



8th Conference of the International Sports Engineering Association (ISEA)

Cost evaluation of different snatch trajectories by using dynamic programming method

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Received 31 January 2010; revised 7 March 2010; accepted 21 March 2010

Abstract

The barbell trajectory of snatch weightlifting has been investigated by several researchers. They suggested three optimal trajectory patterns (type A, B and C). But, there is no agreement for introducing the best overall trajectory. One probable reason would be this idea that the selected criterion used by the previous researchers might not be appropriate. Therefore we used a mathematical approach to judge between the conflicts. We made a multi-segments biomechanical model to evaluate the snatch motions while considering the selected mechanical cost. This method is an appropriate tool for coaches to examine several trajectories for making a good decision.

PACS: 45.10.Db; 45.20.Jj; 45.40.Ln

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Keywords: sport biomechanics, weightlifting, simulation, optimization

1. Introduction

The barbell trajectory of snatch has been investigated by several researchers. They have categorized the optimal lifting motion patterns and introduced several optimal trajectories for snatch weightlifting. Vorobyev [1] suggested three barbell movement patterns (type A, B, and C) for snatch weightlifting (Fig. 1). Garhammer [2] suggested the pattern type A while Baumann et al. [3] reported the type B is the best, and finally, Hiskia [4] concluded from his investigations that the type C is more common than the other types. One reason to this inconsistency is this idea that the selected criterion used by above researchers might not be appropriate.

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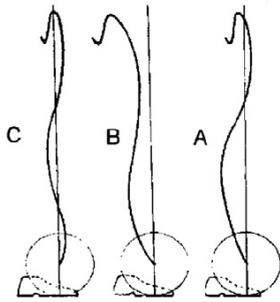


Fig. 1. Three types of barbell trajectory in snatch weightlifting

This criterion was the weightlifters' success to do the snatch. Therefore we offer a mathematical approach to judge between the conflicts. We used a biomechanical model to evaluate the motions while considering the specific mechanical criteria. By using dynamic programming approach we choose the best possible motion according to each trajectory. Comparing the costs of these suggested trajectories, we would be able to introduce the best of them.

2. Methods

A set of motion equations and a criterion equation should be solved together. This situation forms a problem in optimal control domain. One of the possible solving methods is the direct search approach which searches between all solutions of motion equations to find a solution which fulfils the criterion equation. But using this method without any specific search pattern is not practical. There are many algorithms to conduct the search like Genetic algorithm and dynamic programming [5]. We use latter because of its better and faster response.

2.1. Modeling

The anthropometric models can be used to build a biomechanical model of a weightlifter. In proposed model, the body segments converted into solid links and the body joints converted into simple revolute joints. We simplified this model to a five-link two-dimensional sagittal model which can be used for modeling the weightlifting or other general lifting activities [6-7]. This model is made by five links by which shank, thigh, trunk, upper arm and forearm are represented, named L1 to L5. Also, five body joints: ankle, knee, hip, shoulder and elbow are represented O1 to O5 respectively (Fig. 2).

The model motion can be described by five relative joint coordinates (1) and equations of motion may be derived by Lagrange's formula (2) where Q_i^a represents the joint actuating torque and Q_i^d is joint dissipative torque.

$$q_i = (\mathbf{X}_i, \mathbf{X}_{i-1}) \mathbf{Z}_0 \quad i = 1, \dots, 5 \quad (1)$$

$$\frac{d}{dt} \left(\frac{\partial L}{\partial \dot{q}_i} \right) - \frac{\partial L}{\partial q_i} = Q_i^d + Q_i^a, \quad i = 1, \dots, 5 \quad (2)$$

2.2. Constraints

Initial conditions are the angular position of each joint and the barbell velocity at the beginning of motion. Final conditions are the position and velocity of barbell at the end of second pulling phase. We have to prescribe bounds on the joint coordinates, defined by (3) where the lower and upper limits are specified [8]. Also, actuated joint torques have limited values defined by (4) according to Chaffin & Anderson [9].

$$q_i^{\min} \leq q_i(t) \leq q_i^{\max}, \quad i \leq 5 \quad (3)$$

$$|Q_i^a(t)| \leq Q_i^{a,\max} \quad (4)$$

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