Determination of prognostic indicators of technical readiness of athletes in competitive exercises with a flight phase based on video footage

UDC 796.012

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Received by the editorial office on 12.06.2023

Abstract

Objective of the study was to develop computational models and a computer application of prognostic indicators of the technical readiness of athletes in competitive exercises with a flight phase based on video footage.

Methods and structure of the study. During the experiment, video shooting of exercises, calculation models for the analysis of the technique of sports exercises were carried out. The study group of exercises included acrobatic exercises with a flight phase.

Results and conclusions. The original method of constructing a computational model of the flight part of competitive exercises is based on adequate physical and mechanical laws of motion and allows you to form an array of equations for the calculated biomechanical characteristics of an exercise, regardless of the availability of specialized information for calculating the kinematics and dynamics of the flight period.

The developed computational model of biomechanical indicators of movement and a computer application can be used for operational control of the level of technical readiness not only of an acrobat, but also of athletes specializing in those sports in which competitive exercises have a flight period.

Keywords: *biomechanical system trajectory, competitive exercise, flight period.*

Introduction. The competitive activity of highly qualified athletes is highly effective if it is based on objective data of technical indicators of competitive exercises [2, 4]. According to the technology for calculating biomechanical characteristics [3], the initial data of calculation operations are the temporal and spatial characteristics of movements. The time interval between the video frames of the video file is a function of the video recording frequency, and the spatial characteristics are determined in the form of generalized coordinates of the athlete's body links (the angle of the link to the horizontal numerical axis of the Cartesian coordinate system). The most time-consuming operation is the operation of reading the generalized coordinates of the athlete's body links.

At the same time, it should be noted here that not the entire array of calculated kinematic and dynamic characteristics of movements is used for quantitative biomechanical analysis. For example, in [2], eight indicators of the technical readiness of highly qualified trampoline jumpers are identified: the height of the exercise (cm); exercise time (s); coefficient of difficulty (CD) of the most difficult element (c.u.); average CD of one element (c.u.); elements in grouping (number), elements bending, bending (number); quarters in somersaults (number); pirouette turns (number). Two of the eight indicators (exercise performance height and flight time) are directly related to the biomechanical characteristics of movement, the rest are related to the requirements of competition judging and the quantitative calculation of individual elements of the exercise composition.

In this regard, we put forward a hypothesis that for exercises with a flight phase, it is possible to organize such a computer technology for calculating prognostic indicators of the technical readiness of athletes in competitive exercises in which there is no need to use information about the numerical values of the generalized coordinates of the biosystem. The implementation of the functional essence of the proposed technology for constructing computational models is based on the known laws of mechanics and knowledge of the duration of the exercise, which can be obtained from video footage. Knowing the time of the flight phase by the number of video frames replaces the technology for calculating kinematics and motion dynamics according to the classical scheme, in which the spatio-temporal characteristics of motion are calculated from the results of the measurement, which significantly minimizes the time spent on preparatory operations for carrying out computational operations.

Objective of the study was to develop computational models and a computer application of prognostic indicators of the technical readiness of athletes in competitive exercises with a flight phase based on video footage.

Methods and structure of the study. During the experiment, video shooting of exercises, calculation models for the analysis of the technique of sports exercises were carried out.

The study group of exercises included acrobatic exercises with a flight phase (Figure 1). Video filming was carried out with a SONY digital video camera with a frequency of (N) 25 frames per second (N=25).

The exercises were performed by the master of sports of the Republic of Belarus E.A. Yukovich.

Results of the study and their discussion. The videograms (Figure 1) show the main postures of the athlete (upper line), correlated with time (t - bottom line) in the studied exercises. The input data were: N – frequency of video filming); n is the number of video frames of the flight part of the exercise, including the frame of the completion of the repulsion on the support (kadrS = 1), coinciding with the moment of completion of the repulsion “Start” (tS = 0) and the frame of the athlete’s contact with the support after the completion of the unsupported state “Finish” (kadrF = n) coinciding with the end time of the unsupported state “Finish” (tF); X is the horizontal distance from the repulsion point to the landing point in meters - measured with a tape measure): m is the mass of the athlete, g is the acceleration of free fall. Based on these data, calculation models of the kinematics and dynamics of exercises with a flight period were built:

1. Time step (h) between exercise video frames: $h=1 / N$.
2. Duration of the flight part of the exercises (tF): $tF = n \cdot h$.
3. Time to reach the maximum flight altitude (H) (tH): $tH = (tF - tS) / 2$.
4. Duration (ta) of repulsion: $ta = h \cdot (j - i)$. Here: j, i are the number of the video frame of the start and end of the repulsion on the support. According to the statistical data obtained on a sample of 30 acrobats [4], for a single somersault ta=0.12 s, for a double somersault - 0.121 s. Therefore, ta = 0.12 s can be used for ta.
5. The vertical component of the velocity of the common center of mass (CCM) of the biosystem (VY) at the moment of completion of repulsion from the support: $VY = g \cdot tH$.
6. The horizontal component of the velocity of the CCM of the biosystem (VX) at the moment of completion of repulsion from the support is: $VX=X / tF$.

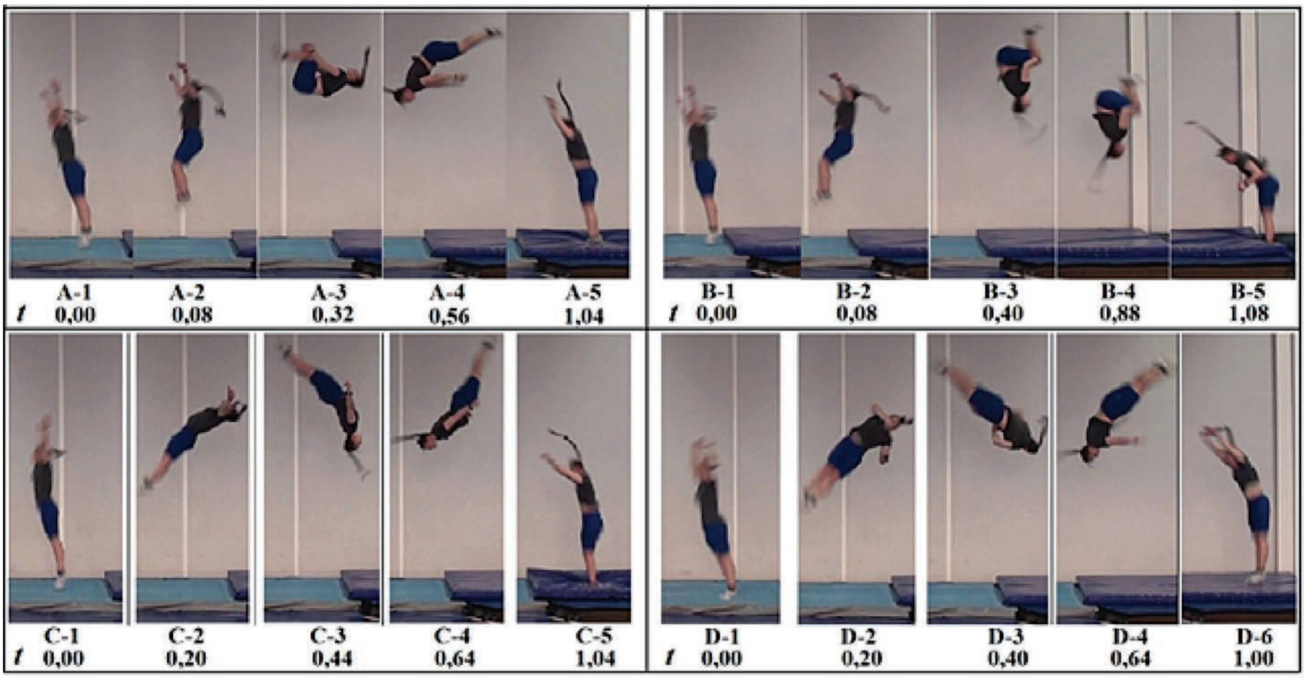

Figure 1. *Acrobatic exercises: A - back somersault in the tuck, B - double back somersault in the tuck, C - back somersault bending over, D - back somersault bending over with a turn of 360 °*

Biomechanical indicators of the technical readiness of an athlete (back somersault, bending over in acrobatics)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
h, (s)	t_F, (s)	t_H, (s)	t_a, (s)	V_Y, m/s	V_X, m/s	V_O, m/s	Q, degrees	H, m	a_Y, m/s²	a_X, m/s²	a_O, m/s²	F_Y, n	F_X, n	F_O, n
0,04	1,04	0,52	0,08	5,10	1,54	5,33	73	1,33	63,7	19,2	66,6	4560	1192	4713

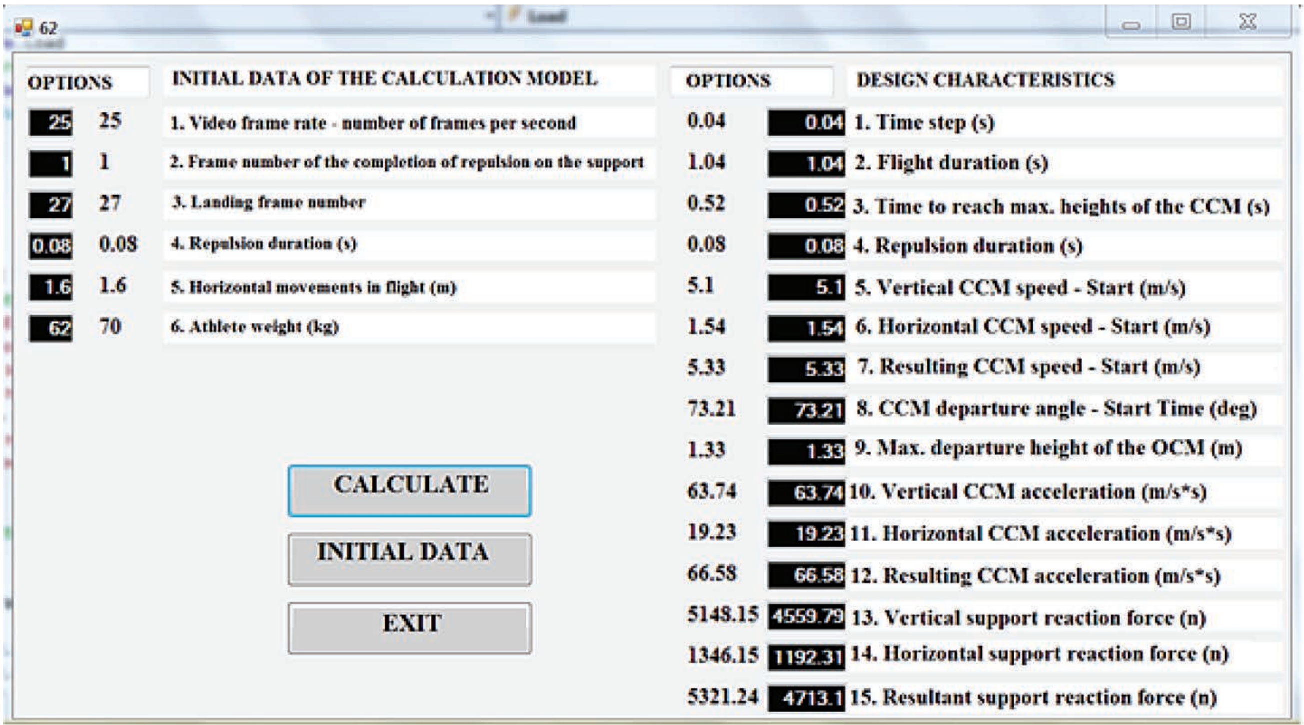

Figure 2. *Results of functioning of the computer application "Computational model of the flight phase of a competitive exercise"*

7. The resulting linear velocity (VO) of the departure of the biosystem's CCM at the time "Start": VO = sqrt[(VX)2 + (VY)2]. Here: sqrt is the square root.

8. Departure angle of the CCM biosystem (Q): Q = arccos (VX / VO).

9. Maximum lifting height of the CCM (H): H = (VY) 2 / 2g.

10. Acceleration of the biosystem's CCM along the vertical (aY) under support conditions at the time "Start": aY = VY / ta.

11. Acceleration of the biosystem's CCM along the horizontal (aX) under support conditions at the time "Start": aX = VX / ta.

12. The resulting linear acceleration (aO) of the biosystem's CCM takeoff at the time "Start": aO = sqrt [(aX)2 + (aY)2].

13. Vertical support reaction force (FY): FY = m·(aY+g).

14. Horizontal support reaction force (FX): FX = m·aX.

15. Resultant support reaction force (FO) at the time "Start": FO = sqrt [(FX)2 + (FY)2].

The table shows in the SI system the calculated values of the indicators of the above list (1-15) according to the input data: N=25; n=26; cadrS = 1; ta=0.08; tS = 0; tF=1.04; X=1.6; m=62; g=9.806.

Exercise C was considered as a test exercise (Figure 1). Figure 2 shows the results of the operation of the original software application based on the Microsoft Visual Basic 2010 Express software system.

The input data of the model test problem is located in the shaded cells of the "parameters" column (left border of Figure 2) and has the default values of the test problem. The solution result is formed in the shaded cells of the "parameters" column to the right of the input data (Figure 2).

When changing the scenario of the task, for example, the athlete's weight increased to 70 kg, this indicator is entered into the corresponding input data cell (the last shaded cell on the left) and the "Calculate" command is implemented with the computer mouse. The modified input and calculated calculated values are printed on the computer screen, and the original data is restored in the darkened windows.

Conclusions. The original method of constructing a computational model of the flight part of competitive exercises is based on adequate physical and mechanical laws of motion and allows you to form an array of equations for the calculated biomechanical characteristics of an exercise, regardless of the availability of specialized information for calculating the kinematics and dynamics of the flight period.

The developed computational model of biomechanical indicators of movement and a computer application can be used for operational control of the level of technical readiness not only of an acrobat, but also of athletes specializing in those sports in which competitive exercises have a flight period.

References

1. Akrobaticheskiye uprazhneniya [Acrobatic exercises] [Electronic resource]. Available at: https://studfile.net/preview/2780849/page:2/. (date of access: 04.14.2023).
2. Balandina S.V. Korrektsiya tekhnicheskoy podgotovki vysokokvalifitsirovannykh prygunov na batute na predsorevnovatelnom etape [Correction of the technical training of highly qualified trampoline jumpers at the pre-competitive stage]. PhD diss. abstract. Kuban State University of Physical Culture, Sports and Tourism. Krasnodar, 2007. 24 p.
3. Zagrevsky V.I., Zagrevsky O.I. Biomekhanika fizicheskikh uprazhneniy [Biomechanics of physical exercises]. Study guide. Tomsk: Izdatelskiy dom Tomskogo gosudarstvennogo universiteta publ., 2018. 262 p.
4. Menkhin Yu.V. K probleme ponimaniya i formirovaniya dvigatelnogo navyka [To the problem of understanding and formation of motor skills]. Teoriya i praktika fizicheskoy kultury. 2007. No. 2. pp. 12-17.