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Properties of some kinematic parameters in handstand technique in artistic gymnastics

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ABSTRACT
PURPOSE: The aim of this study was to determine the difference between key kinematic parameters of handstand phases. METHODS: Sample of this investigation consisted of five second-year students of the Faculty of Kinesiology, University of Zagreb. Variables consisted of kinematical parameters. The kinematic parameters were extracted from the key positions of certain handstand phases: 1st phase–lunge step, 2nd phase–hand support, 3rd phase–back kick, 4th phase–take off, 5th phase–handstand support. Kinematic parameters were extracted with the program package MVN Studio BIOMECH Software (Xsens North America Inc.), and their processing was done using the one-way ANOVA analysis and Bonferroni post-hoc test with statistical significance at $p<0.05$. RESULTS: Results showed statistically significant differences ($p = 0.00$) in the hip angle of the kick leg, the hip angle of the take-off leg, head angle and the duration of all phases of handstand. The Bonferroni post-hoc test showed the differences between the phases of handstand. CONCLUSION: Information were obtained about the significance of the hip angles, shoulders, and head in different stages of handstand execution. By precisely defining all kinematic parameters of handstand performance, it would be possible to early detect causes of mistakes and find the best way to eliminate them. This will help coaches to find the most important exercise and pay attention to key points of handstand.

Key words: artistic gymnastics, biomechanics, performance, technique, acrobatic element

Introduction

In artistic gymnastics, handstand is an acrobatic element that is an integral part of every gymnastic exercise and is present on all apparatus (Uzunov, 2008; Živčić Marković, Krističević, & Aleksić-Veljković, 2015; Živčić Marković & Krističević, 2016). It is performed as a separate element in connection with other acrobatic elements and as a transitional position within another element's technique. The technical execution of handstand technique is governed by the evaluation rules (FIG, 2017). For the correct performance of the handstand the following is important: strength of the entire body, coordination, orientation and flexibility of joints, especially shoulders (Uzunov, 2008; Yedon & Trewartha, 2003; Živčić Marković et al., 2015; Živčić Marković & Krističević, 2016).

Performance of handstand can be divided into several phases: lunge step, hand support, back kick, take-off, ans handstand support (Živčić Marković & Krističević, 2016). In each phase there are certain key points that influence execution of the final phase of handstand – hold of the stretched body in the vertical position. They are related to the following: length of lunge step (1st phase), placement of the hands in relation to the take-off leg (2nd phase), timing of taking the kick with the kick leg which begins with forward bending of the trunk in the lunge step (3rd phase), timing of take-off that begins with the hands fully supported on the floor (4th phase), vertical position of the body in relation to the floor (5th phase) and holding the extended arms along the head through all the phases.

Investigations in the field of the ideal performance model in gymnastics are rare. Prassas (1988) conducted a study of biomechanical modeling on the handstand to estimate and predict rotational forces in the shoulder of the wrist and move the center of gravity from the initial to the final position of the body standing on the arms. The variables that are important for biomechanical research on the handstand are: the phase of the center of mass, the horizontal and vertical positions, velocity, distance between the hands and the feet, differences between the angles and the angular velocities of the hip and shoulder joint (Kim, So, & Yeo, 2006). The aim of this study was to determine the differences between the key kinematic parameters of handstand phases.

Methods

The sample of participants consisted of five second-year students of the Faculty of Kinesiology, University of Zagreb. Participants passed the exam Artistic Gymnastic 1 and they were selected randomly and evaluated by three gymnastic experts. The sample of variables consisted of kinematical parameters. The hip and shoulder angles were defined by the take-off and kick leg. Variable HIPTAKEOFF means the angle of the hip at the side of the take-off leg, HIPKICK=angle of the hip at the side of the kick leg. SHOTAKEOFF=angle in the shoulder on the take-off leg, SHOKICK=angle in the shoulder at the kick leg side. Variable HEAD=head angle. TIME=duration of all phases of handstand. The kinematic parameters were extracted from the key positions of certain handstand phases: 1st phase–lunge step, 2nd phase–hand support, 3rd phase–back kick, 4th phase–take off, 5th phase–handstand support. Kinematic parameters were extracted using the program package MVN Studio BIOMECH Software (Xsens North America Inc.), and their processing was done using the one-way ANOVA analysis and Bonferroni post-hoc test with statistical significance set at $p<0.05$.

Results

Table 1 shows the results of one-way ANOVA analysis of handstand angles in all phases. Results showed statistically significant differences ($p = 0.00$) in the hip angle of the kick leg, the hip angle of the take-off leg, head angle and the duration of all phases of handstand.

Dependent Variable	Multiple R	Multiple R2	Adjusted R2	SS Model	df Model	MS Model	SS Residual	df Residual	MS Residual	F	p
HIPTAKEOFF	0,94	0,88	0,86	70176	4	17544	9679	25	387	45	0,00*
HIPKICK	0,97	0,94	0,93	95033	4	23758	5887	25	235	101	0,00*
SHOTAKEOFF	0,51	0,26	0,14	6698	4	1675	19429	25	777	2	0,10
SHOKICK	0,35	0,12	-0,02	1545	4	386	11378	25	455	1	0,51
HEAD	0,95	0,91	0,89	17926	4	4481	1862	25	74	60	0,00*
TIME	0,74	0,55	0,48	12	4	3	10	25	0	8	0,00*

Table 1. One-way ANOVA analyses of handstand angles in all phases

*statistically significant difference

The Bonferroni post-hoc test showed the differences between the phases of handstand. For the variable HIPKICK, the Bonferroni test (Table 2) indicated the differences between the phase lunge step and hand support (1 and 2), lunge step and back kick (1 and 3), and lunge step and handstand support (1 and 5), between the phases hand support and take off (2 and 4), and hand support and handstand support (2 and 5). The differences were also established between the phases back kick and take-off (3 and 4), and back kick and handstand support (3 and 5).

Cell No.	FAZE	{1} 165,83	{2} 67,667	{3} 67,667	{4} 184,00	{5} 193,50
1	1		0,00*	0,00*	0,51	0,04*
2	2	0,00*		1,00	0,00*	0,00*
3	3	0,00*	1,00		0,00*	0,00*
4	4	0,51	0,00*	0,00*		1,00
5	5	0,04*	0,00*	0,00*	1,00	

Table 2. Bonferroni post-hoc test for the variable HIPKICK

*statistically significant difference

For the variable HIPTAKEOFF, Bonferroni test (Table 3) showed the difference between the phase step lunge and hand support (1 and 2), step lunge and take off (1 and 4), and step lunge and handstand support (1 and 5). The difference was established between the phases hand support and back kick (2 and 3) and hand support and take off (2 and 4), as well as between back kick and handstand support (3 and 5) and take off and handstand support (4 and 5).

Cell. No.	FAZE	{1} 113,50	{2} 177,33	{3} 93,167	{4} 70,167	{5} 195,17
1	1		0,00*	0,86	0,01*	0,00*
2	2	0,00*		0,00*	0,00*	1,00
3	3	0,86	0,00*		0,54	0,00*
4	4	0,01*	0,00*	0,54		0,00*
5	5	0,00*	1,00	0,00*	0,00*	

Table 3. Bonferroni post-hoc for the variable HIPTAKEOFF

*statistically significant difference

In the variable head (Table 4) Bonferroni test showed the difference between all phases.

Cell. No.	FAZE	{1} 187,50	{2} 200,00	{3} 194,83	{4} 202,17	{5} 136,33
1	1		0,19	1,00	0,07	0,00*
2	2	0,19		1,00	1,00	0,00*
3	3	1,00	1,00		1,00	0,00*
4	4	0,07	1,00	1,00		0,00*
5	5	0,00*	0,00*	0,00*	0,00*	

Table 4. Bonferroni post-hoc for the variable HEAD

*statistically significant difference

For the duration of the individual phases, the Bonferroni test (Table 5) showed the differences between the phases hand support and handstand support (2 and 5), back kick and take off (3 and 4), and, finally, between take off and handstand support (4 and 5).

Cell. No.	FAZE	{1} 1,1100	{2} ,62667	{3} 1,3767	{4} ,07500	{5} 1,9550
1	1		1,00	1,00	0,09	0,30
2	2	1,00		0,52	1,00	0,01*
3	3	1,00	0,52		0,02*	1,00
4	4	0,09	1,00	0,02*		0,00*
5	5	0,30	0,01*	1,00	0,00*	

Table 5. Bonferroni post-hoc for the variable TIME

*statistically significant difference

Discussion

The results obtained by ANOVA indicated that there was the statistically significant difference in four kinematic variables: hip joint angle at the side of the kick leg and at the take-off leg, head and the duration of all phases of handstand. The obtained significant difference of the hip angle at the side of the kick leg in the individual phases of the handstand indicates its importance in all stages of handstand performance. Apart from the trunk, the kick leg is the only part of the body which moves throughout the entire performance of handstand. When kick leg leaves the floor, the trunk moves (arms are extended) from the beginning of the lunge step to the last phase of handstand. It should be mentioned that the kick leg defines the position of the body in handstand by it stopping movement exactly in the vertical position, 900 in relation to the floor. Theoretical models of performance techniques suggest that, if the angle of the hip joint of the kick leg is smaller with regard to the trunk, the quality of the kick will be poor (Gautier, Marin, & Thouvareq, 2009; Scotton, Grosso, Ferraris, Caire, & Pizzigalli, 2009; Živčić Marković, et al., 2015). The initiation of the kick leg motion depends on the lunge length and the weight transfer from the body onto the take-off leg. Technical mistakes in performance of the first phase of handstand (lunge step) will be presented in the next phases. That indicates that the lunge step should be longer. If the lunge step is short, the kick leg will be stopped on the floor, a distance between the feet of the take-off leg and the hands on the floor will be short. Also, both the kick and take-off will be incorrect and, in the last phase of handstand, the position of the body and holding a handstand will be unregular. In any further stage errors will accumulate and systematically increase (Kim, et al., 2006). The take-off power determines the establishment of balanced position in the handstand and indirectly depends on the length of lunge step, placement of the hands on the floor and control over the move of the kick leg (Kochanowicz, Kochanowicz, K., Niespodzinski, Mieszkowski, & Biskup, 2015; Yedon & Trewartha, 2003; Uzunov, 2008). As the time length of the lunge step and placement of the hands on the floor is short, the kick leg will have delayed movement in the first and second phases and will need to compensate for it by a stronger take-off from the floor. Interpreting the size of the hip angle at the side of the kick leg, which is a higher angle value, the overall technical execution and handstand support position will be more correct

(Živčić Marković, Milčić, Krističević, Aleksić-Veljković, & Lagančić, 2018). Variable head all phases shows the difference in all phases of handstand. The placement of the straight body in the vertical support and maintenance of the balanced position directly depends on the head position (Gautier, Thouvarecq, & Chollet, 2007; Gautier, et al., 2009; Kim, et al., 2006; Scotton, et al., 2009; Živčić Marković, et al., 2015). If the angle between the head and the body is smaller (the head is backward), the position of the body in the handstand support will be curved. That head position will cause muscular relaxation of the front of the body and lowering in the shoulders. However, the head may be bend (also a small angle value), which will cause the bending (backward or forward) of the body position. Only if the head is straight in line with the trunk extension, then the athlete will be able to establish and maintain the body in the vertical position.
The mentioned mistakes in the separate phases of the handstand will cause disturbances in their duration. In a proper technique performance, the first phase is defined by the lunge step length. The longer it is, the longer the time of holding handstand. The same is valid for the phase of placing the hands on the floor and other phases. Maintenance of the balance position, along with other factors, related to the physical fitness level of the gymnast, will directly depend on the length of the individual phases, particularly the phase of lunge step and kick (Živčić, et al., 2018).

Conclusion

With this research information were obtained about the significance of the hip and shoulders angles as well as of head angles in different stages of handstand execution. By precisely defining all kinematic parameters of handstand performance, it would be possible to early detect causes of mistakes and find the best way to eliminate them. This will help coaches to find the most important exercises and pay attention to key points of handstand. Also, it would be necessary to analyze the kinematic parameters in exercises that serve to the learning a handstand technique.

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Age differences among the Croatian female young pivots in the indicators of basic and handball-specific physical fitness

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ABSTRACT
PURPOSE: The aim of the research was to determine and analyse differences among the Croatian female pivots of a younger-cadet, cadet and junior age (U14, U16, U18) in several basic and handball-specific physical fitness indicators. METHODS: The sample of 23 participants, female circle runners or pivots was drawn out of the population of members of the Croatian handball clubs recognized as promising players within their respective age group. Eighteen tests, defining four latent dimensions: agility, power, dynamic strength and flexibility, were chosen to assess basic and handball-specific motor abilities of the young pivots. Univariate analysis of variance (ANOVA) was used to establish global and individual differences among the age groups. RESULTS: The significant global age differences were established in three variables: at the level of $p<0.01$, in two variables assessing power of throwing and dynamic relative strength of arms, and at the level of $p<0.05$ in the variable assessing dynamic relative strength of the legs. Significant differences were established only between junior and younger cadet pivots since no significant difference was observed between cadets and younger cadets.
Only one variable differed junior pivots from their cadet colleagues ($p=0.01$): bench press with 50% BW (MRSBP5). CONCLUSIONS: The significant global age differences were obtained only in the three indicators of arm and leg strength (explosive and dynamic),