

EVALUATION OF THE KINEMATIC STRUCTURE OF INDICATORS KEY ELEMENTS OF SPORTS EQUIPMENT EXERCISE BY POSTURAL ORIENTATION MOVEMENTS

Litvinenko Y.V.¹, Niznikowski Tomasz², Boloban V.N.³
National University of Physical Education and Sport of Ukraine¹, Ukraine
Faculty of Physical Education and Sport in Biala Podlaska², Poland
Józef Piłsudski University of Physical Education in Warsaw³, Poland

Annotation. *Purpose:* Examine the kinematic structure of indicators key elements of sports equipment exercise (difficult to coordinate). The method of postural orientation movements. *Material:* The study involved acrobats jumpers on the path of high qualification (n = 7). The method used video - computer recording the movements of the athlete. *Results:* Identified nodal elements of sports equipment double back somersault tuck. Exercise performed after rondat and double back flip and stretch after rondat - flick (coup ago). In the preparatory phase of motor actions acrobatic exercises isolated and studied central element of sports equipment - starting posture of the body; in the phase of the main motor action - animation poses of the body; in the final phase - the final body posture (stable landing). *Conclusions:* The method of video - computer registration allowed to perform a biomechanical analysis and evaluation of key elements of sports equipment double back somersault tuck and a double back flip and stretch. Also gain new knowledge about the mechanism of the phase structure of movements when performing double somersaults.

Key words: biomechanics, acrobatics, exercise, sports equipment, double somersault, phase, posture, central element.

Introduction

Method of movements' postural orient is intended for bio-mechanical study of kinematic structure of sport exercises by means of analyzing of preceding and following body postures, body positions in phase structure of fulfilled exercise in order to know key elements of sport technique. Key element of sport technique is a signal position of movement, which pre-determines effectiveness of sportsman's solution of his motion task [3]. Method of movements' postural orient was developed and offered for analysis of sport technique of gymnastic and acrobatic exercises at the end of 70-tees [2]. Then, they perfected the concept and methodology of studying of movements' bio-mechanic, provided scientific-practical principles in works [3, 4, 5, 6, 7, 8, 10]. The authors carried out bio-mechanical study of sport technique of the following exercises: jump-step – jump-step; throw of ball in back jump – catching of ball and rolling on arms and back in rhythmic steps; ball throw in ring in jump - rolling on arms and back in rhythmic steps; forward roll – forward somersault in group position; rondat – grouped back somersault; rondat – arched double back somersault; rondat – double back somersault in combination with temp somersault. We also carried out detail bio-mechanical analysis of exercises on gymnastic apparatuses [4].

The conceptual sense of method of movements' postural orient is that every preceding posture of body in exercise, fulfilled by a sportsman, shall positively influence on bio-mechanic of following body position that permits to fulfill exercise without extra movements in order not to accumulate mistakes in demonstration of an exercise or combination of exercises. "New-coming always strives to follow the preceding... and similar to the order of all existing, the new coming is not a simple sequence but certain remarkable order" – Marcus Aurelius (Speculations. Book forth). In Thai Tsi Tsuan – martial and health related art there are also interesting and instructive ideas. For mastering of this system's exercises at high level it is necessary to pass three compulsory stages.... "First stage – making foundation is mastering of correct body posture and steady steps. Second stage is mastering of main positions or final positions with coming from one posture to other. Third stage is full understanding of all movements" (Magazine "Daruma", 2008, <http://dharuma.ru/?p=222>) [1].

We shall consider scientific and practical facts, which prove the above said. As example we provide our written evaluation of Olympic champion Aliya Mustafinova's (Russia) exercise on gymnastic bars. She fulfilled exercise of increased complexity, but in rather elegant, beautiful and correct manner. All movements matched each other, all preceding and following postured were technically correct; the sportswoman use inner energetic potential of movements through effective transmitting of preceding posture's characteristics (power, space, time) to following posture without accumulating technical mistakes and it permitted to her to demonstrate perfect sport technique of turns, raises, flights over bar, dismount – double somersault with one and half pirouette (www.youtube.com. Alija Mustafina).

In modern "acrobating" of sport kinds of gymnastics (perfection of acrobatic jumps on tract as independent sport discipline, exercises on mat for floor exercises, dismounts from gymnastic apparatuses, vaults and etc) can be bio-mechanically analyzed with seeking of mechanisms, for perfection of technically correct fulfillment and working out of effective training programs. Competition acrobatic jump exercise, which was fulfilled by Byelorussian sportsman – Andrey Kabyshev (rondat – back double somersault in arching position – temp somersault – back turnover – back somersault in arching position with pirouette in first somersault semi-pirouette ion second somersault) can be positively characterized, using the following bio-mechanical categories: the mentioned exercise is of high complexity, was smooth and dynamic; it had clearly recognized body postures; steady position on rest and without rest, technically correct key elements of every acrobatic jump, videlicet: starting posture, multiplication of body postures, final posture (www.youtube.com. Andrey Kabyshev). Acrobatic exercises are the basis of competition programs of sportsmen, who

practice other kinds of sports with complex coordination of movements (free style, jumping in water, jumping on trampoline and other). So, practical recommendations for mastering of exercises' technical structure are demanded. Back double somersault in group position, double back arching somersault – are exercises of high difficulty. Considering multi-functional purpose of the mentioned exercises (fulfillment with stoppage, transferring to combination of exercises; making this exercise more difficult in vertical direction, for example, triple back somersault in group position, triple back arching somersault) the role of technically correct body positions on rest for effective pushing off for somersault increases. Analysis of sportsmen's performances shows that most mistakes in fulfillment of somersaults were registered in pushing offs and landing [15].

Thus, method of movements' postural orient as mean of bio-mechanical study of sport exercises with the help of analyzing of preceding and following body postures, body positions in phase structure of fulfilled exercise is realized in sport science for learning of sport technique's key elements [3 – 7, 11-14].

The work has been fulfilled in compliance with “Combined plan of SRW in field of physical culture and sports of Ukraine for 2011-2015” by topic 2.15 “Control of static-dynamic body balance by sportsman and system of bodies in kinds of sports with complex coordination of movements” and by governmentally financed topic “Technical training of qualified sportsmen on the base of simulation of sport exercises' motion structure”.

Purpose, tasks of the work, material and methods

The purpose of the work – is to study kinematic structure of indicators of sport technique's key elements, of exercises with complex coordination of movements with the help of method of movements' postural orient; to identify key elements in phase structure of exercises (on example of back grouped double somersault after rondat and arching back double somersault after rondat – back turnover).

The method and organization of the research: video-recording of acrobatic exercises (with two digital cameras of 240 shots per second speed. Application of computer program APAS 2000 for receiving of quantitative data about bio-mechanical structure of the analyzed movements. In our research highly qualified acrobats-jumpers on track ($n=7$) participated. Mean indicators of body height, body mass and acrobats' age ($x\pm S$) were as follows: 170. 00 \pm 4. 00 cm, 72. 40 \pm 3.60 kg, 20. 40 \pm 1. 70 years old.

Results of research and their discussion

In preparatory phase of the analyzed somersaults we marked out starting position of body(SP) as sport technique's key element – bio-mechanically rational position of sportsman's body in coordinates' system, on floor, which creates effective conditions for pushing off and controlled upward flight; in phase of main movements – sport technique's key element is multiplication of sportsman body's postures (MP). Multiplication of sportsman body's postures is a process of consequent alternation of instant, fixed postures for creation of holistic movement; these postures determine and characterize content of exercise; in final phase – sport technique's key element was final posture of body (FP) – landing and stoppage.

Phase of preparatory actions. Indicators of angle joints (see fig.1) are as follows: the tested A (variant 1) had angle thigh – torso 177. 0°, the tested B (variant 2) had angle thigh – torso 184. 4°.

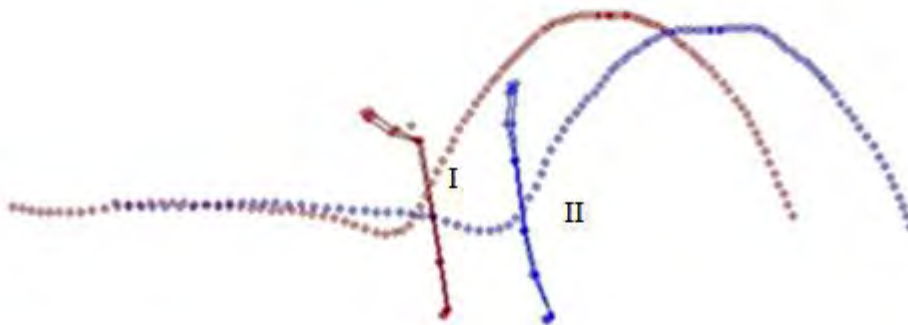


Fig.1. Phase of preparatory movements

Key element of sport technique is starting posture of body for fulfillment of grouped back double somersault after rondat (tested A, variant 1, time 0. 633sec.) and for fulfillment of arched back double somersault after rondat – back turnover (tested B, variant 2, time 0. 583sec.)

In variant 1 sportsman keeps body posture rigidly; he interacts with support, he effectively use energy of elastic deformation. It is proved by scientific fact that resultant curves of speed of sportsman A body's bio links are bunched ((see fig.2), time 0.633 sec.) during short term fixing of starting body posture on support. In variant 2, sportsman B shows excessive plasticity of body position in short term fixing of SP with arms upward and slightly backward. It facilitates arching of body. Certain loss of energy during short term fixing of SP happened; rigidity of

“sportsman-track” system was also lost and, finally, resultants of speed of body bio-links were not bunched (see fig.2, time, 0.583sec.).

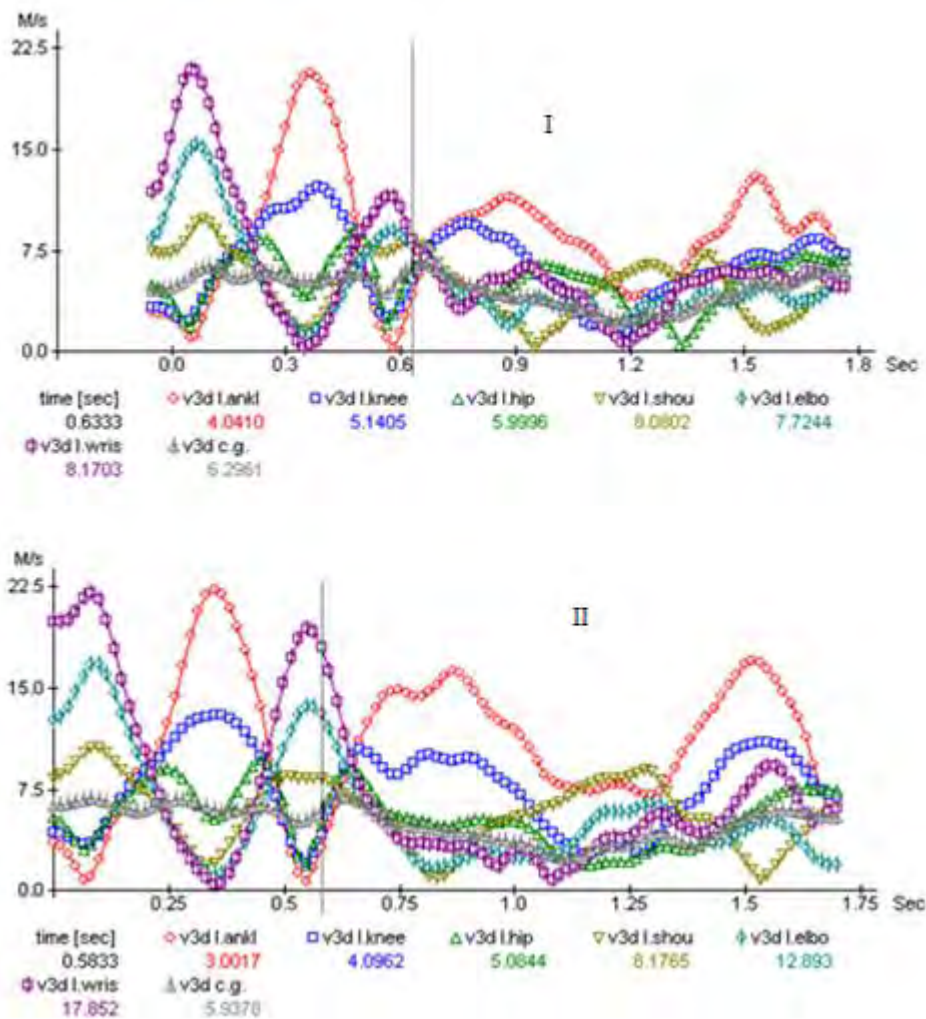


Fig.2. Starting posture of body. Resultants of speed of ankle, hip, elbow, shoulder and wrist joints as well as GMC of sportsmen’s bodies during short term fixing of starting posture for grouped back double somersault after rondat (tested A, upper section of figure, variant 1) and arched back double somersault after rondat-back turnover (tested B, lower section of figure, variant 2): ankle –ankle joint; knee – knee joint; hip – hip joint; should – shoulder joint; elbow – elbow joint; wrist – wrist joint; c.g. – general mass center of body (GMC).

Phase of main movements. Key element of sport technique is multiplication of postures (MP) “grouping” and “straightening” with insignificant bending in hip joints. Sportsmen fulfill first somersault on ascending part of flight trajectory in structure of double somersault (variant 1, time 1. 033sec., angle hip – body equals to 69. 30°; variant 2, time 0. 917 sec., angle hip – body equals to 151. 30°) (see fig. 3).

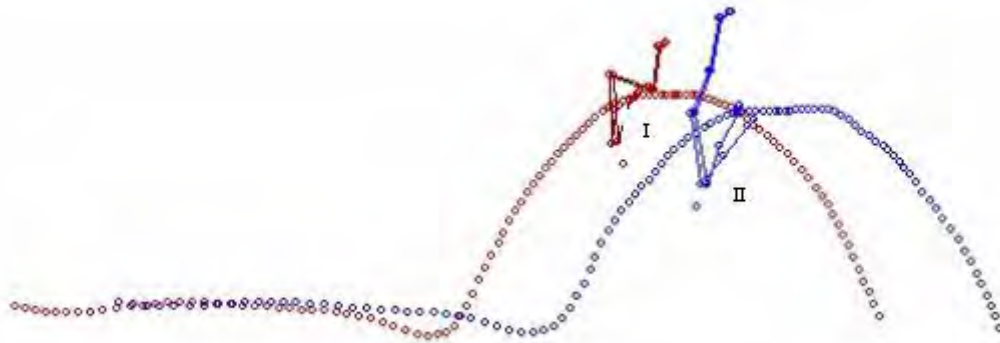


Fig. 3. Phase of main movements of acrobats, who fulfill first somersault at ascending part of flight trajectory in structure of double somersault, Key element of sport technique – MP “grouping” (tested A, variant 1, time 1. 033 sec.), and MP “arching with insignificant bending in hip joints (tested B, variant 2, time 0. 917 sec.)

In variant 1 acrobat A groups tightly, in variant 2 acrobat B takes slightly arched body position to keep speed of rotation in order to ensure uninterrupted passing to second somersault in structure of double somersault (see fig. 4, 5, 6).

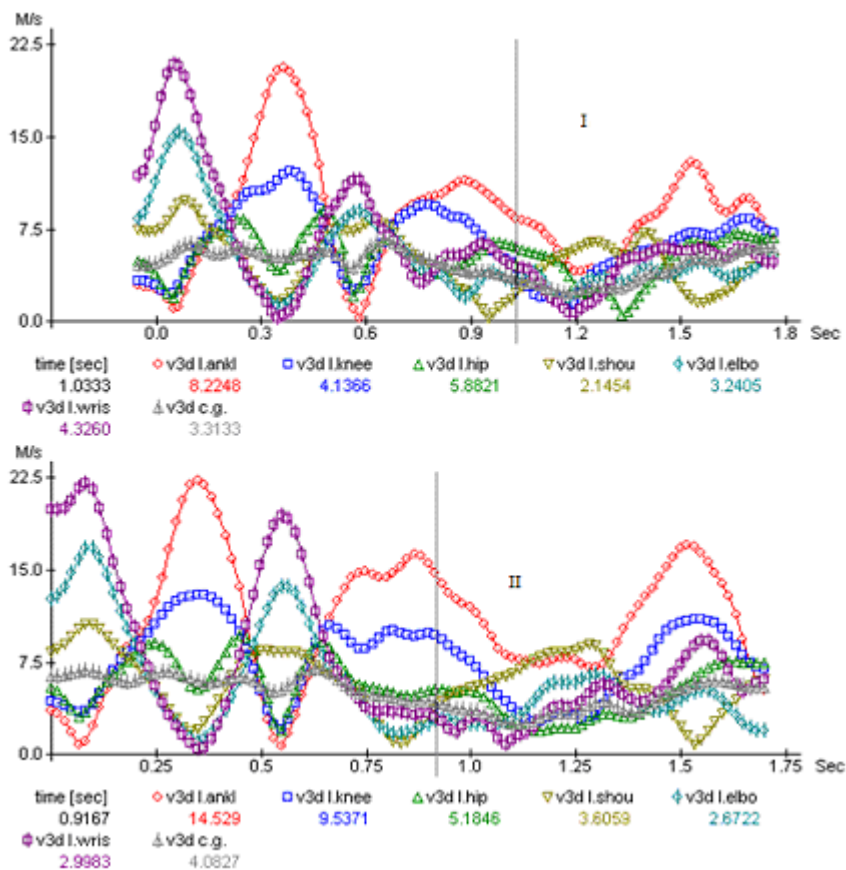


Fig. 4. Resultant speed values of ankle, knee, hip, shoulder, elbow and wrist joints, GMC in phase of main movements; MP in grouped back double somersault after rondat (tested A, upper section of figure, time – 1. 033sec.) and arched back double somersault after rondat – back turnover (tested B, lower section of figure, variant 2, time - 0. 917sec.).

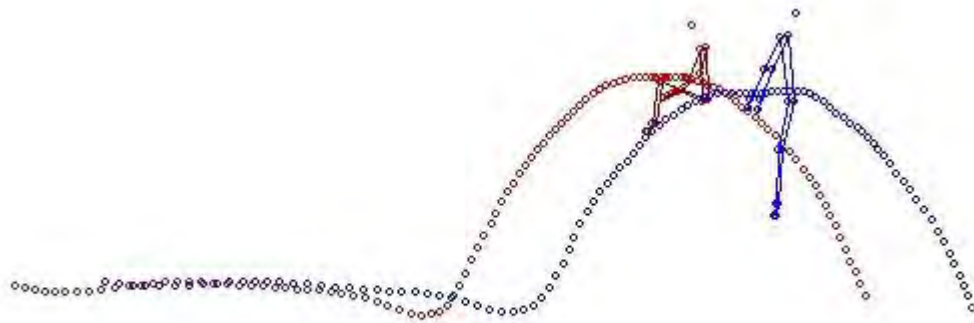


Fig.5. Phase of main movements at acrobats' passing to second somersault (grouped back double somersault after rondat and arched back double somersault after rondat – back turnover. Key element of sport technique – MP “grouping” (tested A, variant 1, time 1. 266 sec.) and MP “arching” (tested B, variant 2, time 1. 183 sec.).

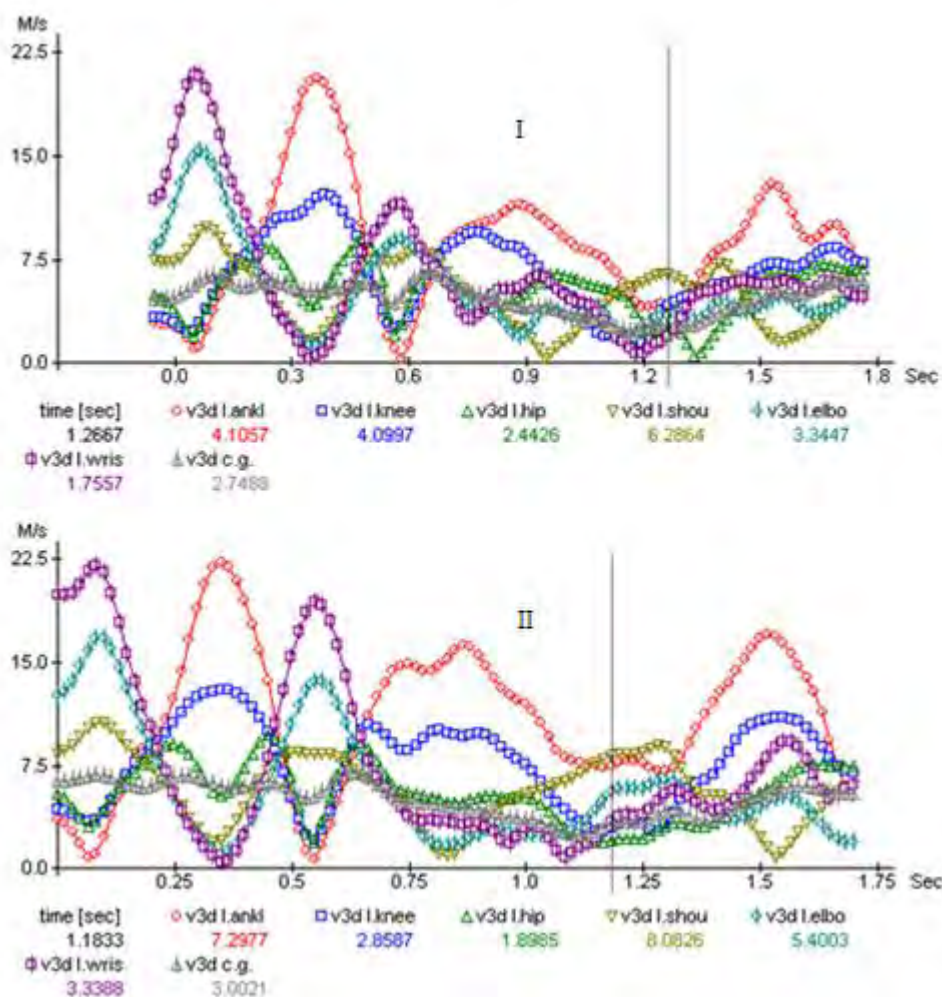


Fig.6. Resultant speed values of ankle, knee, hip, shoulder, elbow and wrist joints, GMC in phase of main movements; MP – passing in second somersault during grouped back double somersault after rondat (tested A, upper section of figure, variant 1, time 1. 266sec.) and arched back double somersault after rondat- back turnover (tested B, variant 2, lower section of figure, time 1. 183sec.).

Phase of final movements. In fig. 7 we present body postures of final phase, which go just before key element – FP (balanced landing), (variant 1 – 1. 750 sec., variant 2 – 1. 683 sec.). In variant 1 hip-torso angle is 144.63°, in variant 2 – 141.93°. Video analysis, pedagogic observations permit to conclude that in variants 1 and 2 sportsmen demonstrate elastic-rigid interaction with support, which facilitated taking optimal FP – “half squatting” with “half bending” of body, arms forward-downward and effective control of body posture on support..

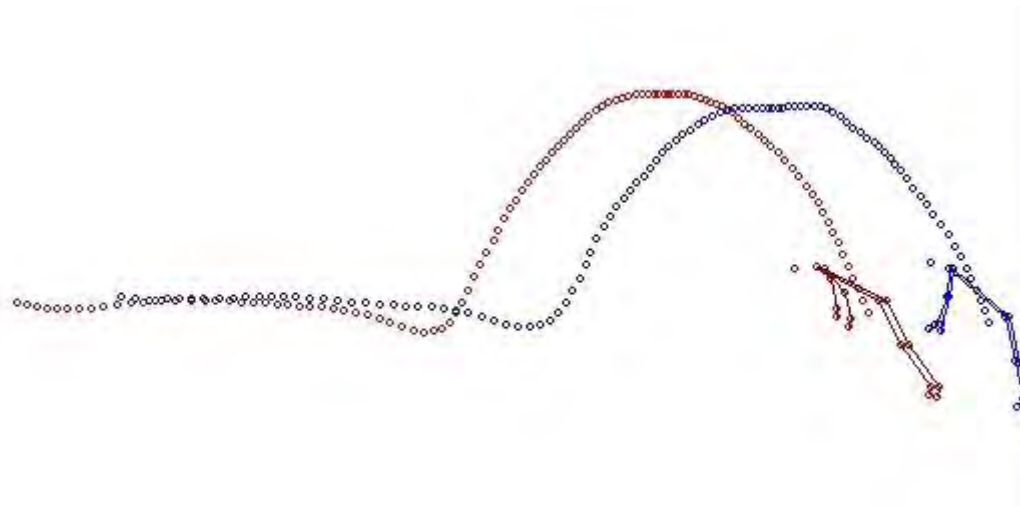


Fig. 7. Phase of finalizing movements with grouped back double somersault after rondat (tested A, variant 1, time 1. 750 sec.) and arched back double somersault after rondat – back turnover (tested B, variant 2, time 1. 683sec.) Body postures on support precede key element FP, i.e. posture of balanced landing (half squatting with forward half bent, arms forward-downward).

Resultant speed values of body's bio links and GMC are proof of effectiveness of movements on support in final phase. They "bunched" in variant 1, time– 1. 750 sec. and in variant 2, time – 1. 683 sec. (see fig. 8). The only exclusion was speed of elbow joints (1. 854 m.p.sec., variant 2).

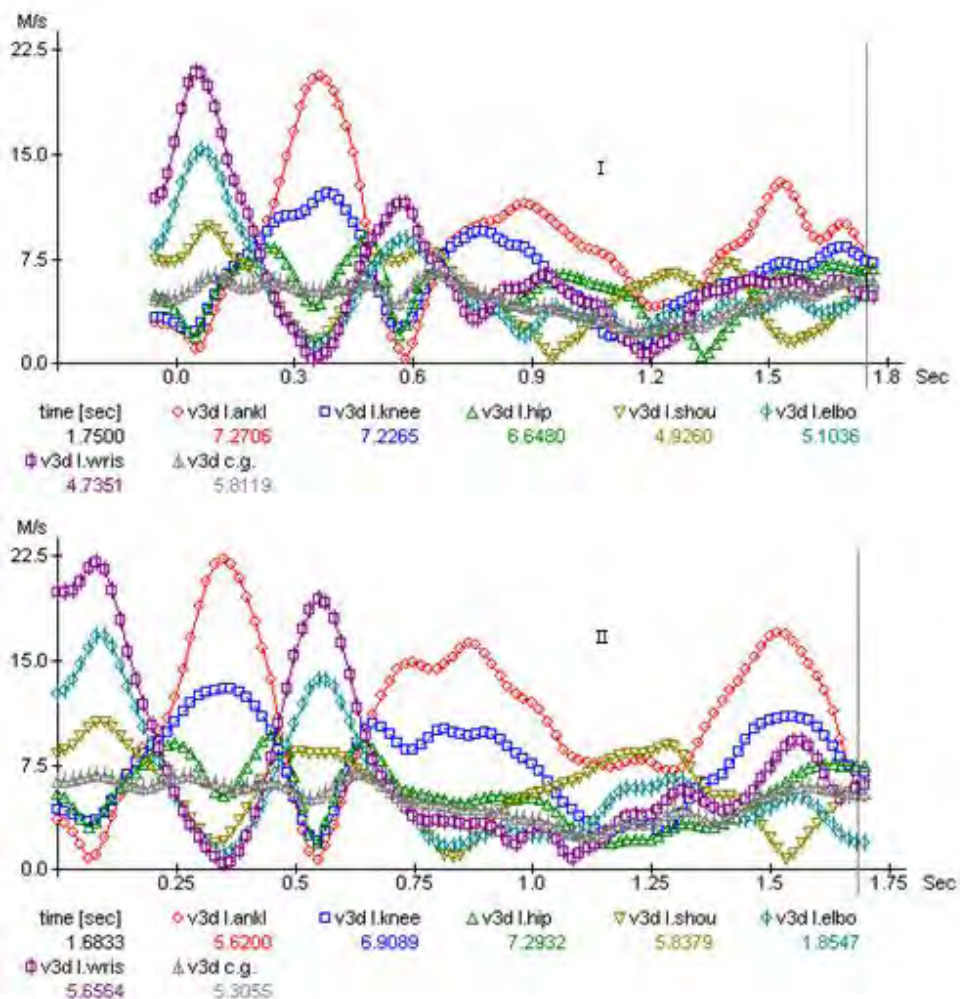


Fig. 8. Resultant speed values of ankle, knee, hip, shoulder, elbow and wrist joints, GMC in phase of final movements (FP) of grouped back double somersault after rondat (tested A, variant 1, upper section of figure, time 1. 750sec.) and arched back double somersault after rondat – back turnover (tested B, lower section of figure, variant 2, time 1. 683 sec.).

Conclusions

In phase structure of acrobatic jumps on track (grouped back double somersault after rondat and arched back double somersault after rondat – back turnover) we, with the help of movements' posture orient method, indentified key elements of sport technique. We found that key element of sport technique is a signal posture of movement, which pre-determines effective following actions in certain exercise.

We have proved that signal postures of the studied by us sport exercises were: starting posture of body (bio-mechanically rational posture of body on support for effective upward flight in somersault), multiplication of body postures (consequent alternation of instant, fixed postures fro creation of holistic movement), final posture of body (landing and stoppage).

Solution of tasks of acrobatic exercises' bio-mechanical analysis and working out of up-to-date training programs will permit to realize significant reserves of training process, improve theory and practice of all kinds of sports, which are characterized by complex coordination of movements.

References:

1. Asmolova V.L. *Zhurnal Daruma* [Daruma journal], 2008, vol.1, pp. 15-20.
2. Boloban V.N., Biriuk E.V. Statodinamicheskaia ustojchivost' tela sportsmena kak pokazatel' effektivnogo obucheniia fizicheskim uprazhneniiam progressiruiushchej slozhnosti [Static-dynamic stability of the athlete's body as an indicator of effective training exercise progressive complexity]. *Optimizaciia upravleniia processom sovershenstvovaniia tekhnicheskogo masterstva sportsmenov vysshej kvalifikacii* [Process control optimization improving technical skills of athletes of the highest qualification], Kiev, KSIPC, 1979, pp. 79 – 85.
3. Boloban V.N. *Reguliaciia pozy tela sportsmena* [Regulation of body posture athlete], Kiev, Olympic Literature, 2013, 232 p.
4. Boloban V.N., Potop V.A. *Nauka v olimpijskom sporte* [Science in Olympic Sport], 2014, vol.1, pp. 44 – 49.
5. Nizhnikovski T., Sadovski E., Boloban V., Mastalez A., Vishniovski V., Begajlo M. *Teoriia i praktika fizicheskoi kul'tury* [Theory and practice of physical culture], 2013, vol.2, pp. 41 – 47.
6. Potop V.A., Grad R., Boloban V.N. *Pedagogika, psihologia ta mediko-biologicni problemi fizicnogo viovanna i sportu* [Pedagogics, psychology, medical-biological problems of physical training and sports], 2013, vol.9, pp. 59 – 72.
7. Sadovski E., Boloban V., Nizhnikovski T., Mastalez A., Vishniovski V., Begajlo M. *Teoriia i praktika fizicheskoi kul'tury* [Theory and practice of physical culture], 2012, vol.7, pp. 98-102.
8. Andreyeva N.O. Key elements of sports techniquis of ball throwing and catching by those engaged in rhythmic gymnastics at the stage of preliminary basic preparation. *Journal of Physical Education and Sport*, 2013, vol.13(1), pp. 46 -52.
9. Boloban V., Sadowski J., Niznikowski T., Wisniowski W. Didactic technology in mastering complex motor tasks. *Coordination motor abilities in scientific research*. Biala Podlaska, Faculty of Physical Education and Sport, 2010, vol.33, pp. 112 – 129.
10. Niznikowski T. *Teaching exercises a complex structure moves when exposed to the elements sports technique technology* [Nauczanie cwiczzeń o złożonej strukturze ruchów przy oddziaływaniu na węzłowe elementy techniki sportowej], Biala Podlaska, ZWWF, 2009, 148 p.
11. Potop V.A., Grad Rafal, Omelyanchik O.A., Begajlo Marta, Boloban V.N. Element nodes of sports equipment double back flip factions and double back flip hunched performed gymnast in floor exercise. *Pedagogics, psychology, medical-biological problems of physical training and sports*, 2014, vol.7, pp. 23-30. doi:10.6084/m9.figshare.1015381
12. Potop V.A., Rafal G., Boloban V.N., Otsupok A.P., Biomechanical characterization dismount from balance beam on the basis of the analysis of key elements of sports equipment. *Pedagogics, psychology, medical-biological problems of physical training and sports*, 2013, vol.12, pp. 58-66. doi:10.6084/m9.figshare.880619
13. Tereshchenko I.A., Otsupok A.P., Krupenya S.V., Liauchuk T.M., Boloban V.N., Sensomotor coordination, theoretical and physical (motor) preparedness of first year students of higher educational institutions of physical education and sport. *Physical Education of Students*, 2013, vol.6, pp. 88-95. doi:10.6084/m9.figshare.840509
14. Tereschenko I.A., Otsupok A.P., Krupenio S.V., Levchuk T.M., Boloban V.N., Evaluation of freshmen coordination abilities on practical training in gymnastics. *Physical Education of Students*, 2013, vol.3, pp. 60-71. doi:10.6084/m9.figshare.663628
15. Sadowski J., Boloban V., Mastalerz A., Niznikowski T. Velocities and joint angles during double backward stretched salto performed with stable landing and in combination with tempo salto. *Biology of Sport*, 2009, vol.26, pp. 87 – 101.

Information about the authors:

Litvinenko Y.V.: ORCID: <http://orcid.org/0000-0003-1137-9952>;
ylitvinenko@mail.ru; National University of Physical Education and Sport
of Ukraine; Fizkultury str. 1, Kiev, 03680, Ukraine.

Niznikowski Tomasz: ORCID: <http://orcid.org/0000-0002-7504-1558>;
wiktorboloban@awf-bp.edu.pl; Faculty of Physical Education and Sport
in Biala Podlaska; ul. Akademicka 2, 21-500 Biala Podlaska, Poland.

Boloban V.N.: ORCID: <http://orcid.org/0000-0001-9119-0695>;
wboloban@ukr.net; Józef Piłsudski University of Physical Education in
Warsaw; 34 Marymoncka Str; P.O.Box 55, 00-968 Warsaw 45, Poland.

Cite this article as: Litvinenko Y.V., Niznikowski Tomasz,
Boloban V.N. Evaluation of the kinematic structure of indicators
key elements of sports equipment exercise by postural orientation
movements. *Physical education of students*, 2014, vol.6, pp. 29-36.
doi:10.15561/20755279.2014.0606

The electronic version of this article is the complete one and can be found online
at: <http://www.sportpedu.org.ua/html/arhive-e.html>

This is an Open Access article distributed under the terms of the Creative
Commons Attribution License, which permits unrestricted use, distribution, and
reproduction in any medium, provided the original work is properly cited ([http://
creativecommons.org/licenses/by/3.0/deed.en](http://creativecommons.org/licenses/by/3.0/deed.en)).

Received: 10.06.2014
Published: 30.06.2014