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Method of biomechanical analysis of kicks of the main course in acrobatic rock'n'roll

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Purpose: *biomechanical analysis of kicks of the main course in acrobatic rock'n'roll.*

Material & Methods: *following research methods were used: theoretical analysis and generalization of data from special scientific and methodological literature; pedagogical observation; biomechanical computer analysis; video footage of the finals of World championships, Europe championships, Cup of Ukraine (2017) in acrobatic rock and roll.*

Result: *biomechanical analysis of the kicks of the main course by qualified athletes was conducted; kinematics characteristics (path, speed, acceleration, effort) of the center of mass (CM) biolinks of the athlete's body (male partner, female partner) were obtained: feet, shins, hips. The energy characteristics are determined – mechanical work and kinetic energy of the legs links when performing the kick of main course.*

Conclusion: *it is established that the method of biomechanical analysis of the kick of the main course performance significantly affects the level of technical training of qualified athletes in acrobatic rock and roll.*

Keywords: *acrobatic rock'n'roll, kick, biomechanics of motor actions, main course, male partner, female partner.*

Introduction

Modern system of training requires constant improvement of the technical preparedness of the rock'n'rol athletes, aimed at implementing effective technical actions of qualified athletes in the conditions of preparation for competitive activities. Strengthening competing in competitions requires coaches and athletes to find new ways to increase the effectiveness of competitive activities [10].

An analysis of recent research and publications on the problem of the technique of performing the main course in acrobatic rock'n'roll shows that the main focus is on the dynamics of the exercise.

It should be noted that the scientific and methodological literature does not adequately address the problem of the efficiency of the biomechanics of the motor actions of the partner and partner in performing the main course in acrobatic rock and roll, which determined the relevance of the chosen research topic.

Purpose of the study: biomechanical analysis of kicks of the main course in acrobatic rock'n'roll.

Objectives of the study:

1. To study the problem of technical training of qualified athletes in acrobatic rock and roll.

2. Determine the biomechanical characteristics of the performance of the kick the main move in acrobatic rock and roll.

Material and Methods of the research

Methods of research were: theoretical analysis and generalization of data from special scientific and methodological literature; photography, video shooting, biomechanical computer analysis, pedagogical observation.

In our studies qualified sportsmen (n=6) of the sports center of childhood and youth "Grand" took part. Appropriate kinematic characteristics of the performance of kicks of the main course were calculated: track path, speed, acceleration, force [1–3].

Energy characteristics are determined – mechanical work and kinetic energy of legs links in the course of the main course.

To determine the biomechanical characteristics of the performance of the kick of the main move by qualified athletes in acrobatic rock and roll, anthropometric indicators of qualified athletes were used: male partner – L-n, female partner – B-va (Table 1).

Mathematical model of trajectory of the center of mass (CM) of *leg* links: foot, shin, hip is used in the work; construction of the segment of passage of the CM of body links [3; 6; 7].

Results of the research and their discussion

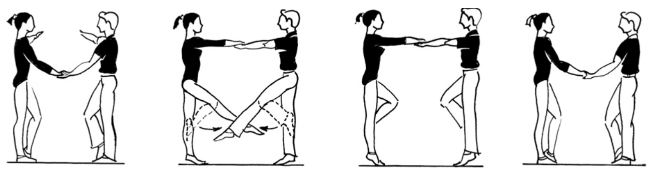
For a long time in the competitive activity in acrobatic rock 'n' roll did not pay attention to the amplitude of the movements in the main course. Analysis of the video footage of the finals of the world championships, Europe of recent times and the finals of the Cup of Ukraine (2017), qualified athletes from acrobatic rock and roll showed a trend in the variability of the amplitude of kicks in the main run (Figure 5) (main course consists of kick-ball-change and kick-stepping exercises). According to the Rules of the WRRC, kick-ball-change (the component of the main stroke) (Fig. 1) at the level 45°[11].

Performing the kick-step (component of the main course) (Figure 2) at a level of 90°, parallel to the floor [11].

Table 1

Anthropometric indicators of male partner and female partner

No.	Indicators	Male partner	Female partner
1.	Body length, cm	179	158
2.	Body weight, kg	77	48
3.	Length of right thigh, cm	51	43
4.	Length of left thigh, cm	51	43
5.	The length of right tibia, cm	41	35
6.	Length of left tibia, cm	41	35
7.	Length of right foot, cm	27	21
8.	Length of left foot, cm	27	21
9.	Weight of right hip, kg	9,4	5,76
10.	Weight of left hip, kg	9,4	5,76
11.	Mass of right tibia, kg	3,85	2,4
12.	Mass of left tibia, kg	3,85	2,4
13.	Weight of right foot, kg	1,54	0,96
14.	Weight of left foot, kg	1,54	0,96
15.	Length of radius (r) of right thigh, cm	23	19
16.	Length of radius (r) of the left thigh, cm	23	19
17.	Length of radius (r) of right tibia, cm	18	15
18.	Length of the radius (r) of left tibia, cm	18	15
19.	Length of radius (r) of right foot, cm	12	9
20.	Length of the radius (r) of the left foot, cm	12	9



Outgoing position *1-st phase* *2-nd phase* *3-rd phase*

Fig. 1. Phases of exercise *kick-ball-change:*
1-st phase – swing-up leg of the male partner and female partner perfume a kick;
2-nd phase – body's CCG moves in the direction of the swing-up leg , which is put on the half-toes, the supporting leg rises;
3-rd phase – supporting leg is puts on the half-toes.

Features of the performance of the kick in the *kick-step* exercise are reduced to the direction of the motor action of the male partner's swing-up leg and female partner. The partner does the kick straight, the partner sideways diagonally.

Construction of a mathematical model of biomechanics of motor actions in the performance of *kick* exercises *kick-ball-change*.

Main course is carried out for 1,5 cycles (t – 1,875 s; tempo 48 cycles in minute; *kick-ball-change: t* – 0,625 s; *kick: t* – 0,12 s).

Biomechanical characteristics of the motor actions of the partner in the performance of kick exercises *kick-ball-change*

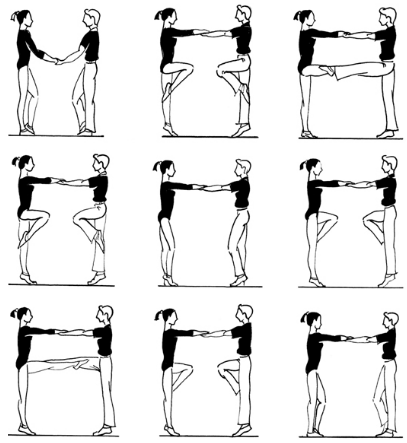


Fig. 2. Kick-step

are shown in Table 2. A male partner performs a *kick-ball-change* exercise with the left foot [9; 11].

In the table there is a numerical value of the effort of the CM legs links with a minus sign. This indicates that the counter-action of gravity is directed towards the force of the CM legs links [4; 5].

On the basis of the obtained kinematic characteristics, the energy characteristics of the leg links are determined – mechanical work $A=\int_0^s F_s ds$ i kinetic energy $E_k=\frac{mV^2}{2}$ [3; 8] when the male partner performs a *kick*.

In the calculation does not take into account the energy consumption of the internal friction of the musculoskeletal apparatus of the athlete and the costs of radiation of the thermal energy of the athlete's body into the environment [3; 7].

Based on the results of building a model of the biomechanics of the motor actions of the male partner, we can state that the energy characteristics of the performance of the *kick* in the *kick-ball-change* exercise have the following meanings:

– mechanical work – 126,22 J;

– kinetic energy – 57,26 J.

1 J ≈ 0,238846 calories (1 calorie = 4,184 J).

Obtained data of constructing the model of the biomechanics of motor actions indicate that during the performance of the *kick* in the exercise *kick-ball-change* male partner spends 30,2 cal. (performing time 0,12 s).

Biomechanical characteristics of the motor actions of the partner in the performance of *kick* exercise *kick-ball-change* shown in Table 3. Female partner performs a *kick-ball-change* exercise with the right foot.

On the basis of the obtained kinematic characteristics, the energy characteristics of the leg links are determined – mechanical work *(A)* and kinetic energy *(E_k)* [2; 3] when the female partner performs a *kick*.

In the calculation does not take into account the energy consumption of the internal friction of the musculoskeletal apparatus of the athlete and the costs of radiation of the thermal

Table 2

Biomechanical characteristics of the CM body links of the male partner body in the performance of the *kick* – exercise *kick-ball-change*

No. i/o	CM body links	Kinematic characteristics						Energy characteristics	
		t (s)	*φ* (deg.)	*S* (m)	*V* ($m \cdot s^{-1}$)	*a* ($m \cdot s^{-2}$)	*F(H)* ($kg \cdot m \cdot s^{-2}$)	*A* (J)	E_k (J)
1.	CM, left thigh	0,12	45°	0,18	1,5	9,7	–14,63	2,63	10,57
2.	CM, left shin	0,12	90°	0,28	2,33	30,2	78,54	21,29	10,04
3.	CM, left foot	0,12	90°	0,83	6,9	89,8	123,2	102,3	36,65

Table 3

Biomechanical characteristics of the CM body links of the female partner body in the performance of the *kick* – exercise *kick-ball-change*

No. i/o	CM body links	Kinematic characteristics						Energy characteristics	
		t (s)	*φ* (deg.)	*S* (m)	*V* ($m \cdot s^{-1}$)	*a* ($m \cdot s^{-2}$)	*F(H)* ($kg \cdot m \cdot s^{-2}$)	*A* (J)	E_k (J)
1.	CM, left thigh	0,12	45°	0,15	1,25	8,22	-8,8	1,32	4,8
2.	CM, left shin	0,12	90°	0,24	2,0	26,6	40,32	9,67	4,8
3.	CM, left foot	0,12	90°	0,69	5,75	75,14	62,72	43,38	15,87

energy of the athlete's body into the environment [3; 7].

Based on the results of constructing the model of the biomechanics of the motor actions of the partners, we can state that the energy characteristics of the performance of the *kick* in the *kick-ball-change* exercise have the following meanings:

– mechanical work – 54,27 J;

– kinetic energy – 25,47 J.

Obtained data of constructing the model of the biomechanics of motor actions indicate that during the performance of the *kick* in the exercise *kick-ball-change* female partner spends 12,97 cal. (performing time 0,12 s).

Construction of a mathematical model of biomechanics of motor actions in the performance of *kick* exercise *kick-step*. Main move is executed during 1,5 cycles (t – 1,875 s, the rate is 48 cycles per minute; *kick-step: t* – 0,625 s; *kick: t* – 0,156 s) (Figure 3, 4).

Biomechanical characteristics of the motor actions of the partner in the performance of *kick* exercise *kick-step* are shown in Table 4.

Based on the results of constructing a mathematical model of the biomechanics of motor actions by the partner, we can

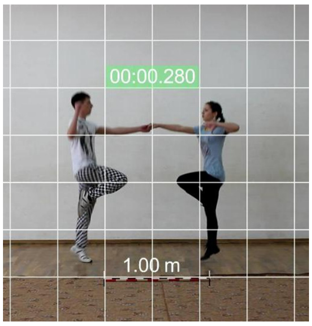


Fig. 3. **Position of the swing-up leg (raising the hip)**

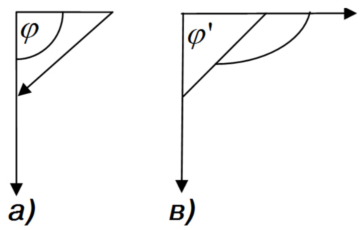


Fig. 4. **Scheme trajectory of the path (S) of the CM links of the swing-up leg (optimal technique for performing the kick in the given parameters):**
a *– lifting of the hip of the swing-up leg, φ=90° (foot at the shin of the support leg);*
b *– performing kick swing-up leg CM leg and foot path extends along the segment forming an angle φ′=135°.*

Table 4

Biomechanical characteristics of the CM body links of the male partner in the performance of *kick* –exercise *kick-step*

No. i/o	CM body links	Kinematic characteristics						Energy characteristics	
		t (s)	*φ* (deg.)	*S* (m)	*V* ($m \cdot s^{-1}$)	*a* ($m \cdot s^{-2}$)	*F(H)* ($kg \cdot m \cdot s^{-2}$)	*A* (J)	E_k (J)
1.	CM, left thigh	0,156	90°	0,36	2,31	23,2	196,04	70,64	25,08
2.	CM, right thigh	0,156	90°	0,36	2,31	23,2	196,04	70,64	25,08
3.	CM, left shin	0,156	135°	0,43	2,75	42,0	123,97	53,3	14,55
4.	CM, right shin	0,156	135°	0,43	2,75	42,0	123,97	53,3	14,55
5.	CM, left foot	0,156	135°	1,25	8,01	121,06	171,34	214,18	49,4
6.	CM, right foot	0,156	135°	1,25	8,01	121,06	171,34	214,18	49,4

state that the energy characteristics of the performance of the *kick* in the *kick-step* exercise have the following meanings:

– mechanical work – 338,12 J;

– kinetic energy – 89,03 J.

Obtained data of constructing a mathematical model of the biomechanics of motor actions indicate that, in order to perform *kick* in the exercise *kick-step* male partner spends 80,8 cal. (performing time 0,156 s).

Biomechanical characteristics of the female partner's motor activities in the performance of *kick-step* exercises are shown in Table 5.

Based on the results of constructing a mathematical model of the biomechanics of motor actions by the partner, we can state that the energy characteristics of the performance of the *kick* in the *kick-step* exercise have the following meanings:

– mechanical work – 120,15 J;

– kinetic energy – 37,9 J.

Obtained data of constructing a mathematical model of the biomechanics of motor actions indicate that, in order to perform *kick* in the exercise *kick-step* female partner spends 28,7 cal. (performing time 0,156 s).

This mathematical model of the biomechanics of the motor actions of the male partner and female partner in the technique of performing the *kick* of the main course in acrobatic rock'n'roll shows the ratio of effective motor actions (lifting and vigorous straightening of the swing-up leg) to movements that are performed by inertia without additional use of muscles [11]:

– time of effective motor action 23%;

– time of inertial motions 77%.

The results of effective ergonomic performance of the kick performance of the main course:

– *male partner: t – 0,432 s, F – 1197 H, A – 802 J, for the time of effective motor actions of the performance of the kick spent 192 calories;*

– *female partner: t – 0,432 s; F –469 H; A – 294,47 J; for the time of effective motor actions of the performance of the kick spent 70, calories.*

Mathematical model and biomechanical characteristics show the effectiveness of the biomechanics of the motor actions of the male partner and female partner, and can be defined ***as the optimal technique for performing kicks for given parameters*** (Figure 4). From this definition it follows that if the male partner and female partner during the *kick-step* exercise in the competitive program increase the angle of the raising of the thigh of the swing-up leg, and also the angle of the knee joint extension, the energy characteristics of the kick performance will increase in their ratio (Tables 6, 7).

When the leg is raised to 110° ($\phi+d\phi$) and the knee joint is straightened to the angle ϕ''=155° ($\phi'+d\phi$) the male partner's energy costs, according to mathematical calculations, increased by 58,2% (Figure 6).

When the leg is raised to 110° ($\phi+d\phi$) and the knee joint is straightened to the angle ϕ''=155° ($\phi'+d\phi$) the female partner's energy costs, according to mathematical calculations, increased by 61,1% (Figure 6).

Figure 3 shows the positions of the swing-up leg with the male

Table 5

Biomechanical characteristics of the CM body links of the female partner in the performance of *kick* –exercise *kick-step*

No. i/o	CM body links	Kinematic characteristics						Energy characteristics	
		t *(s)*	*φ* *(deg.)*	*S* *(m)*	*V* *(m·s⁻¹)*	*a* *(m·s⁻²)*	*F(H)* *(kg·m·s⁻²)*	*A* *(J)*	E_k *(J)*
1.	CM, left thigh	0,156	90°	0,3	1,92	19,42	55,4	16,62	10,6
2.	CM, right thigh	0,156	90°	0,3	1,92	19,42	55,4	16,62	10,6
3.	CM, left shin	0,156	135°	0,35	2,24	24,6	35,52	12,43	6,02
4.	CM, right shin	0,156	135°	0,35	2,24	24,6	35,52	12,43	6,02
5.	CM, left foot	0,156	135°	1,04	6,66	100,9	87,5	91,0	21,29
6.	CM, right foot	0,156	135°	1,04	6,66	100,9	87,5	91,0	21,29

Table 6

Biomechanical characteristics of the CM body links of the male partner in the performance of *kick* – exercise *kick-step* (increment of the formed angles φ and φ' by the value $d\varphi$)

No. i/o	CM body links	Kinematic characteristics						Energy characteristics	
		t *(s)*	*φ* *(deg.)*	*S* *(m)*	*V* *(m·s⁻¹)*	*a* *(m·s⁻²)*	*F(H)* *(kg·m·s⁻²)*	*A* *(J)*	E_k *(J)*
1.	CM, left thigh	0,156	110°	0,44	2,82	34,6	362,8	159,6	37,4
2.	CM, right thigh	0,156	110°	0,44	2,82	34,6	362,8	159,6	37,4
3.	CM, left shin	0,156	155°	0,49	3,14	54,77	173,13	84,83	18,98
4.	CM, right shin	0,156	155°	0,49	3,14	54,77	173,13	84,8	18,98
5.	CM, left foot	0,156	155°	1,43	9,16	158,3	228,7	327,0	64,6
6.	CM, right foot	0,156	155°	1,43	9,16	158,3	228,7	327,0	64,6

Table 7

Biomechanical characteristics of the CM body links of the male partner in the performance of *kick* –exercise *kick-step* (increment of the formed angles φ and φ' by the value $d\varphi$)

No. i/o	CM body links	Kinematic characteristics						Energy characteristics	
		t (*s*)	φ (*deg.*)	*S* (*m*)	*V* ($m \cdot s^{-1}$)	*a* ($m \cdot s^{-2}$)	*F(H)* ($kg \cdot m \cdot s^{-2}$)	*A* (*J*)	E_k (*J*)
1.	CM, left thigh	0,156	110°	0,36	2,3	27,8	103,7	37,32	15,23
2.	CM, right thigh	0,156	110°	0,36	2,3	27,8	103,7	37,32	15,23
3.	CM, left shin	0,156	155°	0,4	2,56	43,7	81,4	32,6	7,9
4.	CM, right shin	0,156	155°	0,4	2,56	43,7	81,4	32,6	7,9
5.	CM, left foot	0,156	155°	1,19	7,63	132,3	117,6	140,0	27,9
6.	CM, right foot	0,156	155°	1,19	7,63	132,3	117,6	140,0	27,9

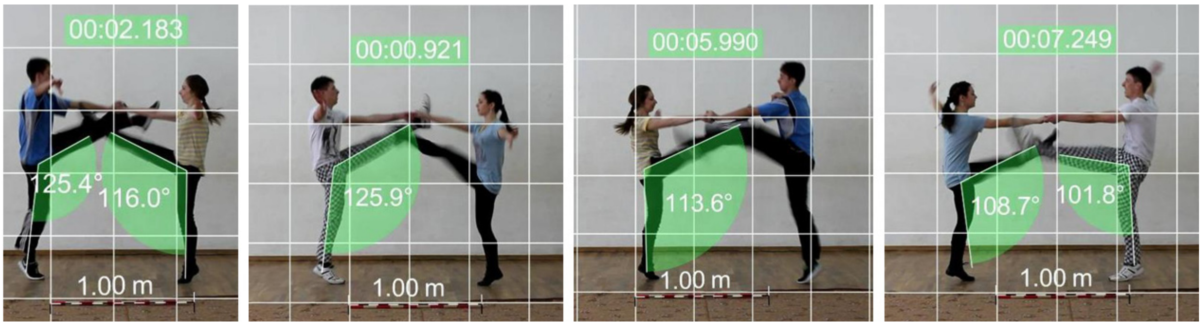


Fig. 5. Variability of the amplitude of the performance of the kick of the main course

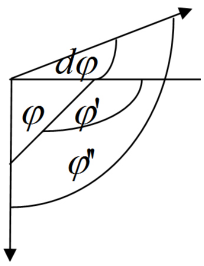


Fig. 6. Scheme trajectory of the path (S) of the CM links of the swing-up leg with increasing angles φ and φ' by the angle $d\varphi$ of the knee extension: *Performing kicks of a swing-up leg with a hip raising to an angle in 110°, CM leg and foot path extends along the segment forming an angle φ''=155°.*

partner and female partner hip raised to the level ϕ=90˚ parallel to the floor.

Figure 5 shows the variability in the amplitude of the performance of the kick in the maximum upper position qualified athlete foot of swing-up leg. Each athlete increases the angles ϕand ϕ′ by the angle *d*ϕ (Figure 6) of the knee extension.

In the competitive program, according to the WRRC Rules, qualified athletes perform at least six major moves [11].

Biomechanical characteristics of the male partner with the optimal technique of *kick* performance in the given parameters during the competition program have definitions: *t – 2,592 s, F – 7182 H, A – 4812 J.* During the time of effective motor actions performing the ***kick*** male partner spends 1150 calories.

With an increase in the angle of raising the hip to 110° (ϕ+*d*ϕ) and straightening the angle of the knee joint of the right and left legs to 155° (ϕ′+*d*ϕ) biomechanical characteristics of the male partner in the performance of the ***kic***k in the main course during the competition program have definitions: *t – 2,592 s; F – 10470 H; A – 7614 J.* During the time of variative motor actions, performing the ***kick*** male partner spends 1819 calories.

Biomechanical characteristics of the female partner with the optimal technique of *kick* performance in the given parameters during the competition program have definitions: *t – 2,592 s, F – 2814 H, A – 1766,82 J.* During the time of effective motor actions performing the ***kick*** f**e**male partner spends *422* calories.

With an increase in the angle of raising the hip to 110° (ϕ+*d*ϕ) and straightening the angle of the knee joint of the right and left legs to 155˚ (ϕ′+*d*ϕ) biomechanical characteristics of the male partner in the performance of the ***kick*** in the main course during the competition program have definitions: *t – 2,592 s; F – 3954 H; A – 2844,6 J.* During the time of variative motor actions, performing the ***kick*** female partner spends 680 calories.

Process of fatigue of qualified athletes takes place during the performance of the competition program. The expenditure of the energy resource of rock'n'rol athletes depends on the performance of the biomechanics of motor actions.

Biomechanics of motor actions of the implementation of the *kick* of the main course by the male partner and female partner in the first case showed the rationality of the *energy characteristics.*

With the increase in the parameters of the kinematic characteristics of the biomechanics of motor actions, the kick in the main course by the partner and partner led to an increase in their *energy characteristics*:

– energy costs of the male partner increased by 58,2%;

– energy costs of the female partner increased by 61,1%.

Conclusions

Proposed biomechanical analysis of the kick main course in acrobatic rock'n'roll gives a creative approach to the technique of mastering basic dance movements, exercises, acrobatic elements in the training process, which will make it possible to improve the technical training of qualified athletes more efficiently and rationally, with less physical effort.

Prospect for further research are to find ways to apply the basics of biomechanics in this direction, using methodological recommendations and writing manuals.

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