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A Dynamic Model for Handstand in Gymnastics

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Abstract: *The aim of the present study was to the analysis of handstand movement in gymnastics by developing the dynamic model. One elite gymnast participated in this study.Seventeenspherical reflective markers were placed on the anatomical landmark of the body to represent the segments. The high-speed video based system was equipped with two cameras.Customized body segment inertia parameters were generated from anthropometric measurements by using the inertia model.Programming for inverse dynamics was by using MATLAB software.Calculations were performed in the MATLAB/SimMechanics environment after recorded the position (handstand) for simulation.We used theDLT for reconstructing 3D from two 2D photographs.The most angular changes were observed in the wrist, whereas the shoulder, hip, and elbow joints were observed, consequently. The most changes in torque were observed in the wrist, shoulder, and hip, respectively.*
Keywords:*Handstand, Inverse Dynamics, Dynamic Model, Joint Moment.*

I. Introduction

The word ‘biomechanics’ is derived from the Greek bios meaning life and mekhaniki meaning mechanics (16). Biomechanics is fundamentally the study of classical mechanics of biological organisms and systems (8). Biomechanics has been further subdivided into the study of the movement itself (kinematics) and the study of forces and kinetic energy (kinetics) (2). Kinematic and kinetic data on an actual performance may suggest that a particular technique is responsible for the outcome but without some method of quantifying contributions, little can be concluded. With a simulation model of the efficacy of various techniques may be evaluated and so give insight into what really produces the resulting motion (16).

Models may be used to address the forward dynamics problem and the inverse dynamics problem (7). In the forward dynamics problem the driving forces are specified and the problem is to determine the resulting motion. In the inverse dynamics problem, the motion is specified and the problem is to determine the driving forces that produced the motion (17).Uses of inverse dynamics for calculate net muscle moments.The conventional calculation of jointtorques is completed by modeling the body as a series of rigid segments connected byjoints and iteratively solving the Newton-Euler equations of motion for each segment inthe model (14).Indirect estimation of joint kinetics using inverse dynamic methods requires the input. These include the segment's total mass, the location of the segment's Center of Mass (COM), and the mass moment of inertia about its COM (4).

Handstand is one of the basicelements of both man and woman acrobatic gymnastics (9). It isoften used as a holding element in routines on floor exercise, rings, parallel bars and balancebeam (11). Here the technical perfection ofa handstand is important since the finalposition of one movement structurebecomes an initial position of another one.The final position ofhandstand is characteristic by a flat anglebetween “longitudinal” body axes – arms –trunk – legs, straight head position (eyesfollowing the hand finger tips) (9).Thebody configuration in a handstand is similarto one in an upright position, which meansthat transfers occur between upper andlower extremities (3).

A number of studies have examined various performance aspects of handstand biomechanics (1, 5, 6, 9, 11, 13). Application of inverse dynamics methods to biomechanicsanalysis of handstand is also well documented in the scientific literature (10, 12, 15).

The purpose of this study was to determine the dynamics model of upper limbs and hip joint incontrol balance during handstand performance and biomechanics analysis.

II. Methods

Oneelite gymnast with the age of 19 yr, the height of 172.5 cm, the weight of 63.6 kg participated in this study. He has no recent injury or surgery that could affect their handstand pattern. Following a brief warm-up activity and attachment of the markers, the subject executed a handstand, he reached to a complete stable balance, then cameras started to record the position of the markers for 5 seconds.The markers placed on the fingers, wrist, elbow, shoulder, head (temporal bone), hips, knees, ankles and toes (15).The high-speed video based system was equipped with two cameras (Vicon mark).The camera placed to 60-degree angle relative to each other and speed set to 120 Hz.Suppose that the wrist and elbow moving in the Sagittal plane, and shoulderand hip moving in the Sagittal and Frontal planes.

Customized body segment inertia parameters were generated from anthropometric measurements (length of the segment, the mass of segment, location of the center of mass) by using the inertia model (10). A calibration structure comprising eight upright poles, each with threemarkers were positioned. Images of the calibration structure were recorded before the subject trial.

For the purpose of measuring alterations in the joints angular change, determining the deviations between the connecting lines of each marker placed on the limbs, the angle of that limb with each of the axis or another limb was measured. In this study, the angle between two limbs was defined as the angular joint of that limb (12).

Programmingfor inverse dynamics wasby using MATLAB software. Input in the program of MATLABhasrecorded Images. The output was the spatial position of the markers.We used theDirect Linear Transformation (DLT) for reconstructing Three Dimensional (3D) from Two Dimensional (2D) photographs.The input in theSimMechanicswas3D joints angular and anthropometric measurements.Camera calibration was effected using an 11 parameter DLT procedure, and unbiased estimates of reconstruction accuracy were determined (10).The output was the joints torque.

Calculations were performed in the MATLAB/SimMechanics environment after recorded the position(handstand) for simulation.The SimMechanics blocks present elements enabling to model mechanical systemsconsisting of rigid bodies connected by joints that represent translational and rotationaldegrees of freedom.

All data were analyzed using SPSS version 19. ANOVA was used at the alpha level set to 0.05.

III. Results

The angular change in wrist, elbow, shoulder and hip in Sagittal plane for the subject is presented in Figure 1. As it can be observed, angular changes in the wrist, in general, are larger than the elbow, shoulder and hip in Sagittal plane, While the least change was present in the elbow joint(Figure 1).

Figure 1. Joint angular changes in Sagittal plane (expressed in degree)

The angular change in shoulder and hip in Frontal plane for the subject is presented in Figure 2. As it can be observed, angular changes in the shoulder, in general, are larger than the hip in Frontal plane (Figure 2).

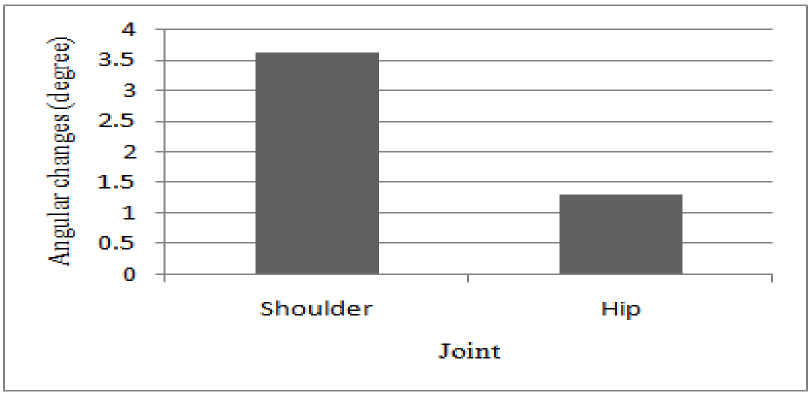

Figure 2. Joint angular changes in Frontal plane (expressed in degree)

Figure 3 presents torque of wrist, elbow, shoulderand hip for the subject in Sagittal plane. An eye inspection of this figure reveals that the highest amount of torque of joints occurred in the wrist joint (30.19 N.m) followed by the shoulder (14.74 N.m), hip (11.12 N.m) andelbow (10.8 N.m), respectively(Figure 3).

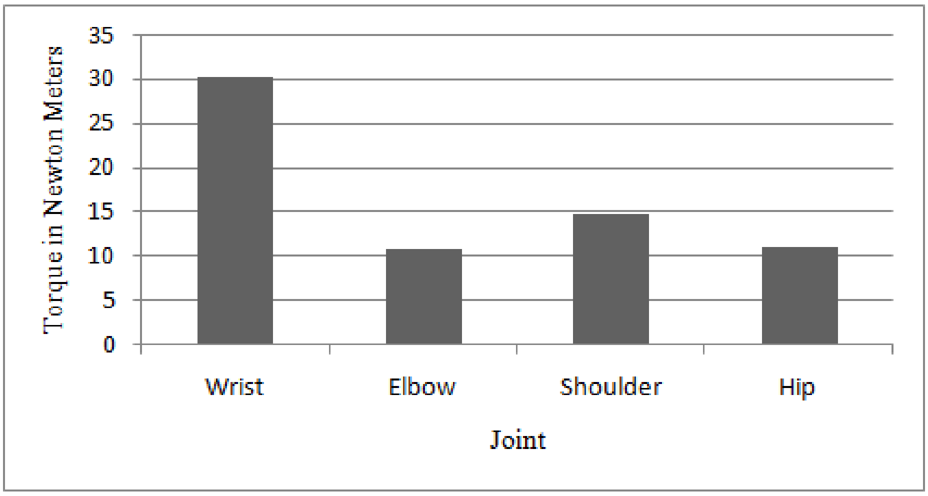

Figure 3. Joints torque in Sagittal plane (expressed in newton meters)

Figure 4 presents torque of shoulderand hip for the subjectin Frontal plane. An eye inspection of this figure reveals that the highest amount of torque of joints occurred in the shoulder joint (4.07N.m) followed by the hip (2.93 N.m)(Figure 4).

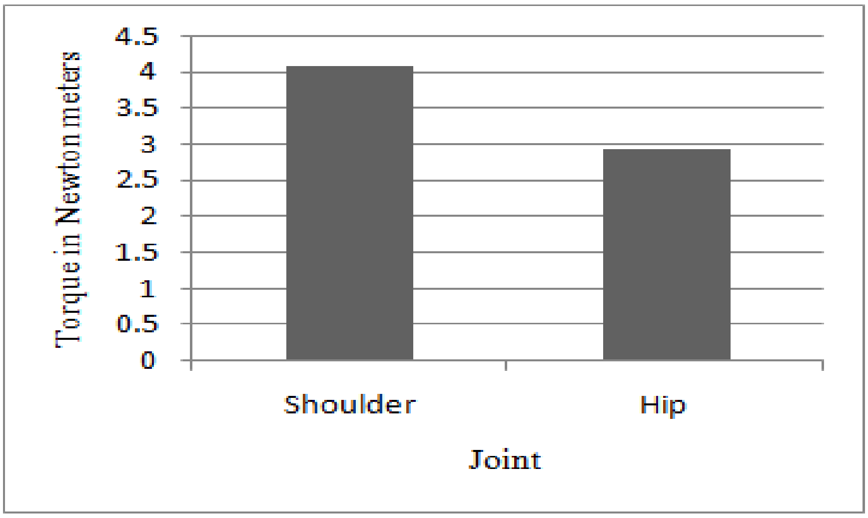

Figure 4. Joints torque in Frontal plane (expressed in newton meters)

IV. Discussion

The purpose of this study was to develop a dynamics model of thehandstand which is the one of the essential skill of gymnasticby SimMechanicsthat could evaluate joints torque requirements.Following the examination of angular changes in wrist, elbow, shoulder and hip, it was concluded that the most angular changes during the handstand in Sagittal plane occurred in wrist followed by shoulder, hip, and elbow, respectively.In this regard, the study conducted by Mohammadi (2011) reported the angular changes in the wrist, shoulder, hip, knee, and elbow inthe execution of handstand in Sagittal plane (12).According to the results of this study,angular changes in the Frontal plane are little. Butin general, angular changes in the shoulder are larger than the hip in Frontal plane.

According to the results of this study, the pattern of torque in the subject was observed in the wrist,shoulder, and hip in Sagittal plane. In the present research, it was observed that three joints, that is, wrist, shoulder, and hip all have contributed to the maintaining the COM within the base of support, but wrist joint shows the highest change in torque and thus it has the major role in the execution of balance on handstand in Sagittal plane.Kerwin and Trewartha (2001) found that wrist, shoulder, and hip torques were significantly correlated with mass center displacement, with wrist torque predominant (10).According to the results of this study, torque in Frontal plane is little. But in general, torque changes in the shoulder are larger than the hip in Frontal plane.

These results indicate that the wrist joint plays the most significant role in maintaining the COM within the base of support.Another technique involving elbow flexion was evident in Slobonov and Newell (1996) and was probably adopted after a failure of wrist strategy to maintain balance(15).It is evident that the synergistic torques at the shoulder and hip were more complex than a simple proportion of the wrist torque although there was quite a strong correlation between shoulder torque and wrist torque and a weaker relationship between hip torque and wrist torque (15).

Yeadon and Trawattha (2003)found thatall gymnasts used the wrist strategy, with time delays ranging from 160 to 240ms,the net joint torques at the shoulder and hip joints were regressed againstthe torques required to maintain a fixed configuration (15).

According to the results of this study, handstand movement occurred in Sagittal plane. Thefindings of the present research are in agreementwithKerwin and Trewartha (10) and Yeadon and Trewartha (15).

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References

[1]. Asseman F and Gahery Y. (2005). Effect of head position and visual condition on balance control in inverted stance. *Neuroscience Letters*, 375: 134-137.
[2]. Blanke D. and Stergiou N. (2008). *Biomechanics. In: Introduction to Exercise Science.* Ed, Housh T. and Housh D., Holcomb Hathaway: Scottsdale.
[3]. Clement G and Rezette D. (1985). Motor behavior underlying the control of an upside-down vertical posture. *Experimental Brain Research*, 59: 478-484.
[4]. Durkin JL and Dowling JJ. (2003). Analysis of body segment parameter differences between four human populations and the estimation errors of four popular mathematical models. *Journal of Biomechanical Engineering*, 125: 515–522.
[5]. Gauthier G, Marin L, Leroy D and Thouvarecq R. (2009). Dynamics of expertise level: coordination in handstand. *Human Movement Science,* 28: 129-140.
[6]. Gauthier G, Thouvarecq R and Chollet D. (2007). Visual and postural control of an arbitrary posture: the handstand. *Journal of Sports Sciences,* 25: 1271. 1278.
[7]. Gordon D, Robertson E, Caldwell GE, Hamil J, Kamen G and Whittlesey SN. (2004). *Research Methods in Biomechanics.* Human kinetics: USA.
[8]. Hamill J. and Knutzen KM. (1995). *Biomechanical basis of human movement.* Baltimore: Williams and Wilkins.
[9]. Hedbavny P, Sklenaříková J, Hupka D and Kalıchová M. (2013). Balancing in handstand on the floor. *Science of Gymnastics Journal,* 5(3): 69-80.
[10]. Kerwin DG andTrewartha G. (2001). Strategies for maintaining a handstand in the anterior-posterior direction.*MedSci Sports Exerc*,33(7):1182-1188.
[11]. Kong PW, Leung SY and Han YS. (2011). Effect of hand placement position on press-to–handstand techniques and stability. *Portuguese Journal of Sport Sciences*. 11: 291- 294.
[12]. MohammadiM,SadeghiH,ShirzadEandKazemiSE. (2011). Functional role of upper limbs and hip in during control balance hand stand performance in male gymnasts. *International Journal of Sport Studies,* 1(2): 85-89.
[13]. Sobera M. (2007). Maintain body balance in extreme position. *Biology of Sport,* 24(1): 81-83.
[14]. Winter DA. (2009). *Biomechanics and motor control of human movement.* 4th Edition, Wiley.
[15]. Yeadon MR and Trawattha G. (2003). Control strategy for a hand balance. *Motor Conrrol,* 7: 411- 430.
[16]. Yeadon MR. and King MA. (2008). *Computer simulation modelling in sport. In biomechanical analysis of movement in sport and exercise.* Ed, Payton CJ and Bartlett RM., London: Routledge.
[17]. Zatsiorsky Vm. (2002). *Kinetics of human motion. Champaign,* IL: human kinetics.