CONTRIBUTION OF TRUNK AND PELVIS ROTATION TO PUNCHING IN BOXING

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INTRODUCTION

Sports involving throwing, striking and kicking activities, such as tennis, squash, baseball, football, among others, demand the production of maximum speed at the end of the distal segment in a kinematic chain. Research done on the biomechanics of these various, yet somehow similar sporting techniques, suggests that athletes generate large hand and foot speeds as a result of a proximal-to-distal sequencing motion. In other words, motion initiates in the larger, heavier proximal body segments and, as the energy increases, proceeds outward to the smaller, lighter distal segments (1). The way in which these mechanics are associated with distal end maximal speeds can be explained by Bunn’s “summation of speed principle” (3). As the name suggests, this principal states that each succeeding segment initiates motion at the time of maximum speed of its proximal segment, generating higher distal end-point speeds than the latter.

Proximal-to-distal sequences have been reported in several sports. Woo and Chapman (2) found a proximal to distal sequence of peak linear and angular velocities from the trunk to the wrist, in a squash forehand stroke. The authors observed that these velocities increased progressively throughout the kinematic chain.

The kinematics of a squash forehand are fairly similar to those of a forehand in tennis, baseball pitching, and even to those of an uppercut punch in boxing. However, to the authors’ knowledge, the existence of a proximal to distal sequencing in boxing has not been reported in literature. Furthermore, the few studies performed on the biomechanics of boxing are focused on the quantitative analysis of punching (force and speed generated) and its relation to head injuries, rather than the punching technique.

With this in mind, the purpose of this study is to investigate the existence of a proximal to distal sequence in boxing, through the 3D kinematic analysis of the uppercut. The author hypothesises that boxers also produce a proximal to distal sequencing motion in order to generate large hand speeds.

METHODS

This investigation represents a case study of a European champion in full contact boxing (26 yrs, 1.67m, 64Kg). The athlete performed 6 uppercut punches in total, 3 with each arm, all in the same stance (right leg leading). The motion was captured with a system of 9 infrared cameras (Qualisys Oqus 300, Qualisys AB, Gothenburg, Sweden), at a frequency of 200Hz, using Qualisys Track Manager (Version 2.2, Qualisys AB, Gothenburg, Sweden). Kinematic data, particularly the absolute angular velocities of the trunk, pelvis, and punching upperarm as well as the angle formed between the first two segments were computed in Visual 3D (Version 4.75.13, C-Motion, Inc, Rockville, USA), following an x-y-z Cardan sequence.

RESULTS AND DISCUSSION

The kinematic analysis of the uppercut technique showed that the proximal to distal sequencing, characteristic from kicking, throwing and striking activities is also used in boxing, to generate high hand speeds. As will be explained, this motion is highlighted in the acceleration phase of the uppercut, which comprises the acceleration of the segments towards the target, up to the instant of impact. During this phase, considering the segments’ kinematics, there seems to be a temporal dissociation of the active muscles – the muscles of the distal segments act after those of the respective
proximal segments – which causes the body to accelerate towards the target in a twisting motion, that starts in the lower limbs and proceeds distally, through the pelvis, trunk and arms, similarly to what has been reported in literature (1). This proximal to distal twisting motion can be observed in Fig 1, in terms of the axial rotation, as the pelvis begins to rotate towards the target (11.59°.s⁻¹ ± 50.88), while the trunk is still rotating in the opposite direction (-125.09°.s⁻¹ ± 49.16), forming a maximum intersegmental angle of 41.42° ± 2.16, in the right uppercut, and 23.80° ± 1.48, in the left. The difference in angles is due to the athlete’s stance, as he performed both punches with the right leg leading.

As a result of the twisting motion, the trunk and shoulder muscles are forced to stretch just before they contract, thus generating elastic energy that will potentiate the contraction. Furthermore, by stretching immediately before contracting, the muscle contraction could greatly benefit from the stretch reflex. In addition, during the acceleration phase, the trunk not only rotates around the longitudinal axis, but also rotates around the antero-posterior and medio-lateral axes, producing a combination of extension and lateral flexion towards the side of the punch. This motion possibly induces the trunk muscles to stretch even more, thus further increasing their contribution to the punching force/velocity.

In line with Bunn’s “summation of speed principle”, this proximal to distal twisting motion is a major contributing factor in the production of high hand speeds, as can be observed in fig. 2 with the subsequent, increasing peaks in the angular velocities of the pelvis (765.19°.s⁻¹ ± 29.49), trunk (866.69°.s⁻¹ ± 42.54) and arm (1404.58°.s⁻¹ ± 102.23 for the right arm), respectively.

![Angular Velocity](image)

**Figure 1**: Axial angular rotation of the pelvis and trunk during a right uppercut. This graph represents the mean values of 3 right uppercuts, normalized in time.

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**CONCLUSIONS**

As the authors hypothesised, the proximal to distal sequencing characteristic of striking and throwing activities, such as tennis, squash and baseball, among others, is also present in boxing. In the particular case of an uppercut, the proximal to distal twisting motion contributed to the subsequent increase in the angular velocity of the pelvis, trunk and arm, as previously suggested by the summation of speed principle. Future research should focus in the development of a biomechanical model that includes the trunk and shoulder muscles, and in the analysis of the electromyographic activity of these muscles, in order to validate the model and provide a better understanding of the use of elastic energy and stretch reflex in this proximal to distal sequence.

**REFERENCES**