RESPONSE SURFACE FOR EXTENTION STRENGTH OF HUMAN TRUNK IN ISOMETRIC EXTENSION

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INTRODUCTION

The mismatch between one's functional capacity and the physical requirements of occupational activities has been considered a significant major cause of LBP and spinal disorders. Finding of the variation in the functional trunk performance in feasible trunk range of motion has been a signifecance concern in rehabilitation, occupational biomechanics and work physiology. Regression models in general can give a good estimate of the maximum performance capacity envelope based on actual measurements[1]. A quantitative understanding of trunk exertions in three anatomical planes and identifying the coupling effects in symmetric and asymmetric postures may be of help in the development of a low-back injury control and prevention strategies.

METHODS

Thirty healthy males (age 25(± 2.5 SD) years, weight 74 (± 5.6 SD) kg) with no history of low back pain in the previous year participated in this study.

Sharif-LIST (Lumbar Isometric Strength Tester device) with three revolute joints and concurrent axes to measure moments accuracy about anatomical axes was used [2]. Experiments of this study were designed to find the relation between the maximum voluntary trunk extension torque about the L5/S1 joint as the dependent variable, and the independent variables were joint angular positions in the three anatomical planes, 3 levels in the transverse plane (-15°, 0° and 15°), 4 levels in the sagittal plane (5°, 15°, 30° and 45°) and 2 levels in the coronal plane (0°, -15°). In addition, exertions were repeated at selected 9 angular postures (24+9=33 trials). The trials were randomized to minimize unintended fatigue and order effects. The moments and angular positions were collected at 100 Hz. Periods of about 2 minutes rest were considered between the exertions to prevent muscular fatigue. A second-order response surface was used to formulate the relationship between isometric extension strength and the three trunk angles.

$$ES = \beta_0 + \beta_1\theta_t + \beta_2\theta_s + \beta_3\theta_c + \beta_4\theta_t^2 + \beta_5\theta_s^2 + \beta_6\theta_t\theta_c + \beta_7\theta_t\theta_s + \beta_8\theta_s\theta_c + \varepsilon$$

Where ES is the isometric extension strength around the L5/S1 joint (N.m), θ_t , θ_s and θ_c are the three trunk angles (degrees) in transverse, sagittal and coronal planes respectively, β_0 is the intercept, β_1 to β_8 are the regression coefficients, and ε is random error ($\varepsilon \sim N(0,\sigma^2)$).To assess the adequacy of the calculated response surface, the lack of fit between the experimental observations and surface response predictions were performed. The R^2 and %SE were computed using response surface analysis.

RESULTS AND DISCUSSION

The results of joint strength response surface for extension exertions and accompany coronal and transverse plane of one subject are shown in Table 1. The R^2 values and *lack of fit* results for joint strength respone surface indicates that the quadratic model is adequate to represent the variability of the maximum trunk torque as a function of joint angular positions in three anatomical planes in feasible trunk range of motion. Furthermore, magnitudes of *percent of standard error of estimation* show that these relation can estimate strength with high degree accurcy. Figure 1 shows variation of extension strength (N.m) respect to flexion and rotaion trunk angle with zero angle in coronal plane.

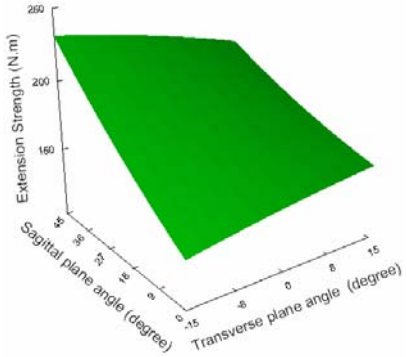

Figure 1: Predicted Extension Strength Response to postures in sagittal and transverse planes & Coronal plane angle=0

CONCLUSIONS

The response surface models developed as quadratic eqution that can adequatly predict the trunk strength as function of its 3D postuers. These models can be used as physiological constraints whiten mathematical performance models [3].

REFERENCES

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Table 1: Strength response surface for extension exertions and accompany lateral bending/ axial rotation for one subject.

Strength	B_0	B_1	B_2	B_3	B_4	B_5	B_6	B_7	B_8	P.L.F.	R^2	%SE
Extension	150.112*	0.814	1.443*	0.574*	-0.008	0.009	0.023	-0.037*	0.03*	0.62	0.93*	4.17
Acc_ T.T	12.479*	0.498*	0.04*	-1.543*	-0.01	-0.004	-0.008	0.003	0.012	0.38	0.83*	15.90
Acc_C.T	15.23*	0.422	-0.328*	-0.809*	-0.015	0.008	0.026*	-0.003	-0.023*	0.23	0.86*	9.50

P.L.F: P-value of Lack of fit test, %SE: Percent of Standard Error of Estimate, Acc_T.T: accompanying Transverse plane Torque, Acc_C.T: Accompanying Coronal Plane Torque,*: P<0.05