transition phase, and showed 7% longer turnover and 12% longer catch phase compare to the NL group (Figure 3).

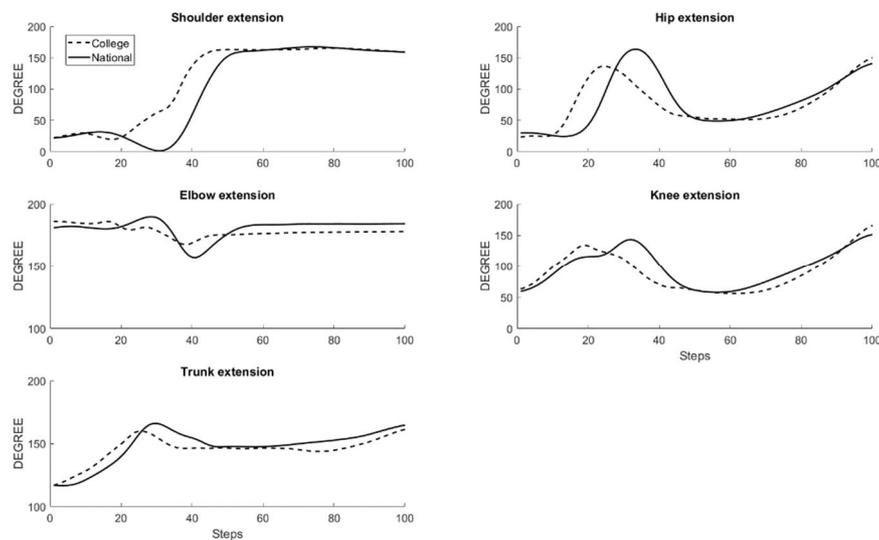


Figure 2. Joint angles for two groups.

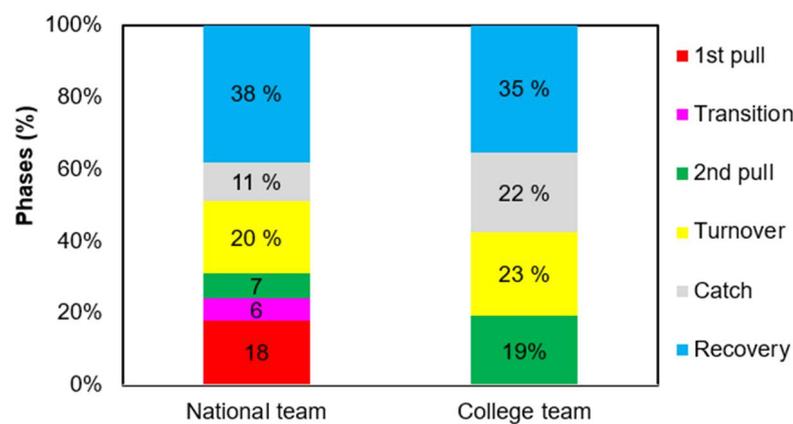


Figure 3. Phase comparison between two groups.

#### 4. Discussion and Conclusions

This study compared the joint angles and snatch phases between two groups. The NL groups had a greater extension of the knee and hip at the 2nd pull as well as a higher range of motion of the elbow during the turnover than the CL. The phase analysis revealed that the CL group did not exhibit a transition phase since no knee flexion occurred during the pulling, and the turnover and catch phases were also longer in CL than the NL group, which indicates not an effective technique. It was similar to previous studies, where they reported that knee flexion during the transition phase and the faster and deeper drop under the barbell during the turnover and catch phases are very crucial during the lifting performance [1,2]. This study provides a comparative analysis of the joint kinematics and phases between the two different level weightlifters, which may help coaches and athletes to develop a training strategy to improve snatch performance.

**Author Contributions:** All authors contributed to the manuscript. For further details please contact the corresponding author. All authors have read and agreed to the published version of the manuscript.

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**Conflicts of Interest:** The authors declare no conflict of interest.

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