LANDING KINEMATICS OF HORIZONTAL BAR DISMOUNTS

H. Geiblinger, P. A. McLaughlin & W. E. Morrison
Biomechanics Unit, Dep't of Physical Education and Recreation and
Centre for Rehabilitation, Exercise and Sport Science, Victoria University of Technology

Dismounts from the horizontal bar require the dissipation of substantial velocities and therefore large forces. The maximum heights from dismounts are seen to be in the order of 4m or more. (Kerwin et al. 1990) reported that maximum heights for double somersault dismounts ranged from 3.45 to 3.73m, and for triple somersault dismounts, 3.89 to 4.08m. The purpose of this study was to investigate the biomechanical characteristics of successful horizontal bar landings. Performances of six male finalists from the individual apparatus finals on horizontal bar at the World Gymnastic Championships 1994, Brisbane, were chosen. The dismounts were recorded at 50 Hz during competitions, with the video cameras positioned on the catwalks above the floor of the competition venue. The analysis included mean and standard deviations of selected kinematic and temporal parameters in order to identify successful competition landing techniques. Analysis of the data revealed a mean maximum CM height during dismount of 3.95 ± 0.16m and an impact velocity at landing of -6.48 m/s. The knee angle at landing was 156" and minimum knee angle during landing was 87'. This available range of motion of 69° knee flexion with a landing phase duration of 0.14sec, was a significant factor for the preparation phase of successful landings. Selected parameters of the results presented in this study may be used to form a representative biomechanical profile for horizontal bar landings.

Introduction

Dismounts on horizontal bar can be classified as movements with rotation in the vertical plane about a fixed horizontal axis. Dismounts from the horizontal bar require the dissipation of substantial velocities and therefore large forces. (Gervais 1993) reported a maximum force of 7 BW for the giant swing prior to release. The maximum heights from dismounts are seen to be in the order of 4m or more. (Kerwin et al. 1990) reported that maximum heights for double somersault dismounts ranged from 3.45 to 3.73m with a flight time of 1.26 seconds, and for triple somersault dismounts 3.89 to 4.08m with a flight time of 1.32 seconds. (Kerwin et al. 1993) provide a more detailed description of the release phase and its importance of the correct release timing for triple back somersault dismounts. These factors are important considerations for the landing of such skills. (Fink 1988) stated that the "release phase" is the most important determinant in the successful performance of release/regrasp (flight elements) skills. The same can be assumed to be true for dismounts. Therefore it is necessary for a gymnast to have several strategies of preparatory giant swings for the execution of different dismounts. (Brueggemann et al. 1994) reported mean values of 4.79 ± 0.33 and 1.04 ± 0.31 m/s for double tucked back somersault, 4.04 ± 0.10 and 1.34 ± 0.67 m/s for double layout back somersault and 5.06 ± 0.28 and 1.19 ± 0.39 m/s for triple tucked back somersault dismounts, respectively, for vertical and horizontal release velocities.

The purpose of this study was to investigate the biomechanical characteristics of successful horizontal bar landings. Although consideration must be given to preparatory elements before release, and biomechanical factors at release, the analysis was mainly focused on the landing phase.

Subjects

Landing performances of six male gymnasts at the World Gymnastic Championships 1994, Brisbane, participating in the individual apparatus finals (competition III) on horizontal bar, were chosen as subjects.

Equipment and Data Capture

Landing performances on horizontal bar were filmed during competitions with two video cameras from the catwalks above the floor of the Brisbane Entertainment Centre. The competition area was lit by high power television lighting. Performances were filmed with two cameras genlocked for time synchronization. This event was filmed at 50 fields/second (50 Hz), with one Panasonic F-15 and 1 Panasonic Super-VHS MS4 camcorder with 11500th second shutter speed. All 50 Hz PAL signals were cabled to a central control room, where the PAL VCR's were located, and were EBU time-coding and recording was done. During subsequent digitization, time synchronization of the camera views was based primarily on the on-screen time code (field-accurate). A back-up system (notebook computer) was also used: a digital-to-analog convertor was triggered in software to send a pulse to an Event Synchronisation Unit - ESU (Peak Performance Technologies), which simultaneously displayed a white block on all recorded PAL video signals (approximately every second). EBU time code generators were also used. The EBU video time code was recorded on the audio track of the videotapes (channel 2).
In order to reconstruct the gymnasts position in three dimensional space from two-dimensional camera views, a PEAK system three dimensional calibration frame of 24 spheres and rods of known co-ordinates was used to obtain a calibration and scaling factor, and was filmed by both cameras before and after each session. The size of each cameras field of view, necessitated the placement of the calibration frame in three positions for the horizontal bar.

Data Analysis

Analysis of the 50 Hz PAL tapes were performed using a Peak Performance Technologies, Inc.-Peak 5, 3-D Motion Analysis System, Denver, USA. 2-D dimensional coordinates of a 21-point body model were manually digitized (effective half-pixel resolution 1024x1024). The coordinates were filtered with a Butterworth low pass digital filter (Winter, 1990), with an 'optimal' cut-off frequency determined independently for the X and Y coordinates of each body point. This was done from the residuals by the Jackson 'knee' method (Jackson, 1973), with the 'prescribed limit' set to 0.1. Total body centre of mass (TBCM) position was determined based on estimated segment centre of mass positions and proportions of total body mass, according to (Dempster 1955). The two 2-D views of the calibration frame were used to construct a Direct Linear Transformation-DLT (Abdel-Aziz & Karara, 1971), which was then used to calculate the 3-D coordinates of the gymnasts from the digitized 2-D coordinates. Linear and angular velocities and accelerations were calculated from the 3-D coordinates by finite differences (Miller & Nelson, 1973).

Digitisation generated positional data which when combined with temporal data generated kinematic parameters; linear and angular positions, displacement and velocities on the three axes as well as a resultant. After the kinematic data was obtained, they were cascaded with the spatial model to generate line model diagrams with the kinematic graphics as well as synchronized with the video tapes to provide the real life view and data characterization.

Results and Discussion

The landings on horizontal bar represented different types of double and triple back somersaults tucked with a forward horizontal velocity.

Parameters	Means	SD
Flight time - release to touch-down (sec)	1.29	0.04
Duration CM from touch-down to minimum (sec)	0.12	0.04
Max. CM height during dismount (somersault) flight (m)	3.86	0.16
CM height at touch-down (m)	0.90	0.06
CM height at minimum (m)	0.63	0.13
CM vertical velocity at impact (rnls)	-7.08	0.18
CM horizontal velocity at impact (rnls)	0.97	0.57
Angle CM to ground contact and the horizontal at touch-down (deg)	97	3
Knee angle at touch-down (deg)	156	10
Minimum knee angle (deg)	87	28
Trunk to horizontal touch-down (deg)	134	8
Minimum (deg)		
thigh to horizontal touch-down (deg)	107	8
Minimum (deg)		
R. hip angular velocity at landing (degIs)	565	103
R. knee angular velocity at landing (degIs)	-798	197
CM vertical velocity at release (rnls)	4.94	0.33
CM horizontal velocity at release (rnls)	1.08	0.62
CM height at release (m)	2.62	0.13

Table 1. Means and Standard Deviation of Selected Landing Parameters for the Horizontal Bar Landing Performances

The recordings of the individual dismounts and subsequent landing performances were qualitatively reviewed to investigate the completion of the last salto of the double and triple back somersaults before the landing. The double back layout dismounts showed a back arched shape for most of the flight phase before re-piking in preparation for the landing. Analysis of the data revealed a mean maximum CM height during dismount, before the landing, of 3.86± 0.16m and an impact velocity at landing of -7.08 m/s. The flight time from bar release to landing touch-down was 1.29 seconds. The release velocity was 4.94 0.33

landing, of 3.86± 0.16m and an impact velocity at landing of -7.08 m/s. The flight time from bar release to landing touch-down was 1.29 seconds. The release velocity was 4.94 0.33 m/s. (Brueggemann et al. 1994), reported mean release vertical velocities of 4.79 0.33 m/s for double tucked back somersault, 4.04 ± 0.1 m/s for double layout back somersault, and 5.08 ± 0.31 m/s for triple tucked back somersault dismounts, which compares to the impact velocity of this study. As a result of the force of gravity, the vertical velocity, and subsequently, the vertical momentum, is decreased from the point of release to the maximum CM height where it will become zero, and than increases continuously up to the moment of landing touch-down (impact). The knee angle at landing was 156 ± 10° and minimum knee angle during landing was 87 ± 28". This available range of motion of 69° knee flexion with a landing phase duration of 0.12 sec, was a significant factor for the preparation phase of successful landings. The mean CM to ground contact and the horizontal at landing was 97 ± 3". Trunk to horizontal at landing was 134 ± 8°, and thigh to horizontal at landing was 107 ± 8°.

This study showed that gymnasts encounter a variety of biomechanical and psychological factors before and during the landing process which influence the landing performance.

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