

APPLICATION OF ARTIFICIAL NEURAL NETWORK TO PREDICT THE JOINT TORQUE OF LOWER LIMBS USING THE PARAMETERS OF GROUND REACTION FORCE DURING VERTICAL JUMP

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INTRODUCTION

The measurement of ground reaction force (GRF) during vertical jump was often used to evaluate the athlete's muscular strength and power of lower limbs. However, the GRF could only specify the muscular power ability of lower limbs in whole and it couldn't reflect the muscle joint torque and neuromuscular control ability at each joint of lower limbs. To get the information of the joint torque, inverse dynamics calculation must be conducted by inputting the kinematic data and the data of GRF [1]. The purpose of this study was to develop an artificial neural network (ANN) model for predicting the joint torque at ankle, knee and hip by using the relevant parameters of GRF during vertical jump.

METHODS

10 male sport students (age: 20.10 ± 0.91 yrs; height: 179.34 ± 4.25 cm; weight: 69.58 ± 3.91 kg) performed counter-movement-jump (CMJ) on a Kistler force platform (1200Hz). Meanwhile, the kinematic data of CMJ were recorded and digitized with a Peak Performance System at 120Hz. The GRF and kinematic data of support phase were than normalized as 100%. To calculate the joint torque at ankle, knee and hip, 2D inverse dynamics model was developed by inputting the GRF, kinematic data and Dempster's body segment parameters [1]. In this study we used a fully-connected, feed-forward network comprised of one input layer, one hidden layer and one output layer trained by back propagation using Gradient Steepest Descent Method [2]. The input parameters of this ANN model were time variables obtained by GRF measurement: time percentage, GRF, vertical displacement of center of mass (c.m.), speed of c.m. and power; the output parameters of the model were time data of joint torque at ankle, knee and hip. The data were scaled before input and rescaled after output. We used the software PCNeuron 4.1 to develop the ANN model and the root mean square (RMS) error of prediction to measure the network fitness..

RESULTS AND DISCUSSION

One subject from the ten was chosen randomly as test sample for evaluating the network fitness. The data of rest nine subjects was used for modeling and training of the ANN. After trial-and-error optimization procedure, a "5-10-3 ANN model"

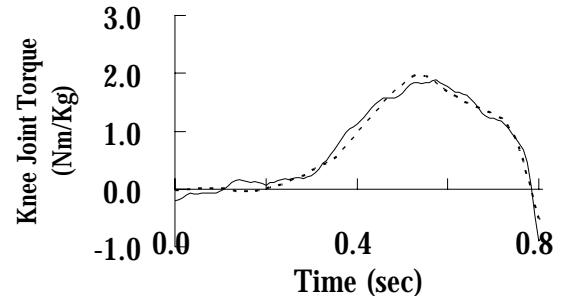


Figure 1: The measured (solid line) and predicted (dotted line) joint torque at knee joint during CMJ.

was found, in which there were 5 neurons in the input layer, 10 neurons (nodes) in the hidden layer and 3 neurons in the output layer.

The results of the test sample (Table 1) showed that, compare to the measured curves, the relative errors of the predicted peak joint torque at three joints were less than 4%. The RMS errors for all three joints were smaller than 0.04 revealing that the prediction errors of this model were well convergent. The predicted and the measured time curve of joint torque were also significantly correlated, the correlation coefficient were 0.967, 0.987 and 0.979 at ankle, knee and hip respectively. The figure 1 demonstrates that the predicted curve of joint torque at knee was fit well to the measured curve. Since the GRF could be simply measured in the sport science, the application of ANN using GRF is meaningful to study of joint torque without inverse dynamics during vertical jump.

CONCLUSIONS

A back propagation ANN was developed by trial-and-error optimization technique to predict the lower limb's joint torque by using GRF during CMJ. We conclude that the ANN using GRF is feasible in the study of joint torque without kinematic measurement and inverse dynamics during vertical jump.

REFERENCES

1. Robertson DGE, et al. *Research Methods in Biomechanics. Human Kinetics*, Champaign, IL, 2004.
2. Schalkaff RJ. *Artificial Neural Network*, New York, McGraw-Hill Companies Inc. 1997.

Table 1: The peak values of measured and predicted joint torque and their relative errors; RMS errors and the correlation coefficient between the measured and the predicted time curve of joint torque at ankle, knee and hip (**: p<.01) .

Joint	Peak Torque Measured [Nm/kg]	Peak Torque Predicted [Nm/kg]	Relative Error [%]	RMS Error (n=100)	r (n=100)
Ankle	-1.908	-1.938	1.56	0.0309	0.967**
Knee	+1.882	+1.972	3.16	0.0327	0.987**
Hip	-2.459	-2.359	3.59	0.0335	0.979**