SEARCH FOR AVAILABLE BIOMECHANICAL TECHNOLOGIES SUITABLE FOR USE IN PHYSICAL EDUCATION CLASSES

Andrey Pomerantsev[1*]

[1]Lipetsk State Pedagogical P. Semenov- Tyan-Shansky University, Institute of Physical Education, Lipetsk, Russia

Abstract. Introduction: One of the most important physical education tasks in school is to learn motor actions. Biomechanical technologies can promote to this process. A school lesson is different from a sports training, so it is necessary keep in mind its specifics. The purpose of the article is to analyse the existing professional biomechanical complexes for their suitability for use in physical education classes. Methods: We studied articles on sports biomechanics and selected 20 professional biomechanical complexes. These complexes can be divided into four technological groups: Optoelectronic Measurement Systems (OMSs), Electromagnetic Measurement Systems (EMSs), Image Processing Systems (IMSs), Inertial Sensory Systems (IMUs). Besides that, we identified 10 crucial categories to estimate opportunity to use biomechanical complexes in school lessons: cost, complexity of setting up and using, assistance need, portability, universality, room volume, construction traumatic, place for using, promptness, volume of data. Thus, each complex was evaluated according to 10 criteria. The biomechanical complex was excluded from further consideration if it got a critical limitation at least one of the criteria. Results: None of the professional biomechanical complexes can be considered suitable for use in physical education classes. As alternative we propose using free biomechanical software and smartphone camera with slow-motion caption.

1 Introduction

Biomechanical laboratories are usually created to study motor actions in sports. The results of scientific research serve to improve athletic performance or prevent sports injuries. For long time it was believed that visual control is enough to teach and to evaluate motor actions in the school's physical education program. It was assumed that teacher needed to correct only gross level motor errors without wasting time on nuances. However, the modern system of physical education and the high-tech world poses the task of revising traditional views on these issues. The contemporary physical education lesson leads to

* Corresponding author: ldclipetsk@mail.ru

complex methodological challenges to accurately assess of motor actions and identification positive effect of classes [1].

It is known that there is a technologies transfer from high level sports to amateur sports and physical education. There are lot examples for sport equipment, sports nutrition and training methods.

The **purpose** of the study is to determine the most promising technologies of biomechanical control for a physical education teacher.

The **hypothesis** is technologies of biomechanical control will become available to the normal physical education teacher after some time due to their mass introduction.

The **design** of research includes next points:

1. To identify and to systematise existing technologies of biomechanical control.
2. To determine the factors that prevent the introduction of biomechanical technologies in the lesson of physical culture
3. To use selected biomechanical technologies in physical education classes practice.

2 Methods

We carried out a literature search (articles) and internet search (biomechanical complexes manufacturer's websites). As a result, more than 20 professional motion capture systems were identified. In addition, we found separate software applications for biomechanical tracking and separate slow-motion video cameras. These both parts combined for research purposes but were not a single complex.

We investigated each system for possible application in the school physical education curriculum. Next criteria were used: affordability, suitability and appropriateness for physical education teacher (Table 1) [2, 3, 4].

Table 1. Criteria for professional biomechanical system selection.

Affordability					
Points:		**1 (Optimal)**	**2 (Acceptable)**	**3 (Significant limitation)**	**∞ (Critical limitation)**
1	Cost	Free	The cost is comparable to the teacher's salary.	The cost is comparable to the school budget.	The excessively high cost.
Suitability					
Points:		**1**	**2**	**3**	**∞**
2	Complexity of setting up and using	Simple and intuitive interface	Using requires special learning	Using requires basic engineering understanding	Using requires experience in software creating
3	Assistance	Teacher can use by oneself without help	The teacher needs an assistant (pupil)	The teacher needs several assistants (pupils).	The teacher needs the help of an adult assistant
4	Portability	Time for setting is not required	Assembly and disassembly are possible between lessons	Assembly and disassembly are possible during day	Assembly and disassembly are possible during several day
5	Universality	Suitable for any sports movement	Suitable for a group of sports	Suitable for a specific sport	Suitable for a particular element of specific movement
6	Room	Using does not reduce the area	System is placed on the unused zone of the gym	System reduces the usable space of the gym	Installation interferes to lessons
7	Traumaticity	Absence of additional constructions	Presence of non-traumatic construction	–	Presence of traumatic construction
8	Place	Anywhere	Indoor gym	Outdoor sport ground	–
Appropriateness					
Points:		**1**	**2**	**3**	**∞**
9	Promptness	Motion analysing in live playback mode	Motion analysing until the end of the lesson	Motion analysing to the next lesson	Motion analysing during a few days
10	Volume of data	Optimal	Redundant	Insufficient	–

Biomechanical technologies were evaluated quantitatively in points according for each criterion. The technology with the lowest score was considered the most acceptable. Technology that was found to be incompatible with the school's educational program on at least one point was rejected from further consideration.

3 Results

We identified four basic technologies according generalization and classification biomechanical complexes process due article [5]: optoelectronic measurement systems (OMSs), electromagnetic measurement systems (EMSs), image processing systems (IMSs), and inertial sensory systems (IMUs).

3.1 Optoelectronic Measurement Systems (OMSs)

OMSs capture light and use contrast to detect the 3D marker position. The biomechanical complex with the largest motion capture area (824 m^2) requires 24 installed cameras. This number of cameras leads to insurmountable limitations for using this system in the school, such as: high cost, inability to quickly assemble and disassemble the system, the complexity of camera synchronization, complexity of configuration and special engineering knowledge. Generally, the method is very time-consuming – mainly due to calibration – and not suitable for daily learning process [6, 7, 8].

3.2 Electromagnetic Measurement Systems (EMSs)

The GPS-GLONASS system can be used to determine the kinematic characteristics [9]. The satellites transmit data that contains information about locations and global time. That allows determining the coordinates of the receiver. The GPS system cannot be used indoors. Beside that system do not give enough data for proper biomechanical analysis [10, 11]. Radio Frequency IDentification (RFID) is a wireless contactless system that uses electromagnetic waves and electromagnetic fields to transmit data from a tag attached to an object to an RFID reader. Such a system is expensive and has a narrow sports specialization [12].

3.3 Image Processing Systems (IMSs)

The method is based on the use of optical cameras and computer vision algorithms. Real-time image processing can be demanding on computer power, so high-tech and expensive components may be required. The data accuracy and price will also be determined by the cameras number.

The Kinect™ sensor was originally invented for a game console. Sensor is widely used in sports movement biomechanical analysis. The system projects an infrared laser speckle pattern onto the field of infrared camera view. Next, the infrared camera detects the speckle pattern distortions and allows to create a three-dimensional map. The device is often used in scientific research due to its low cost. The Kinect camera disadvantage is a small area for motion. Besides that, Kinect™ using requires knowledge in computer technology and programming. Though there are large number of open source programs that let to use Kinect™ for scientific purposes [13, 14].

3.4 Inertial Sensory Systems (IMUs)

Inertial systems include an accelerometer, gyroscope and sometimes a magnetometer. By combining the information from the accelerometer – gravitational acceleration – with the data from the gyroscope – rotational velocity – the orientation of the device can be determined. A magnetometer is used to navigate to Earth's magnetic pole for determine the movement direction.

IMUs systems, though inexpensive, require engineering knowledge and experience in the programming field.

4 Discussion

Thus, all of the well-known professional biomechanical analysis systems have critical limitations that do not allow them to be used in a physical education lessons. At the same time, there are available technologies belonging to the OMSs category.

The problem of similar technologies availability for biomechanical analysis school teacher includes two components: slow-mo video camera availability and a specific software availability. Along with free software applications teachers can use home digital video cameras, photo cameras or smart phone cameras. Less than a decade ago only the world's leading biomechanics laboratories could possess expensive slow-mo video cameras and professional biomechanical systems. However, the mass distribution of digital video devices has significantly reduced the cost of such technologies. For example, since 2017 several global brands introduced smart phones to the market with the ability to shoot up to 960 frames per second. The price of similar devices is less US$1000. The main requirements for biomechanical analysis software are: 1) the ability to quickly transfer the signal from the video camera to the computer; 2) slow motion replay function; 3) the ability to apply explanations to the video sequence (in the form of arrows, geometric shapes, inscriptions etc.); 4) the ability to process video (transcoding to various formats, cropping, selecting a fragment, rotating, resizing, adding remarks, rotating by 90°, etc.); 5) the ability to do linear and angular kinematic analysis [15]. Programs must be not demanding on computer power, have a clear and smart interface. It is also possible to use mobile applications on a smart phone.

The use of biomechanical technologies is justified in the school curriculum for the following movement groups: a. for static movements – to determine the centre of gravity, evaluating of the equilibrium condition; b. for traumatic movements – to reduce the risk; c. for rapid movements – to control the movement parameters (fig. 1).

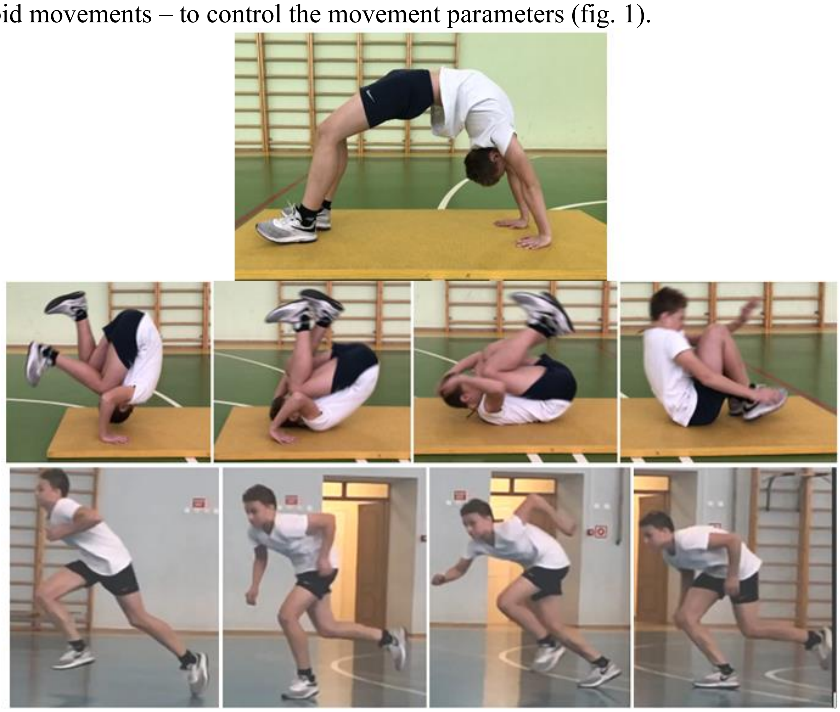

Fig. 1. Frames for biomechanical analysis of school curriculum movements: top – static movement; centre – traumatic movement; bottom – rapid movement.

5 Conclusion

None of the professional biomechanical complexes can be considered suitable for use in physical education classes. As alternative we propose using freely distributed software and smartphone camera with slow-motion caption. For the analysis of linear and angular kinematics we recommend using Kinovea software. The program is intuitive and has a user-friendly interface. To prepare videos should be used any smartphone camera with caption more 200 fps.

References

1. F.P. Carpes, Adv.Physiol. E. 45(1), 34-36 (2021)
2. J. Thompson. Low Cost Video Motion Capture System, in XXVII Congress of the International Society of Biomechanics, ISB, Calgary (2019)
3. J.G. Richards, Hum Mov Sc 18(5), 589–602 (1999)
4. D. Zhong, S. F. Chang, J Vis Com Im Repres, 15(3), 330–347, (2004)
5. E. Kruk, Eur J Sp Sc, 18:6, 806-819, (2018)
6. J. Schmidt, D.R. Berg, H-L. Ploeg, L. Ploeg, Int. J. Exper Comp Biomech, 1, 114–127 (2009)
7. J. Spörri, C. Schiefermüller, E. Müller, PloS One, 11(8), e0161757 (2016)
8. T. Monnet, M. Samson, A. Bernard, L. David, P. Lacouture, Sport Engin, 17(17), 171–181 (2014)
9. M. Gilgien, J. Spörri, P. Limpach, A. Geiger, E. Müller, Sensors, 14(10), 18433–18453 (2014)
10. T. Sathyan, R.Shuttleworth, M.Hedley, K.Davids, Behavior Res Meth, 44(4), 1108–1114 (2012)
11. B. Perrat, M.J. Smith, B. S. Mason, J.M. Rhodes, V.L. Goosey-Tolfrey, J Sports Eng Tech, 229(2), 81–91 (2015)
12. A.A.N. Shirehjini, A. Yassine, S.Shirmohammadi, IEEE Trans Instr Measur, 61(6) (2012)
13. T. Dutta, Appl Ergonom, 43 (4), 645–649, (2012)
14. B. Bonnechere, B. Jansen, P. Salvia, H. Bouzahouene, L. Omelina, F.Moiseev, Gait & Posture, 39(1), 593–598 (2014)
15. B. Bačić, Augmented Video Coaching, Qualitative Analysis and Post-production Using Open Source Software, in 30th Annual Conference of Biomechanics in Sports, Melbourne (2012)