DETERMINING THE BIOMECHANICAL STATUS OF THE BASIC MOTOR SKILLS

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Abstract

The goal of this research was to determine the biomechanical status of the basic motor skills. The results show that the greatest biomechanical similarity is between run and leap, and the lowest is between run and catch, and run and stationary dribble. The largest force of biomechanical relationship with all other skills is present in hop. The skills covered by the research have heterogeneous biomechanical structure. By applying the method of principal components there have been identified three groups of skills. Information on the biomechanical status of motor skills can be helpful in the creation of the curriculum for the subject of physical and health education for children from elementary school.

Keywords: *qualitative biomechanical analysis, biomechanical similarity, homogeneity, relationship, structure, basic motor skills*

INTRODUCTION

Knowledge of the biomechanical principles allows a more efficient and thorough definition of human movements. Biomechanics as a fundamental science within the qualitative biomechanical analysis enables accurate determination of the biomechanical status of motor manifestations, which in turn enables the selection and construction of the variables to be made so that any movement can be defined in the whole biomechanical space (Tufekchievski & Aceski, 2009). Various authors have investigated the biomechanical status of motor manifestations using qualitative biomechanical analysis (Mitrevski et al. 2006, Tufekchievski, 1988, Klincharov, 1997, Andreevski, 2005, Anastasovski, 2001)

Fundamental movement skills are forms of movements that constitute the basis for more complex movements present in sport, recreation and other forms of physical activity (Okely & Booth 2004, Haywood & Getchell, 2005, 2009). In such forms of movements they exist in all curriculums in physical and health education for children of preschool age and elementary school from 6-10 years. Considering the importance of the representation of the basic motor skills in the curriculum, the purpose of the research was to determine their biomechanical status which includes getting information for biomechanical similarity, biomechanical homogeneity, force of biomechanical relationship and biomechanical structure that can be used in creating curriculums.

METHODS OF RESEARCH

The sample of basic motor skills was consisted of 12 (6 locomotor and 6 manipulative): run, gallop, slide, hop, leap, horizontal jump, catch, overhand throw, underhand roll, stationary dribble, forehand, kick. Both groups of motor skills are analyzed as a whole. The total sample of biomechanical variables that covered all the basic motor skills is 99, out of which 12 variables for defining the purpose, 13 for defining the initial and final position, 52 for defining the functional-anatomical characteristics and 22 for defining the mechanical characteristics.

The fundamental movement skills were first analyzed by the method of qualitative biomechanical analysis (Tufekchievski et al. 2008), and the results are shown in the ordinal matrix, which gives us information about the basic biomechanical characteristics of each motor skill. Moreover, each skill (element) is a vector where the value 1 indicates possession of the biomechanical characteristic which is of prime importance for successful performance of the skill, the value of 5 indicates possession of the biomechanical characteristic with less importance and 0 lack of the biomechanical characteristic in that skill. The rows represent the vectors of motor skills (entities) and the columns, vectors of biomechanical variables.

From the basic ordinal matrix, first we determined the coefficients of biomechanical similarity among the analyzed skills, which formed symmetric matrix of standardized measures of similarity between skills. Then we established the full biomechanical similarity or homogeneity and force of biomechanical relationship among skills. This procedure is described in the Heraclitus algorithm (Momirović et al., 1983) and Alprobila (Tufekchievski, 1988).

Then we analyzed the latent biomechanical structure of skills via factorization of inter similarity matrix among skills, by the method of principal components, using Kaiser-Gutman-'s criterion for retention of significant principal components. This procedure is described in detail in the Alprobila algorithm (Tufekchievski et al., 1989).

In the further proceedings the unrotated factor matrix is rotated in orthogonal solution with Varimax rotation and oblique solution with Direct Oblimin rotation, thus defining projections of skills vectors by the identified factors, the exhausted part of the total variance of each skill with the defined significant principal components, i.e. the size of the communality of analyzed skills, and the size of the described part of the total variance of each extracted component.

RESULTS

In Table 1, where the coefficients of inter-similarity are presented, we can note that the highest coefficients range from .571 to .772, and the lowest range from .080 to .104.

The coefficient of biomechanical similarity of the entire system of motor skills (CBSS) (Table 1) is quite low .282.

The coefficients of force of biomechanical relationship (Table 2) range from .171 to .358.

According to the Kaiser-Gutman's criterion for retention of significant principal components with characteristic root over one, three significant principal components were defined, which explain the analyzed space with 59,457% (Table 3).

Based on the projections of the motor skills vectors on the defined main components, we defined three groups of skills, with similar structure, which have distinct measures of biomechanical similarity (Table 4).

Table 1. Standardized measures of biomechanical similarity among the fundamental movement skills and the coefficient of biomechanical similarity of the entire system of motor skills (CBSS)

No.	Movement	1	2	3	4	5	6	7	8	9	10	11	12
	Skills	Run	Gallop	Slide	Hop	Leap	Hor. Jump	Catch	O. Throw	Un.Roll	St. Dribble	Forehand	Kick
1	Run	1											
2	Gallop	.512	1										
3	Slide	.495	.673	1					CBSS = . 283				
4	Hop	.556	.559	.542	1								
5	Leap	.772*	.408	.391	.563	1							
6	Hor. Jump	.085	.175	.159	.294	.117	1						
7	Catch	.080*	.225	.202	.238	.083	.316	1					
8	O. Throw	.254	.327	.307	.306	.227	.203	.359	1				
9	Un.Roll	.312	.269	.207	.200	.305	.239	.339	.571	1			
10	St. Dribble	.080*	.135	.112	.079	.083	.093	.263	.454	.242	1		
11	Forehand	.122	.118	.118	.104	.145	.178	.184	.188	.295	.275	1	
12	Kick	.467	.460	.395	.502	.405	.145	.308	.280	.306	.103	.157	1

DISCUSSON

The greatest similarity in terms of the defined biomechanical characteristics is present between these skills: run and leap with coefficient .772. The lowest similarity is present between the skills: run and stationary dribble with coefficient .080, and run and catch with coefficient .080.

Given the relatively low coefficient of full biomechanical similarity of motor skills (.283) it can be concluded that this sample of selected motor skills is quite heterogeneous. A similar heterogeneity of basic motor skills with a .291 coefficient was obtained in the research of Aceski (2009) which included three groups of basic motor skills analyzed as a whole, in a total of 24 skills.

The largest force of biomechanical relationship between skills (CFBR) can be seen in the skill hop with coefficient .358. That shows this skill, in terms of structure is the most similar to the other motor skills. The lowest coefficient .171 is observed in the motor skill of a manipulative kind

Table 2. Coefficients of force of biomechanical relationship (CFBR)

Fundamental movement skills	CFBR					
Locomotor	Run	Gallop	Slide	Hop	Leap	Horiz. jump
	.340	.351	.327	.358*	.318	.182
Manipulative	Catch	O.Throw	U. Roll	S.Dribble	Forehand	Kick
	.236	.316	.299	.174	.171*	.321

Table 3. Significant characteristic roots (Eigenvalues), percentage of the total variance of the significant principal components (% Total Variance), cumulatively significant characteristic roots (Cumulative Eigenvalues) and cumulative percentage of the total variance of the significant principal components (Cumulative%).

No.	EIGENVALUES	%TOTAL VARIANCE	CUMULATIVE EIGENVALUES	CUMULATIVE %
1.	4.321	36.010	4.321	36.010
2.	1.768	14.731	6.089	50.741
3.	1.046	8.716	7.135	59.457

Table 4. Projections of skills based on the defined components (C) and communalities h^2

No.	Movement Skills	VARIMAX COMPONENT			DIRECT OBLIMIN COMPONENT			h^2
		C1	C2	C3	C1	C2	C3	
1	Run	**.850**	.165	-.184	**.875**	.079	-.290	**.784**
2	Gallop	**.742**	.109	.227	**.742**	-.005	.148	.613
3	Slide	**.724**	.068	.210	**.731**	-.044	.136	.573
4	Hop	**.783**	.024	.282	**.793**	-.104	.209	.693
5	Leap	**791**	.179	-.189	**.812**	.101	-.291	.694
6	Hor. Jump	.124	.068	**.777**	.067	-.019	**.778**	**.623**
7	Catch	.102	.367	**.678**	.010	.305	**.648**	.604
8	Over. Throw	.254	**.719**	.214	.152	**.697**	.121	**.627**
9	Un. Roll	.257	**.680**	.170	.163	**.660**	.080	.557
10	St. Dribble	-.022	**.749**	.020	-.126	**.783**	-.053	.562
11	Forehand	.058	**.565**	.060	-.021	**.577**	-.001	.326
12	Êick	**.631**	.172	.222	**.618**	.076	.148	.477

forehand, which means that this skill is the least similar in terms of defined characteristics with other skills.

Following the method of principal components three sets of skills are obtained. Similar research was conducted by Aceski (2009), which included 24 motor skills resulting in six groups of elements.

The most significant projection on the first component (C1) was observed at the vectors of motor skills run, gallop, slide, hop, leap and kick.

According to the biomechanical classification (Tufekchievski & Aceski 2009) this group includes skills that according to their manifestation can be defined as: run - cyclic movement with generalized asymmetric anatomical structure of both legs, gallop and slide - cyclic movement with asymmetric anatomical structure of one leg, hop - cyclic movement with complex anatomical structure of one leg, leap - cyclically-acyclic movement with a complex anatomical structure of one leg, kick - cyclically-acyclic movement with asymmetric anatomical structure of one leg.

This component can be conditionally defined as a group of skills of locomotion kind with the exception of the skill - kick. A common feature of this group of skills is the dominant role of the lower limbs during their performance.

The most important projections on the second component (C2) are observed in the skills: overhand throw, underhand roll, stationary dribble, forehand.

According to the biomechanical classification this group of elements includes skills of manipulative kind that can be defined as: overhand throw and underhand roll - acyclic movements with generalized asymmetric anatomical structure, stationary dribble - cyclic motion with asymmetric anatomical structure, forehand - acyclic movement with asymmetric anatomical structure of an arm.

This component can be defined as a set of skills of manipulative kind. The main feature of this group of skills is the dominant role of the upper limbs in their performance.

On the third component (C3) the most important projections are made by the horizontal jump and catch, which according to the biomechanical classification can be defined as acyclic movement with generalized symmetrical anatomical structure and acyclic movement with symmetrical anatomical structure of the hands.

This component can be defined as a group of locomotor-manipulative type. These skills have symmetrical anatomical structure of upper limb movement in the sagittal plane, which is an important requirement for success in the performance of these skills.

Regarding the degree of the described part of the total variance of each element with the defined significant principal components i.e. the size of communalities of the analyzed motor skills, it can be concluded that most of the total variance of a single element in the first component (C1) is explained in the skill run $h^2 = .784$, which indicates the dominant place of this skill in the analyzed system. In the second component (C2), the highest communality is held by the skill overhand throw and in the third component (C3) the skill horizontal jump $h^2 = .623$.

CONCLUSION

Based on the obtained results it can be concluded that greatest biomechanical similarity was present between the skills of run and leap, and the lowest between run and catch, and run and stationary dribble.

In respect of the defined biomechanical characteristics the basic motor skills in general have a heterogeneous structure.

The greatest force of biomechanical relationship with other skills is present in the skill hop. The biomechanical structure of basic motor skills is composed of three factors.

The qualitative and quantitative representation of basic motor skills in the curriculum of physical and health education should reflect the actual needs of the student and the lessons in physical and health education based on the scientific data about their biomechanical status. This in turn would allow their rationalization as one of the conditions for proper implementation supported by scientific knowledge that will facilitate the proper physical and mental development of children through correctly selected, proper dosage and optimal methodological set activities.

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УТВРДУВАЊЕ НА БИОМЕХАНИЧКИОТ СТАТУС НА ОСНОВНИТЕ МОТОРНИ ВЕШТИНИ

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(Оригинален научен труд)

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Апстракт

Целта на истражувањето беше да се утврди биомеханичкиот статус на основните моторни вештини. Резултатите покажуваат најголема биомеханичка сличност помеѓу вештините трчање и прескокнување, а најмала помеѓу трчање и фаќање на топка, како и помеѓу трчање и водење на топка со рака во место. Најголема сила на биомеханичка поврзаност со сите останати вештини е присутна кај потскокнување со една нога. Вештините опфатени со истражувањето имаат хетерогена биомеханичка структура. Со примена на методата на главни компоненти утврдени се три групи на вештини. Информациите за биомеханичкиот статус на моторните вештини можат да бидат од корист при креирањето на курикулумите по предметот физичко и здравствено образование за деца од одделенската настава.

Клучни зборови: *квалитативна биомеханичка анализа, биомеханичка сличност, хомогеност, поврзаност, структура, основни моторни вештини*