Performance Evaluation for Weightlifting Lifter by Barbell Trajectory

Ying-Chen Lin, Ching-Ting Hsu, Wei-Hua Ho

Abstract**—**The purpose of this study is to investigate the kinematic characteristics and differences of the snatch barbell trajectory of 53 kg class female weight lifters. We take the 2014 Taiwan College Cup players as examples, and tend to make kinematic applications through the proven weightlifting barbell track system. The competition videos are taken by consumer camcorder with a tripod which set up at the side of the lifter. The results will be discussed in three parts, the first part is various lifting phase, the second part is the compare lifting between success and unsuccessful, and the third part is to compare the outstanding player with the general. Conclusion through the barbell can be used to observe the trajectories of our players lifting the usual process cannot be observed in the presence of malfunction or habits, so that the coach can find the problem and guide the players more accurately. Our system can be applied in practice and competition to increase the resilience of the lifter on the field.

Keywords**—**Computer aided sport training, Kinematic, Trajectory, Weightlifting.

I. Introduction

IN Taiwan, weightlifting is one of the focuses in Olympic training programs. In recent years, Taiwan Weightlifting Team has good achievements and performances. Amongst them, the 53-kilogramme class player, Hsu Shu-Ching won a silver medal in 2012 London Olympic Games, which attracts people's attention to weightlifting. Hsu Shu-Ching even won the gold medal and broke the world record in 2014 Incheon Asian Games, and that makes researchers get interested in doing research in weightlifting.

Weightlifting coaches often use mirrors, verbal assistance and other auxiliary training methods or equipment to let athletes know whether their actions are correct or not. If coaches don't have enough experience or the proper method to find the tiny differences, they may find difficulty in observing improvement or physical fatigue [1]. Athletes often forget their actions after they have finished the lifting, and that decrease the effective of the training.

Recording sport video is one of the currently used training methods, which has accessible and convenient features. The coach gives the players the feedback of kinematic analysis by recording motion pictures. However, in the past, people often do kinematic analysis with Siliconcoach [2] or other relevant kinematic analysis software. Although the software can provide a number of kinematic data analysis, for example: the barbell trajectory, the overall time, and the angle and limb of each phase, but this kind of software takes a lot of time to complete a full kinematic analysis by manual operation. Since weightlifting is a sport that takes short time to complete, the long analysis time not only reduces the coaches' and athletes' will of using that kinematic analysis software but also affect the immediacy and practicality of information feedback.

Weightlifting barbell trajectory is a common way of weightlifting kinematic analysis [1]. By using the barbell trajectory diagram to observe malfunction or habits that cannot be observed with eyes throughout the weightlifting process, which helps the coach to find out problems and coach the athletes more accurately. However, the aforementioned kinematic analysis software is very time-consuming while analyzing barbell tracks. Taking Siliconcoach as an example, a 10-second action takes more than 10 minutes to complete a full barbell trajectory extraction. Hsu et al. proposed a computer aided weightlifting training system which extracts the barbell trajectory from video sequence automatically and efficiently to assist weightlifting kinematic analysis and application [3]. The system can reduce 95% barbell trajectory analysis time and increase the system's real-time feedback resistance comparing to traditional kinematic analysis software. In this paper, we take Women 53-kilogramme class weightlifting competition in 2014 Taiwan College Cup as an example, in order to let coaches and players get barbell trajectory information in a short time, increase ability to respond in the spot during practice and competition and develop better tactic to achieve their goals.

The rest of this paper is organized as follows. Section II provides review of relevant works which discuss kinematic characteristics of weightlifting. Method of our research article is shown in Section III. Results and discussions are provided in Section IV, which show our analysis results and discuss the effective of our observation. The conclusions are made in Section V.

II. Review of Relevant Works

According to [4], [5] point out that the weightlifting is a sport that requires technique, power and flexibility. Snatch is a continuous movement which lifter pulls the barbell from the ground and lifts the arms straight to top of the head [5]. Storey et al. point out that the snatch movement from start to finish takes approximately 3 to 5 seconds [6]. Because weightlifting is a short time cycle sport, some scholars have pointed out that the use of a simple system to provide real-time information for athletes and coaches can help training and competition analysis [1].

In the past, weightlifting research methods mostly used the barbell trajectory, velocity or acceleration of barbell, joint

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angles and velocity to do the research [1]. The barbell largest deviation in the vertical axis is horizontal displacement. When the trajectory at vertical axis deviation is too large, the barbell is likely to cause instability in the state, and may cause athletes does not fluent when lifting [7]. The weightlifting movement can be divided into five phases [8]; some scholars use the movement of the right knee joint angle [9] and barbell height [10] to carry out these two phases.

The phases are defined as follows.

1) The first pull: from the barbell lift-off the ground until the first maximum knee extension.
2) The transition from the first to second pull: from the first maximum knee extension until the first maximum knee flexion.
3) The second pull: from the first maximum knee flexion until second maximum extension of the knee.
4) The turnover under the barbell: from the second maximum extension of the knee until the achievement of the maximum height of the barbell.
5) The catch phase: the barbell achievement of the maximum height until stabilization in the catch position with the barbell overhead.

In past research among sensors often utilize to find characteristics of barbell movement in space [1], [11], [12], these authors use acceleration sensors the three-dimensional movement of barbell in position, the projection of two-dimensional coordinates is set to establish the barbell's trajectory. Sensor is an efficient and accurate way to obtain the trajectory. Through sensor, either acceleration or movement distance of objects can be accurately use. However, the sensor device on top of the barbell, the barbell self -turning may cause sensor misjudgment or the psychological impact of the athletes are in need of special consideration [3]. Moreover, [1] pointed out that when lifters complete the lifting, the barbell thrown from the air will produce 170.1G of gravity, in addition to the sensor may cause misalignment, and even may be damaged. In addition, the official competition which cannot use the sensor on the barbell, the researcher cannot take this observation of lifters' athletic performance during the competition. Establish barbell trajectory through video analysis techniques for computer-aided weightlifting training should along with the efficiency and accuracy of the method [3].

So in this research article, our earlier work which a computer aided weightlifting training system is utilized [3]. Weightlifting barbell color information and motion information are utilized to identify the coordinate in video frame and connect it with the trajectory. In addition, the algorithm is further implemented as a computer-aided training system, and applied to the actual competition among. Through automatically and efficiently rendering barbell track to achieve the purpose of immediate feedback, increase efficiency in guiding the coach and the athletes in the competition's ability to improve and make it possible for sport science researchers to assess the overall condition of the players.

III. Method

We take 2014 Taiwan College Cup weightlifting competition women's group 53-kilogramme class snatch action as an example. The competition was held in Gushan High School on 24th to 25th of May, 2014 in Kaohsiung, Taiwan, R.O.C. It was an open and public competition, and could be recording. We utilize a general consumer digital camera with a tripod to record videos. The camera position was set on the broadside of the lifters. The height and the position of the camera and tripod are fixed during the process. The focal length of camera is also fixed to record all of the trunk and side action of the lifters. We utilized a self-developed computer aided weightlifting training system to gather the barbell trajectory automatically and evaluate the performance of the lifter.

Fig. 1 Self-developed computer aided weightlifting training system with barbell trajectory

The blue line in Fig. 1 shows the vertical axis, which is the starting center position of the barbell. The green trajectory means the barbell rising; the red trajectory means the barbell falling. The videos are processed to gray scale to reduce background color influence and make users can easily observes the trajectory. This process does not require video format convert. The analysis computer is a laptop computer with i7 CPU, 8G RAM and Windows 7 operating system.

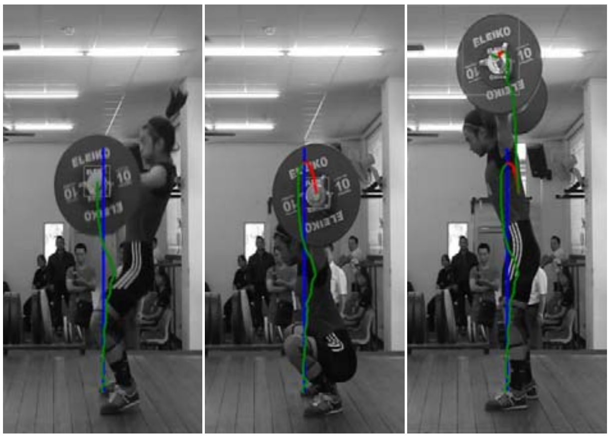
IV. Results and Discussions

We observe snatch barbell trajectory. Three lifters' kinematic are analyzed and discussed. We discuss three parts. The first part is the kinematic analysis of the lifter in various lifting phase; the second part is to do kinematic analysis for the lifting success and failure of the same lifter; the third part is the kinematic analysis of difference between outstanding and general player's successful lifting.

A. Lifting Phase

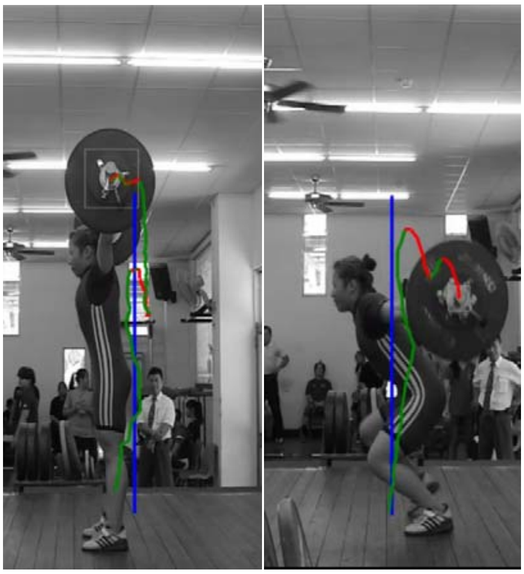
Fig. 2 shows the movement of the snatch barbell trajectories in various phases [6]. We can observe from Fig. 2 that the lifter in Figs. 2 (a) and (b) (first pull and transition to the start the second pull). The barbell trajectory is close to the center axis, and there is no significant shift. However, in Fig. 2 (c), the force of second pull phase, there is a little rearward of barbell, which means the center of weight of the lifter shift backward in this phase.

(a) first pull (b) translation to the second pull (c) completion of the second pull



(d) turnover (e) catch (f) recovery

Fig. 2 The six phase of snatch



(a) success (b) failure

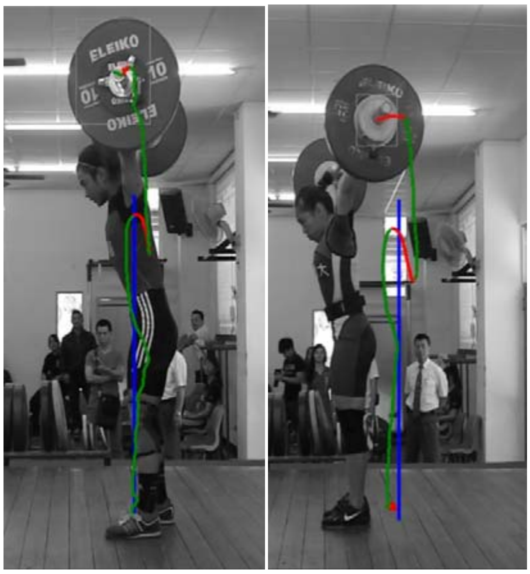
Fig. 3 Success and unsuccessful lifting

Fig. 2 (d) is the turnover phase. In this phase, the lifter corrects the barbell position back to close to the vertical axis and reduces the trunk imbalances due to the excessive center of weight of the barbell shifting [7]. In Fig. 2 (f), we can see the movement that the player catching the barbell is quickly; thereby it reduces the time to support the whole weight of the barbell.

Figs. 3 (a) and (b) are shown the successful and failure lifting, respectively. This figure shows the twice-lifting barbell complete trajectory for the same lifter. In Fig. 3 (a), we can find that the lifting succeeds when the barbell trajectory is close to the definition vertical line and the trajectory shift is smaller in the catching phase. In Fig. 3(b), the barbell trajectory in completion of the second pull phase is moving backwards, while turnover phase the lifter try to correct barbell position back to the vertical axis. However, it is obvious that there is a huge barbell trajectory shift in catching phase, causing the centre of weight of barbell to shift backwards and result in lifting failure.

B. Comparison of the Outstanding and General Lifter

In Fig. 4, we can obtain that the biggest difference between the two athletes is the barbell trajectory in the turnover phase to the catch phase. Although these two lifting are successful, however, the general lifter presents a larger shift rearward. In the catching phase, the outstanding lifter keeps the falling distance of the barbell shorter than the general lifter does, which reduces the time of the trunk supporting the whole barbell weight and shorten the time to complete the movement.



(a) Outstanding lifter (b) General lifter

Fig. 4 The comparison of outstanding and general lifter

V. Conclusions

In the process of weightlifting, the fluency of movement is a very crucial aspect to lifters. If the movement is not smooth, the players may fail to lift or even get injured. Therefore, the barbell trajectory can be utilized to observe the lifting process and diagnostic incorrect movements and bad habits. Moreover, it helps the coach to find out the problems and guide the lifter more accurately. Via the aforementioned results, we are using a self-developed computer aided weightlifting training system with barbell trajectory to quickly and automatically obtain a barbell trajectory, which can be utilized in the practice and competition. It has low computational complexity, which means coaches and players will not need to spend a long time dealing with cumbersome operation to do the analysis. It provides the barbell trajectory information of players in a short time so that coaches can adjust the movement and condition quickly for lifters to increase the resilience and competitiveness in the competition.

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