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MEASUREMENT OF JOINT RANGE OF MOTION IN SPORTS PRACTICE

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Abstract

Goniometry, measurement of the range of joint motion, is one of the basic diagnostic methods used in orthopedics, physiotherapy, or physical education and sports practice. However, we find differences in goniometric examinations and stated physiological range of motion of individual joints among the authors of professional publications. Based on the analysis of the professional literature, we selected the most frequently used data for the physiological range of joints, on which we can base the measurements. Our goal was to create a methodological material in the form of a video program with a methodical procedure and illustrative examples of measuring the angles of selected joints for the purpose of physical education and sports practice. It was realized within the project Internal Competition of the University of West Bohemia in Pilsen, in which students of the master program Physical Education Teacher participate. The creation of the video program was also initiated thanks to cooperation with the New Technologies – Research Center, University of West Bohemia in Pilsen, where we participate in research that deals with the development of personalized models of the human body. In the future, we would like to use the methodology to examine and compare the flexibility of athletes from different sports (also the flexibility of men and women, or different age categories - children, youth and adults).

Keywords

Goniometry; joint range; sport; educational video program.

1 INTRODUCTION

Goniometry or measurement of joint range of motion is one of the basic diagnostic methods used in orthopedics, physiotherapy, or physical education and sports practice. The standard internationally recognized orthopedic method for measuring and recording the range of motion in individual joints is the SFTR method (S-sagittal, F-frontal, T-transverse, R-rotation), developed by J.J. Gerhardt. The method was first published in 1963 (Russe & Gerhardt, 1975). Using the SFTR method, all joint movements are measured at a given zero (initial) position. The measurement is performed with a goniometer, which can be manual, electronic or different type. There are three degree scales on the body of the goniometer: 0°-180°, 0°-90°, 180°-360°. The goniometer also includes a scale in centimeters and inches, which is displayed on the moving arm (Janda & Pavlů, 1993). In practice, due to its simplicity, the planimetric method, which records movement in one plane, is often used.

In general, a physiological range of motion corresponding to the full range of motion in the joint is required from a health point of view. Pathologically, the range of motion in the joint may be reduced (hypomobility) or increased (hypermobility). Each sport loads the joints differently and also emphasizes the range of motion of other joints (e.g. in coordination-aesthetic sports as rhythmic gymnastics, the norm of the range of joints is shifted towards hypermobility). The range in the joint can be passive (performed by a coach, physiotherapist) or active (performed by the evaluated individual by the activity of the relevant muscle groups in the joint area). For optimal evaluation of the range of motion from the perspective of a coach or physiotherapist caring for a particular athlete, it is necessary to know the required range of motion of individual joints with respect to the optimal course of movement within specific sports skills. When investigating the active range, the examined person performs the movements himself. During the movement, we can also monitor whether the examined

person does not feel pain at any stage of the movement and whether the extent of the joints in both limbs or the side-oriented movement (left, right side) is the same (Rychlíková, 2019). Examination of active joint ranges may also include examination of movement stereotypes (Haladová & Nechvátalová, 2010) or a classical muscle test according to Janda (Janda el al., 2004).

Most foreign research studies focus primarily on examining the joint range of motion in the non-athletic population. An interesting study was conducted, for example, by Araújo (2008), who measured the range of motion of various joints in 4711 non-athletes aged 5-91 years. He used his own Flexitest flexibility measurement method. He confirmed the already known theory that flexibility decreases with age and that women show greater flexibility than men since childhood, which was supported by the results of Yun et al. (2002). In sports practice, we find studies from specific sports, which deal with the extent of one joint (knee, shoulder, etc.), or a group of the most loaded joints. In combat sports such as Podrigalo et al. (2017), in football studies focus on the joint range of motion of the lower limbs (hip, knee, ankle), such as Ostojic and Stojanovic (2007).

2 OBJECTIVES

2.1 Creation of a video program for joint range motion measurement

Nowadays, the trend is to use modern technologies and online tools to communicate information of various kinds more quickly and clearly. This trend does not avoid training issues or individual work with clients in physical education and sports practice. Illustrative and easily reproducible are detailed demonstrations for goniometric measurements of the range of motion of individual joints. Freely available video demonstrations within educational programs are aimed primarily at physiotherapists. These examples are relatively detailed, complex and difficult to reproduce for the training and teaching practice of students of physical education and sport.

Our objective was to create a methodological material in the form of a video program with a detailed, sufficiently illustrative procedure of measuring the angles of selected joints for the purposes of physical education and sports practice. This task was addressed within the project Internal Competition of the University of West Bohemia (UWB) in Pilsen, VS-21-055, realized this year. Students of the Center for Physical Education and Sport, Faculty of Education, UWB in Pilsen participate in the project. The methodology is modified and simplified so that the result can be used in sports and coaching practice without the need for physiotherapeutic training. Nevertheless, the basic instructions must be followed to avoid measurement bias. In the video program the emphasis is placed on the key measurement points so that the same measurement rules and procedure are always followed. This is the goal of the methodological material in the form of video demonstrations showing the exact procedure of individual measurements.

The creation of a video program with examples of measuring the range of joints was initiated thanks to cooperation with the NTC (New Technologies – Research Center) UWB in Pilsen, where the main author of this article participates in research on the development of personalized human body models. Within this cooperation, it is necessary to measure a set of anthropometric parameters (weight, height and other 22 data concerning the circumferences, lengths and widths of individual body segments) in a large and diverse group of probands. Personalized models of the human body are used to describe the risk of injury during an impact (road, rail or air transport) and to optimize safety features and clinical practice models to improve medical care as well as improve life in fields as obstetrics, surgery, orthopedics and rehabilitation. Researchers from the NTC have requested to extend the measurement of anthropometric parameters by joint range of motion. The aim is to gain a more holistic view of the human body and to create more realistic and accurate personalized models. Our part of involvement and cooperation therefore involves measuring joint range of motion by different target groups and accurately documenting the methodology

used, so that it is possible to collect data in a similar way using more trained examiners without the need for medical or physiotherapeutic education.

2.2 Use of joint range motion measurement in pedagogical and sports practice

Next to the cooperation with NTC, our goal in the field of pedagogical and educational practice is to use this methodology contained in video program for research within the final theses of bachelor's or master's degree students of physical education and sport. In physical education practice, we purposefully deal with physical activities for various age categories and various sports disciplines. In the future, we therefore plan to closely monitor and clearly summarize joint range of motion within various sports specializations.

3 METHODOLOGY

The methodology of joint range of motion examination is standardly described in the available professional literature, it is based on the SFTR method stated in the Introduction chapter and has become the standard international orthopedic method for measuring and recording the range of motion in individual joints (ISOM = International Standard Orthopedic Measurements) (Šíblová, Hlinecká & Kačírková, 1995).

The goniometer is usually applied from the outside of the joint and is only in light contact with the body. The center (axis) of the goniometer is placed in the axis of movement of the examined joint. The axis of motion in the joint determines specific joint prominences or anatomical points, the determination of which is very important for measurement. The stationary arm of the goniometer runs parallel to the longitudinal axis of the stationary part of the body, the moving arm goes parallel to the moving part of the body (Janda & Pavlů, 1993). Measurements in our video program (starting position, fixation and attachment of the goniometer) were performed according to Russe and Gerhardt (1975) and supplemented according to Janda and Pavlů (1993). A two-armed plastic goniometer was used to measure the range of motion in a given joint.

To measure the joint range of motion, it is necessary to proceed from the physiological range of the joints (angles given in degrees). However, authors of professional literature and various educational scripts slightly differ in values. In our survey, we compared the methodology described by Janda and Pavlů (1993), Čihák (2001), Rychlíková (2019), Kolář (2020), Norkin and White (2016) and the methodology presented in other media (e.g.: https://is.muni.cz/do/1451/e-learning/kineziologie/elportal/pages/pohyby_v_kloubech.html).

4 RESULTS

4.1 Physiological joint range of motion

Based on the analysis and comparison of the available professional literature, we selected the most frequently used data for the physiological range of joints, on which we based our measurements. Tables 1 and 2 show examples selected from professional publications by Czech authors.

Table 1 – Physiological joint range of motion according to selected Czech authors – ankle, knee, hip, torso

Body segment/ joint	**Movement**		**Source (publication)**				
			Kolář (2020)	Rychlíková (1019)	is.muni.cz (2010)	Čihák (2004)	Janda a Pavlů (1993)
ANKLE	DORSIFLEXION		20°-30°		20°	20°-25°	10°-30°
	PLANTAR FLEXION		40°-50°		30°	30°-35°	45°-50°
KNEE	FLEXION		120°-150°	120°-150°	160°	140° active (130°-160°)	125°-160°
	EXTENSION		5°-10°	do 10°	0°	5°	0°-10°
HIP	FLEXION		140°	140°	130°	120° (in stand)	120°-135°
	EXTENSION		20°	25°	30°	13° (in stand)	10°-30°
	ABDUCTION		50°	60°	45°	40° (without flexion)	30°-50°
	ADDUCTION		45°	30°	0-45°	10° (in stand, without flexion)	10°-30°
	EXTERNAL ROTATION		50°	50°-70°	15°	15°	45°-60°
	INTERNAL ROTATION		40°	20-30°	35°	35°	30°-45°
TORSO	FLEXION (ventral flexion)	C	30°-35°		60°	90°	40°-45°
		Th	35°-40°		45°-50°	90°	80°
		L	55°-60°			23°	20°
	EXTENSION (dorsal flexion)	C	80°-90°		75°		45°-75°
		Th	20°-25°		25°	45°	
		L	30°-35°				
	LATERAL FLEXION	C	35°-40°		45°	30°	45°
		Th	20°-25°		25°-30°		35°-40°
		L	20°-30°			35°	35°-40°
	ROTATION	C	45°-50°		80°	60°-70°	50°-60°
		Th	25°-35°		30°-45°	25°-35°	20°-45°
		L	5°			5°-10°	20°-45°

Table 2 – Physiological joint range of motion according to selected Czech authors – elbow, shoulder, wrist

Body segment /joint	**Movement**	**Source (publication)**				
		Kolář (2020)	Rychlíková (1019)	is.muni.cz (2010)	Čihák (2004)	Janda a Pavlů (1993)
ELBOW	FLEXION	130°-150°	130°-145°	135°-145°	125°-145°	145°-150°
	EXTENSION	0-10°	0°-10°	0°-5°	slightly exceed 0°	0°-10°
	PRONATION	180°	do 90° during flexion in the elbow	180°		80°-90°
	SUPINATION	180°	do 90°	180°	180°	80°-90°
SHOULDER	VENTRAL FLEXION	150°-170°	150°-170°	90°-100°	80°	160°-180°
	DORSAL FLEXION (extension)	40°	40°	40°-60°		30°-60°
	ABDUCTION	90° 160-80° = change of position (oppression)	90° 160°-180°	90°-95°	96° (55°)	90°-180°
	ADDUCTION	20°-40°	20°-40°	75° across the body axis		120°-130°
	HORIZONTAL ABDUCTION	40°-50°		45°		20°-30°
	HORIZONTAL ADDUCTION	130°-160°		135°		120°-130°
	EXTERNAL ROTATION	60°	40°-60°	90°	90°	55°-95°
	INTERNAL ROTATION	70°	70°-90°	90°	90°	45-90°
WRIST	PALMAR FLEXION	40°-60°	90°	70°-90°	90°	80°-85°
	DORSIFLEXION (extension)	60°-80°	60°	65°-85°	85°	70°-85°
	RADIAL DUCTION	15°-20°	25°-30°	15°-20°	20°	15°-20°
	ULNAR DUCTION	45°	30°-40°	45°	40°	30°-35°

4.2 Video program for measuring joint range of motion

Two devices were used to record the individual measurements – a mobile phone (iPhone 7) and a digital camera (Canon EOS 77D). The camera also took photographs, which are used in the video program to show the starting positions for individual measurements, the positions of the goniometer and the resulting values displayed on the goniometer. For the subsequent processing of video recordings, the freely downloadable program Filmora 9 (Figure 1) was used, in which the individual videos were cut into one unit.

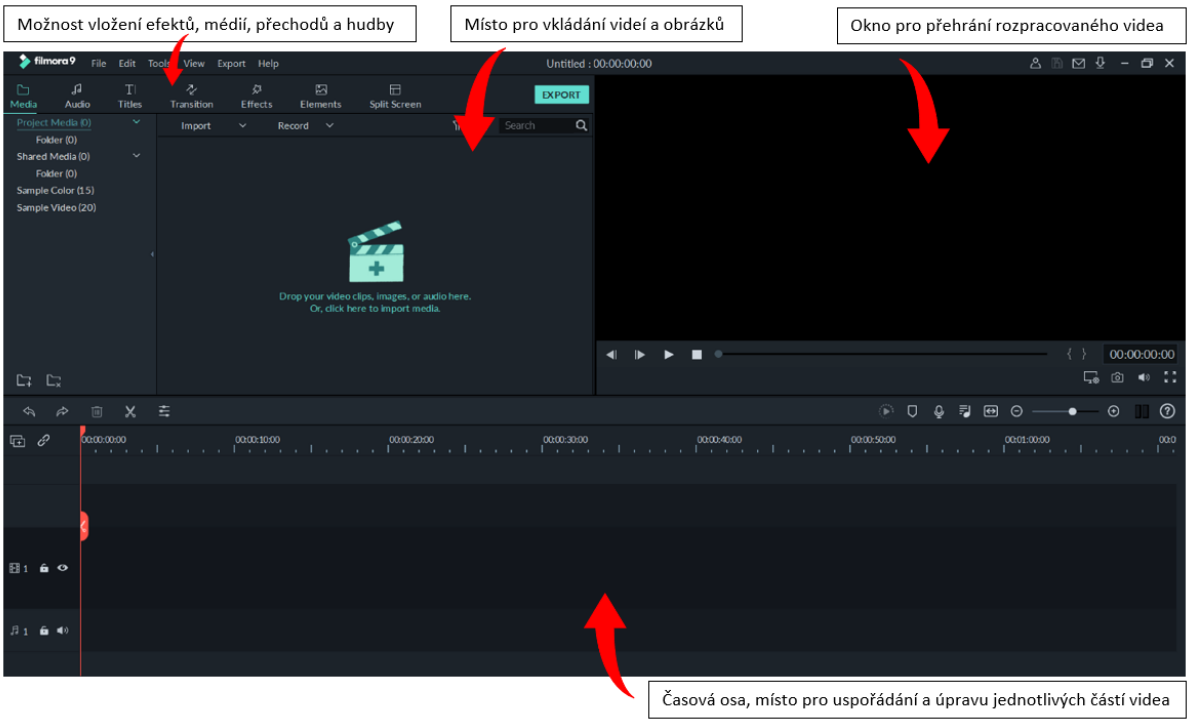

Figure 1 – Description of the environment of the Filmora 9 program

The video program designed as an accurate guide to measuring the range of motion in individual joints is divided into main parts according to the measured joints and then other more detailed parts focused on individual movements in joints are processed separately. The video always contains the name of the joint being measured, the movement in which the range of motion is measured, and the physiological range of motion that an average person should reach. The name is followed by a demonstration and description of the starting position, a picture and a description of the goniometer attached to the proband's measured joint and a description of the measurement itself. This preparatory manual is followed by a record of the measurement process itself, which is always shown in real speed of motion and subsequently for greater clarity in slow motion. At the end of the video, a place on the goniometer is shown, which shows the desired result value in degrees. Some movements in the lumbar and thoracic spine are measured with a measuring tape. An example of the already processed video is shown in Figure 2.

Table 3 contains a list of joints / body segments and individual measured movements, which we focused on in the video program.

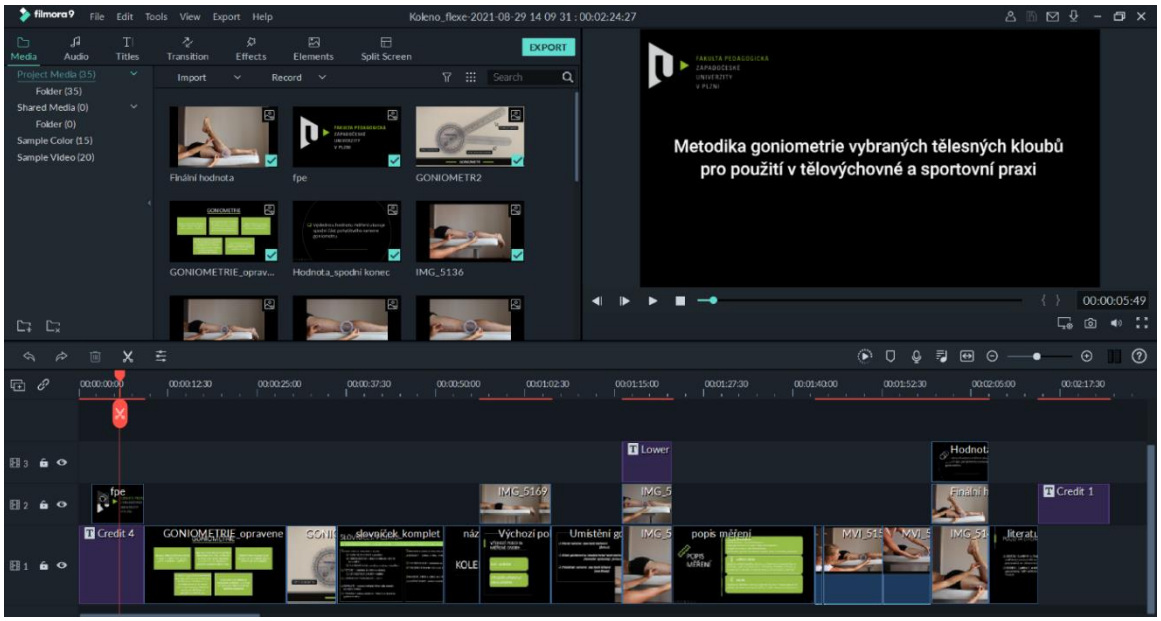

Figure 2 – Demonstration of the video processing

Table 3 – Individual joints / body segments contained in the video program

Joint/ body segment	Movements						
Head	flexion	extension	lateral flexion	rotation			
Shoulder	flexion	extension	abduction	internal rotation	external rotation	horizontal abduction	horizontal adduction
Elbow	flexion	extension	pronation	supination			
Wrist	dorsiflexion	palmar flexion	radial duction	ulnar duction			
Torso	flexion	lumbar extension	thoracic flexion	thoracic extension	rotation	lateral flexion	
Hip	flexion	extension	abduction	adduction	internal rotation	external rotation	
Knee	flexion	extension					
Ankle	dorsiflexion	plantar flexion	inversion	eversion			

5 CONCLUSIONS

The main objective of the project, to create methodological material in the form of a video program, was fulfilled. Video program is comprehensive, well-arranged, illustrative and user friendly. After its complete finalization, the video program will be placed in the study aids (Moodle, Courseware) of various subjects of the Center of Physical Education and Sport, Faculty of Education, University of West Bohemia.

Using the methodology contained in the video program, we are going to find out and compare the flexibility of athletes from different sports. Some sports (especially aesthetic-coordination) emphasize a larger range of joints and others, on the other hand, reduce the flexibility of some joints by one-sided loading. At present, measurements are being carried out on athletes who carry out water sports (swimming, synchronized swimming) and on basketball players. In the future, we would like to compare

the flexibility of women and men, as well as different age categories (children, adolescents, adults and seniors). We are going to compare the sporting and non-sporting population, individuals with sedentary job and those who are exposed in the work process to one-sided repetitive movement (belt production, etc.). We are aware that the joint range of motion is not only given by the passive movement in the joint, but also by the functional condition of the muscles surrounding the joint. Therefore, following the created video program, we would supplement our research with elements based on a muscle test, i.e. testing of tonic (shortened) and phasic (weakened) muscle groups around measured joints, so that we get a comprehensive picture of the flexibility of athletes and other target groups.

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