BIOMECHANICAL CONSIDERATIONS FOR A NEW DESIGN OF THE PARALLEL BARS

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INTRODUCTION

The cross-sectional outline and dimensions of the wooden parallel bars are given by the FIG norm. It further states that a downward force of 1350 N applied to the middle of one bar should result in a deflection of approximately 6 cm. To date, bars are made from laminated wood with inlays designed to prevent braking. The "egg" shape is ergonomical for moves performed in suspended or supported positions and must be considered superior to round bars.

Many moves performed in modern gymnastics require the bars to be opened and present a lateral or oblique loading of both or a single bar. The large deflections that result from the bar geometry are a potential cause of shoulder injuries and may be detrimental to performance.

The purpose of the present study was thus to determine whether one could modify the bar in a way to make it behave (deflection-wise) as if it was round without changing the ergonomical shape or the basic material of the bars.

METHOD

The load-dellection characteristics of existing bars in vertical, horizontal and oblique directions was measured using a HBM load cell and a special clamping device that allowed rotation of the mounted bar about its long axis in steps of 45 degrees.

On the basis ol' this data a simple but realistic Finite Element Model was constructed with the aim to check the feasibility and determine the required minimum size of an inlay with a high module of elasticity. More complex volume models were then employed to determine shape and position of the inlays.

RESULTS

The empirical findings on the existing bars are almost trivial: the deflections caused by horizontal forces are approximately 50% larger than the deflections caused by vertically acting forces of the same magnitude (Fig. 1). The load-deflection curves are practically linear in the range tested (150 to 1500 N).

Simulations with the simple FE model showed, that changing the module of elasticity of the lateral bar elements should have the desired effect. The required cross-sectional area of the inlay depends on the material used. For an E-module of 10^5 N/mm^2 an area of 0.5 cm^2 was determined.

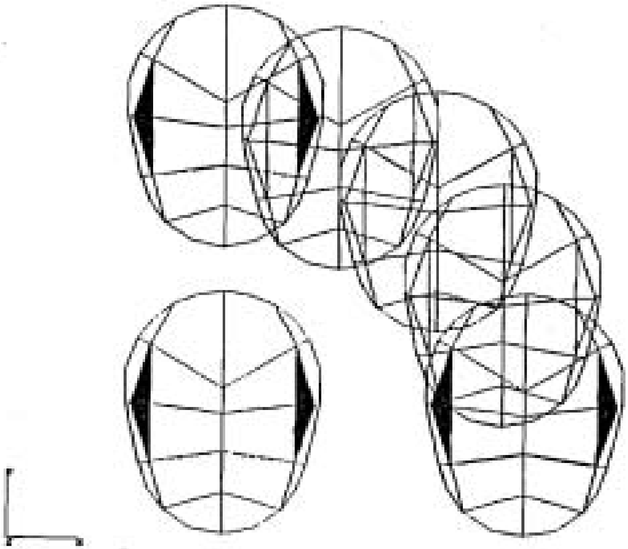

Figure 1: Deflection diagram for a traditional bar acted upon by a force of 1350 N at different angles.

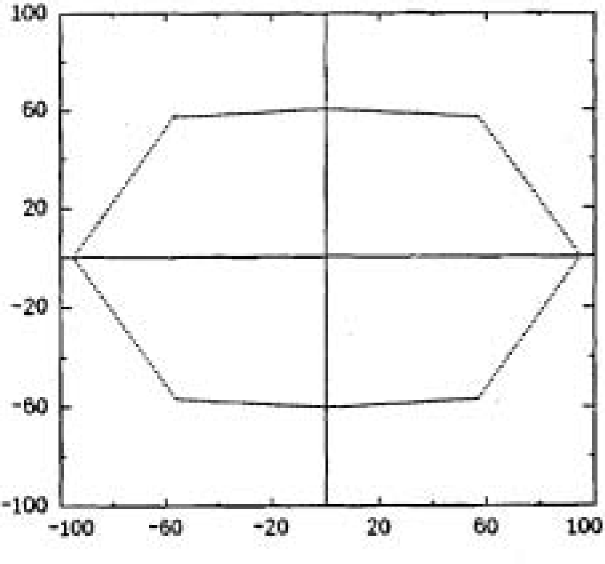

Figure 2: Frontal view of the deflection at the middle of the bar as computed by the Finite Element Model.

The shear stresses were computed to be below the critical values for the materials and bonding used.

In the much more complex volume model the geometrical shape and position of the inlay was varied with the aim of stiffening the bar to horizontal loads while keeping the vertical behaviour constant. The result also takes into consideration the technical problems associated with the production of the bar. The generated frontal view of the bar deflection at its mid-point (Fig. 2) shows, how a unifonn behaviour is predicted for new bars with triangular inlays despite the unchanged outside "egg" shape of the bar.

On the basis of the computations prototype bars were constructed using a specific technique for applying and bonding inlays of carbon fibers. Empirical measurements verify that the aim of constructing bars with a "round" deflection diagram from an "egg" shaped bar has been achieved through the proper combination of wood and carbon fiber inlays (Fig. **3).**

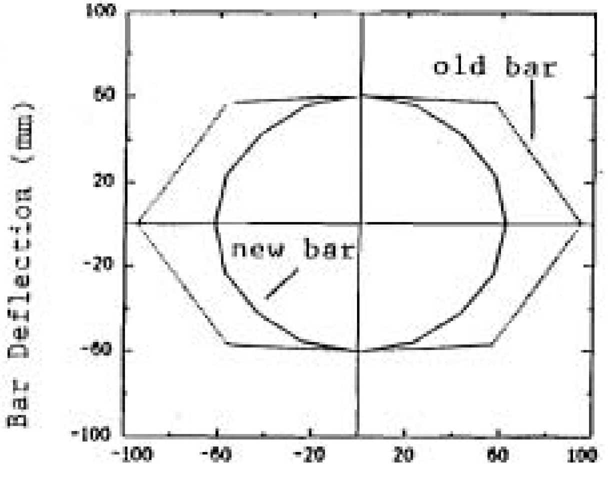

Figure 3: Comparison of the old and newly designed bar

CONCLUSIONS

Norms are necessary to guarantee standardized apparatus in gymnastics training and competition. However, gymnastics constantly evolves - a competitive environment asks for innovation. The gymnastics apparatus must be biomechanically optimized in the sense that it will allow optimum performance and prevent injuries for a wide spectrum of gymnasts. Why give up the advantages of the present bar shape if it is possible to adapt to the demands placed upon the apparatus through the new lateral moves by selectively changing the deflection characteristics? The findings of this study should be considered in the ongoing discussion about new FIG norms.
The present study also shows that FEM can replace costly trial and error approaches - if one asks the right questions.

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