Extended Abstract

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Gymnastic Movements with Strain of Parallel Bars

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Gymnasts have to use a special movement pattern for particular long swing movements to gain elasti parallel bars to complete long swing movements artistically and therefore needs to study not onl dynamics but also the dynamic properties of exercise apparatus to minimize the execution errors. In o mass 50.4 kg national level gymnast of China performed three repetitions of a long swing element under bars. The time history of middle points of wooden bars and all joint angles were measured by using sy high speed cameras (100 Hz). The ViconT40 digitizing software was sued to find the all coordinates o markers (14mm) which were attached on parallel bar-gymnast system. Based on the overall readings, we a 3D mathematical model for the parallel bars apparatus using four damped spring-mass model displacement-force characteristics. This 3D model can demonstrate dynamic properties of parallel bars with any long swing movements for any gymnast.

2. Introduction and research problem/issue

Gymnastic movements which start with long swing under the parallel bars are highly difficult compared with other movements of parallel bars apparatus because of the verity of evaluations w introduced by FIG based on long swing movements (Code of Point MAG, 2017). Therefore, gymna utilise strain of the parallel bars in the correct manner. For this aspect, gymnasts have to use a special pattern for particular long swing movements to gain elastic energy of parallel bars to complete movements artistically. The gymnast essentially needs to study not only the body dynamic but also th properties of exercise equipment/apparatus which interact with their movement to minimize the execu (Yamasaki, Yasuhiro & Gotoh, 2008). As a solution for this problem, biomechanical models can provide important results which are based on performance (Hiley 2005). A 2D frontal plane modal for the parallel bars apparatus was developed assuming that th movements of the tops of the metal posts are negligible (Linge S, Hallingstad O & Solgerg, 2006). W that the tops of the metal posts were interacting with long swing movements. Therefore, we designed a bars model to observe the correct dynamic properties of parallel bars which are engaged in long swing m

Keywords: dynamic stiffness, gymnastic, long swing, model, parallel bars

3. Research Methodology

A 3D mathematical model was designed using four massless spring dampers and two point masses to o dynamic properties of wooden bars. The Kene's procedure (Kane & Levinsion, 1985) was used to system's dynamical equations. In the first part of the study, a 31kg pendulum was attached to the middl wooden bar and the oscillations on frontal, sagittal and transvers planes were observed. This expe repeated for a 50 kg mass pendulum in the same manner. In the second part of the research, a national lev of China (50.4 kg) performed four repetitions of a long swing movement: forward giant swing backw salto tucked to upper arm hang, under four different conditions on the middle of parallel bars. Reflecti (14 mm) and ten high speed camera set up (ViconT40, 100 Hz) were used to observe time history markers on parallel bars and subjects. The coordinates of necessary markers were calculated using digitizing software. Hence, we calculated kinematic and kinetic values using Matlab R2014b software an the parameters of spring dampers of mathematical model. Finally, the pattern of dynamic force varia middle points of the parallel bars due to the particular long swing movement was calculated.

4. Results and findings

The norms of the Federation of International Gymnastic Federation demand vertical midpoint stiffness t the range of 19,000-27,400 N.m^{-1} (FIG Norms 1997, FIG Norms 2016, Linge S, Hallingstad O & Solg We found the vertical midpoint stiffness (Kz) in the dynamic situation. From the 31kg and 50 kg pen got horizontal stiffness values as 20,073 N.m^{-1} and 19,512 N.m^{-1} respectively. The 3D Model of p satisfied other stiffness values for the X direction (parallel to the initial position of a wooden bar) and the as 27,633 N.m^{-1} and 10,009 N.m^{-1}. Though the 2D model was designed assuming

that the metal posts' movements in the X direction are negligible, we observed that the stiffness value direction (27,633 N.m^{-1}) considerably influenced the long swing movements on parallel bars.

5. Conclusions, implications and significance

The 3D parallel bars model can demonstrate how gymnasts use dynamic force to complete a 'forward g backward double salto tucked to upper arm hang on bars with arm support's movement using all thre stiffness values. This 3D model can demonstrate dynamic properties of any long swing movement for an

6. References (Selected)

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