Original Article

Introduction of electronic devices in the test of flexibility

VICTOR KORYAHIN¹, GENNADII IEDYNAK², OKSANA BLAVT³, LESIA GALAMANDJUK⁴,
MYKOLA PROZAR⁵, ANDRIY ZAIKIN⁶, TAISIYA VESELOVSKA⁷, VICTOR GOLUB⁸, TETYNIA
KUCHER⁹, TATYANA GURTOVA¹⁰
^{1,3,10.}Lviv Polytechnic National University, UKRAINE,
^{2,4,5,6,7.}Kamianets-Podilskyi National Ivan Ohiienko University, UKRAINE

Published online: June 30, 2020

(Accepted for publication: June 22, 2020)

DOI:10.7752/jpes.2020.04251

Abstract

The urgency of this study is due to the lack of a method to objectively assess the level of mobility in the joints and to obtain information during the evaluation of the level of flexibility, which is determined on the basis of theoretical analysis and experimental verification of existing techniques. The purpose of the study was to explore the possibility of using the latest technology to improve the technique of testing the level of mobility in the joints. To solve the research tasks used the following methods of the theoretical and empirical level were used: analysis, synthesis, comparison, abstraction, induction, generalization and systematization for obtaining theoretical and empirical materials and scientific modelling. The article confirms the feasibility of introducing electronic devices into the testing process to obtain clear objective information and implement operational testing of the level of development of flexibility. The technological method of evaluation and control of flexibility is offered. The developed technology for determining the state of mobility in the joints is that monitoring the testing process is carried out by fixing one end of the cord to the athlete's extremities, and the other end of the cord – in the rotating mechanism of the drum, the signal from which is transmitted to the electronic computing device, and the value of which is judged by condition of mobility of joints. The main purpose of integrating the developed flexibility control device is to intensify the control process to enhance its information capability. This approach allows to purposefully adjust the process of sports training on the basis of an integrated approach to the development of physical qualities.

Key Words: mobility in the joints, evaluation, technology, monitoring.

Introduction

The development of achievements in world sports requires continuous search of new effective means of preparation of athletes of different qualifications (Koryahin, et al., 2019). The further growth of athletic skill can be achieved by rationally constructing the preparation process, which requires a comprehensive study of indicators that characterize the state of various aspects of preparedness, and by developing a reliable informative control system (Balagué, et al., 2017; Preatoni, et al., 2013).

It has been determined that the improvement of physical fitness of athletes depends on the successful development of effective means and methods of improving physical qualities that, to a certain extent, ensure the performance of muscular work and propose various requirements for the functional state of the body of athletes (Edwards, 2010). Flexibility (i.e., index of mobility level in joints) is one of the most informative indicators of physical fitness of athletes. Flexibility allows to perform movements in joints with greater amplitude. In all sports, results are, to a certain extent, attributed to the ability to achieve greater scope of movement (Arajo, 2004; Draga, et al., 2020). Therefore, the determination of the level of mobility in the joints is one of the determining factors for evaluating the dynamics of physical fitness, which allows athletes to purposefully manage this process (Schmidt, & Wrisberg, 2008; Tanner, & Gore, 2012).

According to (Nuzzo, 2020; Solodovnykova, 2015), flexibility is an important physiological factor in sport. Flexibility is a complex physical quality; it is not a general characteristic, but is specific to a particular joint and its exact movements. This complicates the problem owing to the presence of many joints and muscles associated with the movements of these joints and movements of body parts around them. These factors are important when choosing a measurement and testing procedure for athletes in various sports (Behm, et al., 2017; Chow, et al., 2017). It is necessary to assess the needs of a specific sport with their subsequent use as the basis for determining the joint and its movement, which needs to be tested (Ivashchenko, et al., 2017). The definition of flexibility is necessary to obtain quantitative knowledge, which allows to evaluate the components of growth of special ability to work and determine the nature of problems associated with poor performance or the possibility of injury (Capobianco, et al., 2018).

By generalizing relevant literary sources on this issue (Arajo, 2004; Magill, & Anderson, 2017; Vanhelst, et al., 2016) it was determined that the level of joint flexion is of interest to trainers, sports researchers, and rehabilitation specialists. These professionals believe that this physical quality is important for sports activities. In general, flexibility is seen as an important component of sports performance, injury prevention, and rehabilitation. Thus, documented information on measurement procedures and flexibility training techniques is required (Magill, & Anderson, 2017; Khudolii, et al., 2015). Existing data on the results of flexibility studies are characterized by inaccuracies in terminology, lack of descriptions of their structure, and use of many tests, most of which are not generally accepted.

The assessment and measurement of flexibility include:

- ensuring athlete's performance of movements required for technical elements for a certain sport with the minimum load on muscular–tendon tissues;
- implementation of continuous control over increase and decrease of flexibility as a result of training;
- identification of reasons for the lack of effectiveness of technical actions by athletes or for the risk of injury;
- evaluation of the rehabilitation procedure after injury and assistance in determining fitness of an athlete before returning to sports activities (Magill, & Anderson, 2017; Schmidt & Wrisberg, 2008).

Flexibility testing procedures should include measurements of the amplitude of joint movements to demonstrate the ability of muscles to elongate within their structural constraints. Some flexibility testing procedures are described in the literature such as the Cuarton test, Wales and Dillon tests, the use of a Hamburtsev goniometer, radiography, and Leuton angle meter (Arajo, 2004; Magill, & Anderson, 2017).

The main drawbacks of the abovementioned approaches are the lack of standardization for the following parameters:

- use of different units of measurement: linear measurements and degrees;
- use of relative and absolute indicators;
- starting positions: it is impossible to fix the output zero position;
- measurement of active and passive amplitudes;
- estimation of an external force during passive movements.

In general, these techniques do not allow to obtain reliable figures owing to the large number of uncontrolled variables and the lack of continuous registration of test results. Thus, there is a need for a fundamentally new approach to address this issue.

This objective can be achieved by identifying approaches to improve the method of determining the level of mobility in the joints and predetermine the choice of topic and direction of research. The analysis of available publications on this issue suggests that the solution to this problem is related to the use of modern advanced technologies for obtaining urgent objective information (Balagué, et al., 2017; Capobianco, et al., 2018; Draga, et al., 2020). The technological fundamentals of this issue in the field of sports training require scientific elaboration, which is recognized by many scholars (Estivalet, & Springer, 2009; Preatoni, et al., 2013; Koryahin, Blavt, & Ponomaryov, 2019). Currently, few aspects have been developed in the field of sports science, and the proposed approach of automated monitoring has not been used. Therefore, additional consideration should be given to the study of the effectiveness of automated flexibility testing techniques in the context of modern electronic devices.

The purpose of this study is to substantiate and implement modern electronic technological tools to improve the testing of flexibility.

Materials and methods

To achieve research objectives, theoretical and empirical approaches were used (e.g., analysis, synthesis, comparison, abstraction, induction, generalization, and systematization) to obtaining theoretical and empirical materials and perform scientific modelling.

The research strategy is focused on the integration of information resource of newest electronic technologies to ensure the effectiveness of flexibility testing. Our innovative idea proposes the integration of interdisciplinary and project-based approaches. The research strategy was focused on the integration of information resources to achieve effective testing. We aimed to intensify the pedagogical process of testing, which considerably enhanced its informative capabilities. The informatisation of monitoring in the context of our study involved building the infrastructure of means of receiving, storing, accumulating, and processing information. This required the creation of a breakthrough compute-ahead device for controlling flexibility, whose work was focused on ensuring the effectiveness of testing, enriching the control information data, and enhancing the results (Koryahin, et al., 2020).

Scientific modelling (Ivashchenko, & Khudolii, 2016) was used to create the device to be studied: the use of technical means provided the simulation an experimental character. This required the creation of a breakthrough compute-ahead device for testing flexibility, whose work was focused on ensuring the effectiveness of testing, enriching the control information data, and enhancing the results.

Results

To carry out an objective evaluation and ensure the reliability of results, the use of electronic devices in the testing of mobility amplitude in the joints is proposed. Thus, we developed an electronic device (Fig. 1), which is based on a method for determining the mobility of joints using a laser displacement sensor (Hotra, et al., 2018)

The proposed system consists of a drum (equipped with a system for returning it to its original position), a cord (one end of which is attached to the drum, and the other end is attached to the athlete), and a laser displacement sensor located directly near the drum.

The movement of the limb by the athlete turns the drum, which is detected by the motion sensor. The return of the drum to its original position is achieved by the return mechanism. The use of such system reduces the effect of tremor on the result during the execution of test procedures.

The Borland Delphi 6.0 software environment was used to develop the program (Bracke, et al., 2007).). The position of the optical motion sensor was read every 100 ms (time was measured using an instance of the TTimer class). The dependence of the change of the selected screen coordinate (x or y) on time is depicted using the components of TChart and TLineSeries classes. All text fields for setting parameters (e.g., duration of the exercise or the conversion factor of screen pixels in physical units of length) are protected from the input of incorrect data (user cannot enter characters in the text field that cannot be in the representation number); default values and allowable boundaries of the corresponding numbers are set. At each observed time, the time and current coordinates of the mouse cursor are written to the files stored on the disk and are available for further processing. The program calculates the maximum deviation of the mouse cursor (at both coordinates), and when the exercise is finished, the maximum result in physical units is displayed on the screen. Exercise ends after the "Stop" button is pressed or after the specified duration of the exercise. At each screen time, only the elements that are required by the user are visible; other graphic objects are hidden. The program has successfully passed various testing, including load-testing with large volumes of data for writing files and long duration of exercises. In the long run, it is planned to simultaneously implement software processing of data from several optical motion sensors.

Fig. 1. A system for determining mobility in joints using a laser displacement sensor:

- 1 – a cord;
- 2 – drum;
- 3 – laser displacement sensor;
- 4 – sensor mounting system

The developed technology for determining the state of mobility in the joints is summarized as follows. The testing process is carried out by fixing one end of the cord to athlete's extremities; the other end of the cord is fixed to the rotating mechanism of the drum, the signal from which is transmitted to the electronic computing device; the obtained value depends on the mobility of joints. The use of developed device eliminates the subjective definition of indicators of flexibility associated with the perception of the person who conducts this monitoring because the testing process contains a device that outputs values that depend on joint mobility; thus, reliable data can be obtained.

Figure 2 shows the fixation of one end of the cord of the various limbs of the athlete. The developed joint testing device includes electronics, which is electrically connected to a laser motion sensor, located on a drum with a cord, one end of which is fixed on the subject of monitoring.

Determination of the mobility of the joints is carried out as follows: one end of the cord is fixed on one of the extremities of athlete, and the other end of the cord is fixed in the rotary mechanism of the drum, on which the rigidly mounted laser sensor of movement is installed, the signal from which is transmitted to the electronic computing device and the value of which is judged by the state of mobility of the joints.

Fig. 2. Determination of the amplitude of motion in the joints:

a – in the hip joint (bending);

b – in the hip joint (withdrawal);

c – in the shoulder joint (extension);

where: 1 – athlete; 2 – cord; 3 – drum; 4 – laser transfer sensor; 5 – electronic computing device.

The advantages of using our proposed technology for testing the level of mobility in the joints are exact flexibility testing procedure:

- urgent receipt of the result;
- quantitative estimation of the amplitude of motion in degrees;
- no need to determine the center of rotation of the joint;
- the starting position is standardized due to the monitor's performance;
- automatic retrieval of multiple test results in the form of an electronic protocol.

Dicussion

Currently, one of the problems faced by researchers in sports is a need for the radical adjustment of the control system in the direction of modernization and introduction of innovative approaches and modern technologies of organization (Schmidt & Wrisberg, 2008; Preatoni, et al., 2013; Ivashchenko, et al., 2017). We agree that the adoption and use of modern electronic devices will help to solve the current problems of control (Clarys & Cabri, 1993; Estivalet, & Springer, 2009; Haake, 1996; Mac-Duggala, 1997).

Our research confirms research (Capobianco, et al., 2018; Edwards, 2010; Kavanagh & Menz, 2008), that postulates that automating the process of obtaining and processing monitoring information in the process of sports training helps to increase the efficiency of obtaining test information in real time and reduces the time spent on testing.

The scientific novelty of the results of this study is that for the first time an electronic monitoring device for flexibility testing, developed on the basis of modern electronic technologies, was presented. The study complements the results of our own research (Koryahin, Blavt, & Ponomaryov, 2019; Koryahin, Mukan, Blavt, & Virt, 2019; Koryahin, et al., 2019; Koryahin, et al., 2020) on the use of new technologies in testing.

The main methodical result of this work is that the use of the developed system allows to intensify the testing process during the physical training of athletes. In turn, this allows to comprehensively evaluate the current issue of control and determine the need for adjustments in the training program in accordance with the results to improve the management of the training process. This reasoning agrees with those in previous studies (Balagué, et al., 2017; Preatoni, et al., 2013; Schmidt, & Wrisberg, 2008). The results of our study confirmed the existing points of view on this issue (Corbin & Noble, 1980; Magill, 2007; Wilson, 2001).

Conclusions

The level of development of flexibility of athletes is an important prognostic indicator of sports fitness. A promising directions for improving the quality of joint flexion testing is the development and implementation of special digital devices for this process, which should ensure the objectivity of the results. The use of latest technologies to test flexibility is a powerful methodological basis for the scientifically based improvement of the process of sports training, which will significantly increase the effectiveness of training. Further research is planned to develop the latest information technology to reorganize other test samples to obtain clear control in the field of sports.

Conflicts of interest

No conflicts of interest exist.

References

- Arajo, C.G.S. (2004). Flexitest: an innovative flexibility assessment method. Champaign IL : Human Kinetics.
- Balagué, N., Torrents, C., Hristovski, R. & Kelso J.A.S. (2017). Sport science integration: An evolutionary synthesis. *European Journal of Sport Science*, 17(1), 1240-1249. <https://doi.org/10.1080/17461391.2019.1593509>.
- Behm, D.G., Blazevich, A.J., Kay, A.D., & McHugh, M. (2016). Acute effects of muscle stretching on physical performance, range of motion, and injury incidence in healthy active individuals: A systematic review. *Applied Physiology, Nutrition, and Metabolism*, 41(1), 1-11. <https://doi.org/10.1139/apnm-2015-0235>.
- Bracke, W., Puers, R., & Van Hoof, C. (2007). Ultra low power capacitive sensor interfaces. Springer.
- Chow, G.C.C., Chung, J.W.Y., Ma A.W.W, Macfarlane, D.J., & Shirley, S.M.F. (2017). Sensory organisation and reactive balance control of amateur rugby players: A cross-sectional study. *European Journal of Sport Science*, 17(4), 400-406. doi:<https://doi.org/10.1080/17461391.2016.1257656>.
- Capobianco, R.A., Almuklass, A.M. & Enoka, R.M. (2018). Manipulation of sensory input can improve stretching outcomes. *European Journal of Sport Science*, 18(1), 83-91. <https://doi.org/10.1080/17461391.2017.1394370>.
- Draga, P., Ozimek, M., Krawczyk, M., Rokowski, R., Nowakowska, M., Ochwat, P., Jurczak, A., & Stanula, A. (2020). Importance and Diagnosis of Flexibility Preparation of Male Sport Climbers. *Int. J. Environ. Res. Public Health*, 17, 25122512. <https://doi.org/10.3390/ijerph17072512>
- Edwards, W.H. (2010). *Motor Learning and Control From Theory to Practice*. California: Wadsworth.
- Estivalet, M., & Springer, P. (2009). *The Engineering of Sport*. Paris: Springer-Verlag.
- Hotra, Z., Mykytyuk, Z., Diskovskiy, I., Barylo, G., & Vezyr, F. (2018). Optic sensors of enzymes with sensitive environment based on cholesterol liquid crystals. In 14th International Conference on Advanced Trends in Radioelectronics, Telecommunications and Computer Engineering, TCSET, 716-719. <https://doi.org/10.1109/TCSET.2018.8336300>.
- Ivashchenko, O., Khudolii, O., Iermakov, S., & Harkusha, S. (2017). Physical exercises' mastering level in classification of motor preparedness of 11-13 years old boys. *Journal of Physical Education and Sport*, 17(3), 1031-1036. <https://doi.org/10.7752/jpes.2017.03158>
- Ivashchenko, O. & Khudolii, O. (2016). Methodological approaches to pedagogical control in the process of physical education of girls 12-14 years old. *Teoria ta Metodika Fizičnogo Vihovanna*, (4), 13-24. doi:<https://dx.doi.org/10.17309/tmfv.2016.4.1175>. (in Ukrainian)
- Kavanagh, J.J., & Menz, H.B. (2008). Accelerometry: A technique for quantifying movement patterns during walking. *Gait & Posture*, 28(1), 1-15. doi:<https://doi.org/10.1016/j.gaitpost.2007.10.010>
- Khudolii, O.M., Iermakov, S.S., & Ananchenko, K.V. (2015). Factorial model of motor fitness of junior forms' boys. *Journal of Physical Education and Sport*, 15(3), 585-591. doi:10.7752/jpes.2015.03088.

- Koryahin, V., Mukan, H., Blavt, O., & Virt, V. (2019). Students' coordination skills testing in physical education: ICT application. *Information Technologies and Learning Tools*, 70(2), 216-226. <https://doi.org/10.33407/itlt.v70i2/>
- Koryahin, V., Blavt, O., Vanivska, O., & Stadnyk, V. (2020). Potential of new technologies in providing efficiency of pedagogical control in physical education. *Teoriâ ta Metodika Fizičnogo Vihovannâ*, 20(1), 25-31. <https://doi.org/10.17309/tmfv.2020.1.04>
- Koryahin, V., Iedynak, G., Blavt, O., Galamandjuk, L., Ludovyk, T., Stadnyk, V., Bezgrebelnaya, E., & Afonin, V. (2019). Hardware operational control of spatial and temporal parameters of the athlete's movement. *Journal of Physical Education and Sport*, 19(4), 367, 2424-2428. <https://doi.org/10.7752/jpes.2019.04367>
- Koryahin, V., Blavt, O., & Ponomaryov, S. (2019). Innovative Intestification of Testing of Strength Endurance in Physical Education of Students With Chronic Diseases. *Teoriâ Ta Metodika Fizičnogo Vihovannâ*, 19(3), 116-122. <https://doi.org/10.17309/tmfv.2019.3.02>
- Magill, R.A., & Anderson, D. (2017). *Motor learning and control: Concepts and applications* (11th ed.). McGraw-Hill International Edition.
- Nuzzo, J.L. (2020). The Case for Retiring Flexibility as a Major Component of Physical Fitness. *Sports Med*, 50, 853-870. <https://doi.org/10.1007/s40279-019-01248-w>
- Preatoni, E., Hamill, J., Harrison, A.J., Hayes, K., Van Emmerik, R.E.A., Wilson, C. & Rodano, R. (2013). Movement variability and skills monitoring in sports. *Sports Biomechanics*, 12(2), 69-92. <https://doi.org/10.1080/14763141.2012.738700>
- Solodovnykova, M. (2015). Peculiarities of Flexibility Development in Middle Schoolers. *Teoriâ Ta Metodika Fizičnogo Vihovannâ*, (3), 17-24. <https://doi.org/10.17309/tmfv.2015.3.1144>. [in Russian].
- Schmidt, R.A., & Wrisberg, C.A. (2008). *Motor Learning and Performance: A Situation-based Learning Approach*. (I. Champaign, Ed.). Human Kinetics.
- Tanner, R., & Gore, C. (2012). *Physiological Tests for Elite Athletes* Second. Edition Human Kinetics, Inc.
- Vanhelst, J., Beghin, L., Fardy, P.S., Ulmer, Z., & Czaplicki, G. (2016). Reliability of health-related physical fitness tests in adolescents: The MOVE Program. *Clin. Physiol. Funct. Imaging*, 36, 106-111. <https://doi.org/10.1111/cpf.12202>