Biomechanical power measurement in vertical jump

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Abstract — The paper presents an investigation on biomechanical power measurement methods in a vertical jump from a static position (squat jump) or from a dynamic one with static foot either (countermovement jump).

Keywords — Vertical jump biomechanics, power measurement, inertial sensors

I. INTRODUCTION

Vertical jump without the help of a run-up is a widely used gesture to determine subjects’ sports attitude or explosive performance by measuring the mechanical power output [1]. In spite of its wide use there is no standardization neither for quantities to be measured nor for signal processing required to obtain power.

As a simplification it is possible to take into account only jump maximum height since it is of course strictly correlated to legs’ mechanical power output [2-5]. One of the simplest tests includes a high jump from a standing position and the measurement of the maximal height the subject is able to reach by extending arms [6]. The maximal height resulting from such test is actually the practical result due to mechanical energy exchange between ground and legs, anyway a deeper characterisation of the power output might be useful, considering for example a direct power measurement and its time evolution during the gesture, that certainly give much more information about subject’s performance.

Furthermore, by introducing surface electromyography it is possible to correlate power output and muscle activity and/or force output and muscles activation timing to obtain information useful for example in more specific training sessions [7]. Usually practical applications of such tests focus on external mechanical power but from a biomechanical characterisation the overall power including the one required to fast moving body and legs segments is of great interest.

Different test modalities are reported in the literature. Traditional squat jump starts from a static position with knee and hip flexed and the jump takes place by a fast whole body elongation including arms. Another possibility is a dynamic pre-activation by a countermovement requiring muscles elongation, followed by a fast contraction. It has been found that such a condition increases power output, probably due to muscle elastic properties [8].

Several measurement systems are used to characterize the gesture [9]. One of the simplest is based on the measurement of body linear displacement by using a sensor in contact with the body, a typical example is the using of a draw wire encoder or potentiometer. During the jump the subject draws the encoder wire attached to his/her waist. The subject’s height time history is recorded for further off line processing. More detailed methods are based on video systems and required the subjects to be instruments with proper markers placed on specific anatomical landmarks. Such a system offers a complete characterization of the biomechanical kinematics in two or even three dimensional space. Moreover, a force platform may be included in the set giving information about jump dynamics by measuring ground reaction force [10].

II. METHODS AND PROCEDURES

A. Experimental set-up

In this paper we focus on power measurement considering alternative methods to obtain either external mechanical power or overall power required to carry out the gesture [11]. We consider experimental results obtained with a measurement system including both kinematic and dynamic sensors. Kinematic characterization of the gesture is obtained through a redundant measuring system including video system with active markers and a high quality camera, and inertial sensors placed on main body segments. Dynamics is characterized by a force platform measuring three axial ground reaction force. Beside that acceleration measurements are available by an inertial sensor placed on the subject’s back at L3 position where we identify the Centre of Mass height in standing position. An experimental procedure has been developed to guarantee test repeatability and reproducibility and to characterise results variability. For this purpose several test are carried out by a subject in a test session and several subjects undergo test sessions in different days. Reproducibility is verified by reproducing tests sessions with same subjects in different time. A test session includes set up tests at beginning and conclusion, squat jumps, countermovement jumps and proper resting periods.

B. Data processing

On the basis of available measurement signals it is possible to indirectly measure according to different strategies. It is worth to underline that in any case, we are focusing on
mechanical power only and not on physiological power.

Table 1 schematise the available methods to obtain a power measurement.

In the final paper we will compare results from these methods considering also their repeatability to give a quantitative scenario of the different power measurement possibilities and their reliability.

Output power is of course the main contribution to the overall power that includes the power required to move body segments. As for the external power, the latter contribution can be obtained either from marker position video measurements or by inertial angular position and velocity measurements. In this case also results will be discussed focusing on their repeatability and compatibility. The information provided will be useful for an estimation of power measurement uncertainty.

### REFERENCES


