ERGONOMICS AND "USABILITY" APPLIED ON THE TRAINING OF MUSCULAR FORCE QUALITIES

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"Usability" is introduced, for the first time, as an ergonomics criterion concerning the development and functional evaluation of the muscular force qualities training programs, based on the use of biomechanics methodology. Thus, the main purpose of the present study is to introduce ergonomics applied to the training as a method to prevent WRMSDs (Work-Related Musculoskeletal Disorders) that cause the high loads and efforts as well as overuse, regarding mechanical work and power. "DynaSoft 2.0" is a 3D Inverse Dynamics package that allows for the evaluation of the developed mechanical loads during the repeated series of exercises in the training of muscular force qualities. "DynaSoft 2.0" makes possible the treatment of data not obtained from "turn-key systems" that could be too expensive, and, the user has the possibility to have by own the control of all analysis processes constructing purposeful anthropometric models.

KEYWORDS: Biomechanics, training ergonomics, usability, DynaSoft 2.0.

INTRODUCTION: The training of the muscular force qualities (Strength, Power, and Fatigability) has a paramount place in the training in all sports and modalities (Fig 1). Also, sports training is a controlled process, that is driving human factors to develop their force quality capabilities in a specific environment, that is, Hardware, Software, and Orgware with Safety, Efficiency, and Comfort. However, the training process has been exclusively orientated to improve sports performance with no considerations concerning the prevention of muscle-skeletal disorders and injuries caused by high-level efforts and overuse. Risk factors can be either intrinsic (growth-related, anatomical, physiological, psychological and history-related) or extrinsic ones (incorrect technique, improperly training, sports equipment and environment). Incorrect technique and improperly strength training are the primarily risk factors for muscle-skeletal disorders in young athletes (Pećina & Bojanić, 2004) and their effects are posture specific (Zatsiorsky, 2003). Changes in exercises patterns concerning kinematic and dynamic parameters modify the intensity of the mechanical loads and their effects on the joint structures. In this context, it could be very useful to introduce the concept of *Usability* in the design and execution of training programs. By defining usability as the "effectiveness, efficiency and satisfaction with which specified users achieve specified goals in specific environments." The concept of training ergonomics comes from the need to be the trainer aware and take care about the prevention of overuse sports injuries. ISO 9241 for instance, supports a wide variety of usability designs activities, including a) analyzing and defining system requirements, b) redesigning workplace layout, c) supporting and training users, and, d) redesigning task. On the other hand, it could be very useful to high-quality training, for Olympic, Paralympic, and Youth athletes. Thus, special care has to be taken considering that the training of muscular force qualities is vital for rehabilitation. On the other hand, up to now, training has been on the concept of one repetition maximum (1RM) that is lacking reliability. Finally, in the design and execution of the training, there are no concerns about motor variability or motor control. According to those above, there is a need for training ergonomics based on the Biomechanics methodology for both, functional evaluation of the neuro-mechanical performance of the locomotor system and analysis of the exercises that compose the training of muscular force qualities. The purpose of this study is to present "DynaSoft 2.0" software, based on 3D Inverse Dynamics, and its possibilities to resolve usability questions in the training of muscular force qualities. "DynaSoft 2.0" makes possible the treatment of data not obtained from "turn-key systems" that could be too expensive, and, the user has the possibility to have by own the control of all analysis process.

METHODS: "DynaSoft 2.0" software is a validate program (Gianikellis et al., 2012), developed for the Microsoft Window's operating system in MATLAB R2010a environment, accepting as input standard ASCII data files exported from different measurement chains and data collection systems (motion capture, force platforms, EMG).

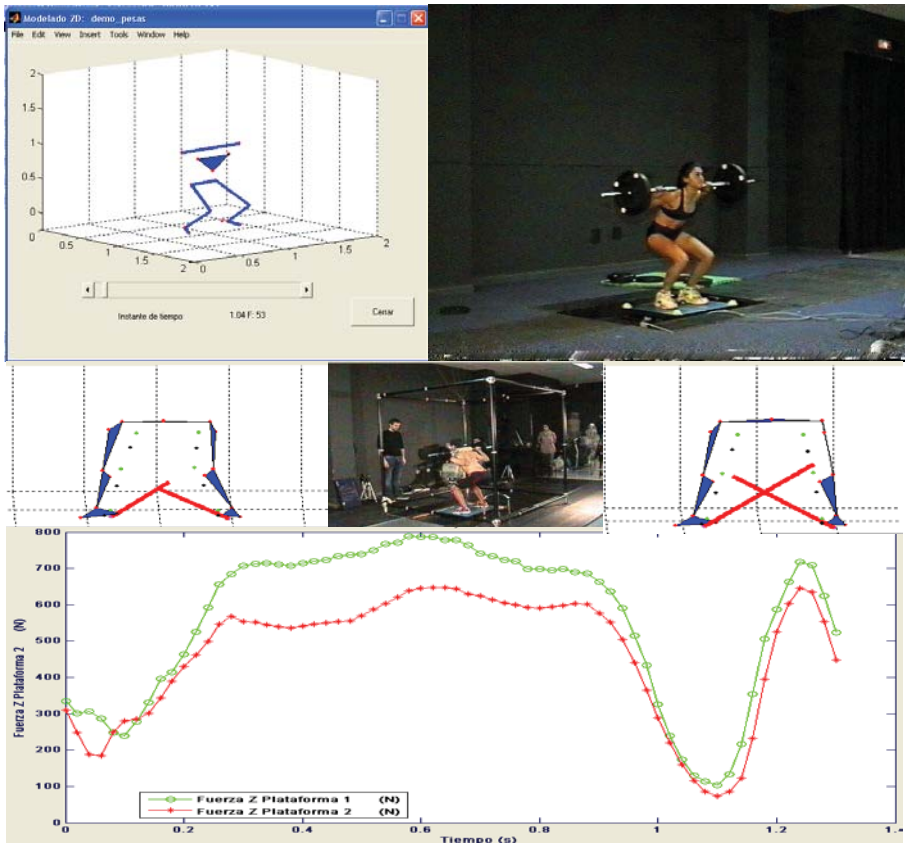

Figure 1. Experimental Setup and simulation based on 3D Inverse Dynamics of a "Squat" exercise.

The "DynaSoft 2.0", flowchart (Fig. 2) includes:

i. "Smoothing" techniques for 3D kinematics.
ii. 3D Kinematics including temporal, spatial and spatial-temporal analysis.
iii. Database of internal parameters based on the most common anthropometric models.
iv. Inverse dynamic analysis including mechanical power analysis.
v. Toolbox for digital signal processing of EMG signals.
vi. Stabilometric analysis based on the center of pressure displacements.
vii. Graphics and animation of rigid solid models.
viii. Reports outputs.

RESULTS: "DynaSoft 2.0" is a user-friendly software package enabling the description, analysis, and evaluation of motor patterns. Data can be obtained from different commercial electronic systems and instruments. Data processing of technical and scientific staff to get feasible information about the biomechanical and motor control of fitness training and rehabilitation exercises (Fig. 3).

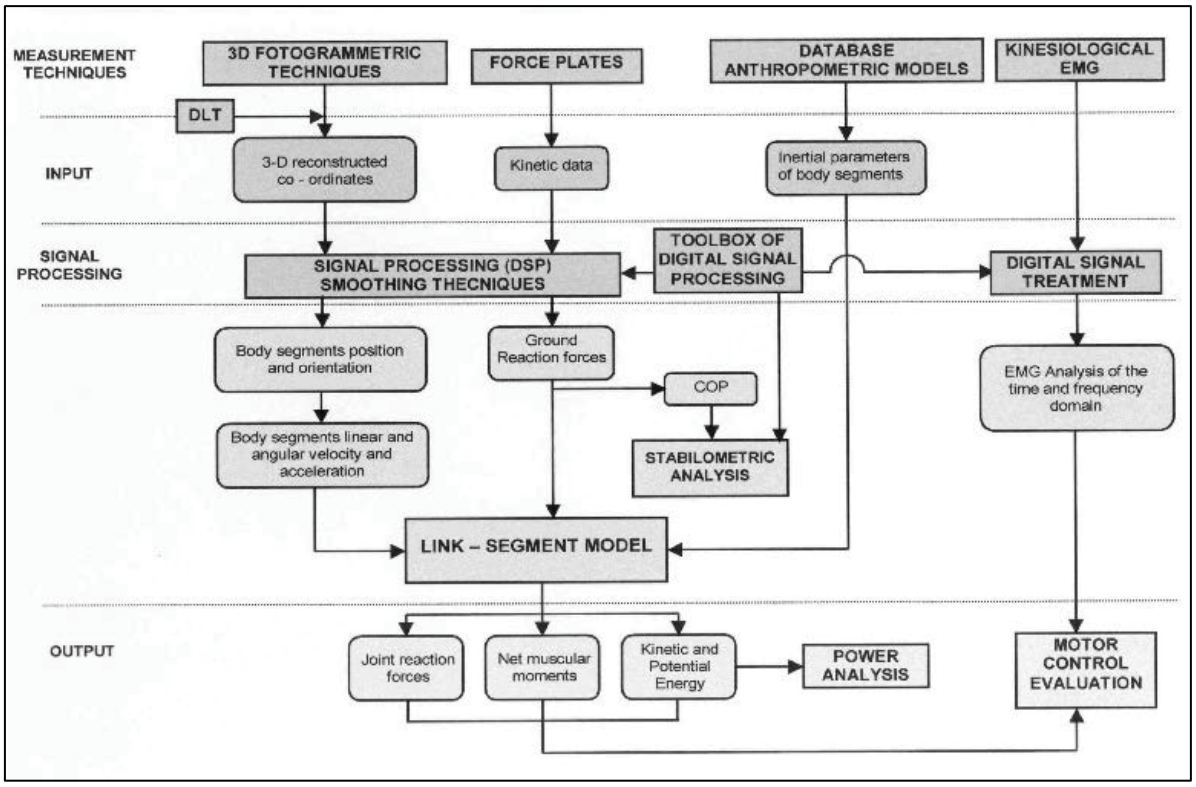

Figure 2. Flowchart of the "DynaSoft 2.0."

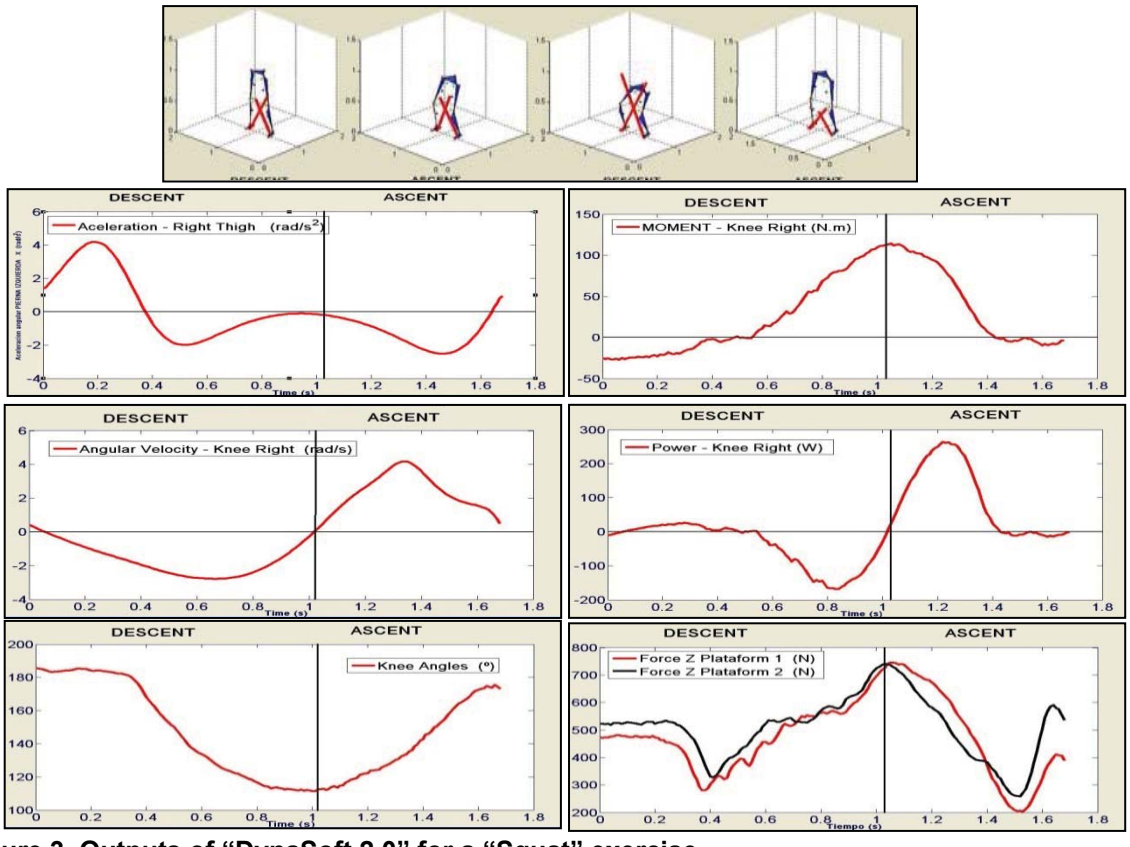

Figure 3. Outputs of "DynaSoft 2.0" for a "Squat" exercise

The software includes:

A. Smoothing and differentiation using GCVSPL (Woltring, 1986)
B. Calculation of all linear and angular 3D kinematics parameters with emphasis to the attitude vector and Euler angles especially for small angles (<10º). These facilities are useful to evaluate posture and postural stability. Besides, all-time parameters (instants, phases, frequencies, and so forth) can be saved for later analyses.
C. The user possibility to make decisions concerning the most appropriate anthropometric model to obtain inertial parameter.
D. Possibility to get subject's anthropometric parameters using 3D video photogrammetry.
E. Three-dimensional Inverse Dynamics.
F. Calculation of the net muscular moments and mechanical work. "Power analysis" is possible giving information respect to the functioning of biokinematic chains.
G. Tridimensional simulation and animation of the movement.
H. Kinematics and Spectral analysis of the Centre of Pressure
I. Electromyography analysis in the time, frequency and time-frequency domain
J. Graphical representation and animations
K. Improve teaching for biomechanical signal processing methods including signal rectification, normalization, windowing, and padding, filtering factor determination, filtering methods, Fourier transformation, spectrum analysis, etc.

CONCLUSION: "DynaSoft 2.0" is a user-friendly package enabling "postural stability dynamics and variability" analysis, " power analysis" and "muscular intervention analysis" of motor patterns in the force qualities training, fitness and rehabilitation fields based on 3D Inverse Dynamics making possible to resolve usability questions in the training of muscular force qualities.

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Acknowledgements

This presentation is supported by a grant (CTS037) from the Government of Extremadura (Spain)

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