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Application of the Computerized Functional Diagnosis System with the Sensor Wiva® Science in the Evaluation of the Effectiveness of Rehabilitation of Patients with Back Pain Syndrome

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Abstract. An assessment of patients' functional state, performed in accordance with rehabilitation results objectivization methods, supports the diagnosis of patients' health and allows to plan and implement the most effective therapeutic strategy, as well as to monitor progress of the rehabilitation process, which increases patients' chances for recovery. Objectivization of functional diagnostics is also carried out through the selection of appropriate research methods and tools. Intensive development of rehabilitation requires the use of modern, objective diagnostic methods. The aim of this paper is to assess the usefulness of a computerized functional diagnostics system with the Wiva® science sensor in the diagnostics and assessment of rehabilitation effects in patients with spinal pain syndromes. The method of measuring spine mobility described in this article has a great potential, due to the use of the Wiva® science sensor computerized functional diagnosis system. The system, combined with Biomech software, may be used for objective and precise functional analysis of joints and spine in active and passive exams. It may also be used in physiotherapy, orthopedics and neurology, in the activation process, as well as in multidirectional and objective assessment of motor performance in children, adolescents, the elderly, and athletes. It is an excellent aid in developing rehabilitation programs. It is also an appropriate tool for widespread clinical applications, as well as other uncontrolled environments. The Wiva® Joint Mobility protocol is a simple, fast, accurate and reliable tool used to monitor progress of treatment/rehabilitation of patients with joint or spine mobility disorders; hence, its usefulness in clinical practice is high. The development of objective diagnostic methods used in monitoring the progress of treatment will undoubtedly contribute to further improvements and higher effectiveness of the implemented therapeutic programs.

Keywords: rehabilitation, physiotherapy, computerized functional diagnosis system, Wiva® science sensor, objectivization, diagnostic methods, computer measuring devices, spinal mobility, Evidence Based Medicine

INTRODUCTION

Rehabilitation of patients with spinal pain syndromes is still a current and debatable issue. Many researchers are looking for effective non-pharmacological treatments confirmed with high-quality scientific research, which would promote development and improvement of physiotherapeutic methods [1, 2, 3, 4, 5, 6].

A separate issue is the clinical assessment of biomechanical body parameters, which is essential for the rehabilitation and prevention of musculoskeletal system diseases. Properly performed assessment and analysis of patients' functional status allows to plan and execute the rehabilitation process, as well as to control its progress [7]. It is very important to apply objectivization of rehabilitation results in clinical practice during the diagnostic and therapeutic process [8, 9]. In the field of functional diagnostics, accurate, effective and objective measuring tools are necessary [10], as a series of tests needs to be conducted. Methods limited to viewing or simple clinical observations of a patient are subjective and thus prone to errors, whilst the result is often dependent on the examiner's experience

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[9]. A number of methods fail to solve the above-mentioned problem. Modern physiotherapy research should be carried out with an appropriate method which meets the following requirements: is objective (able to register certain parameters that can be converted into absolute values); is reliable in measurements (sufficiently eliminates the phenomenon of so-called 'posture stability') [11]; is accurate, precise, repeatable and comparable; is easy to use in various conditions; takes up little time and is not expensive [8, 9, 10]; is based on clinical guidelines, is patient-oriented and reflects patients' aims and preferences (*goal setting*), and executed in accordance with the rules of *Evidence Based Medicine* (EBM) [12]. A method fulfilling the above-mentioned conditions may be widely used in mass studies and rehabilitation, where subsequent measurements (exams) must be compared with each other to assess the effectiveness of therapy. The results of such research allow for rational and beneficial therapeutic decisions. Modern, objective diagnostic methods of spatial motion analysis [13, 14, 15, 16] are particularly useful for such assessments. These methods include computerized measurements of spine mobility in diagnostics of patients with musculoskeletal disorders.

The analysis based on the observation, measurement and description of the spine movement parameters is an indispensable component of the clinical trial [17], especially when the symptoms of the disease are related to the musculoskeletal system. Measurements of spinal mobility may be taken with a standard goniometer [8, 19] or with modern kinematic evaluation tools [14].

The aim of this paper is to assess the usefulness of a computerized functional diagnostics system with the Wiva® science sensor in the diagnostics and assessment of rehabilitation effects in patients with spinal pain syndrome.

MEASUREMENT METHOD

The computerized functional diagnostics system with Wiva® science sensor has been tested and approved by the Rizzoli Orthopedic Institute (Bologna).

The Wiva® sensor is a device necessary to perform functional tests. Obtained parameters allow to analyze the progress of rehabilitation and training with software (protocols). System's construction enables connecting the Wiva® sensor to a computer via Bluetooth (wireless connectivity), which allows for the use of the Biomech Studio software [20].

Studies on the functional assessment with the Wiva® system meet all basic scientific criteria: they are valid due to the existence of an external standard, and they are repeatable and reliable, which means that the variability of the observer and device is kept to a minimum [8, 9, 10]. Wiva® system also helps evaluate the progress of patient's rehabilitation, as well as patient's condition after treatment [14, 15].

Wiva® Joint Mobility protocol is designed for an objective and precise functional analysis of joint and spine mobility in active and passive exams.

This innovative solution ensures automatic measurement of angular motion in the anatomical planes of particular sections of the musculoskeletal system and eliminates measurement errors resulting from the subjective assessment of the diagnostician during manual goniometry. During online measurement, movements are recorded in all planes, which helps quantify the degree of compensation during movement in each direction.

The Wiva® science system enables quick measurements of the range of motion without advanced skills required for traditional goniometry. Automatic recording of angular measurements eliminates the need for manual reading and saving measurement results.

The procedure for joint mobility tests with the Wiva® Joint Mobility protocol is carried out as follows:

1. Placing the Wiva® sensor and stabilizing the patient properly;
2. Start of data registration;
3. Fixed position of the patient for 4 seconds;
4. Movement of a given body part throughout its range of motion;
5. Determining the upper limit of range of motion;
6. Completion of data registration;
7. Recording of the results [20].

The patient's initial position during the test is a key element of the goniometry, since it is used as a zero position and helps stabilize the proximal joint segment. In the Wiva® Joint Mobility protocol, a series of initial positions has been developed to perform the following test procedure: *A series of the recommended testing positions*:

1. Placing the joint in the initial position of 0 degrees;
2. Executing the movements throughout the whole range of motion;
3. Ensuring stabilization of the proximal joint segment [20].

An objective examination of spine mobility with the Wiva® science sensor requires movement of the subject in all possible directions and ranges: bending forward in a standing position and leaning backwards, bending to the left and right side in a standing position, as well as rotational movement to the left and right in a sitting position with arms folded on the shoulders. This test helps assess the range and quality of movement. Patient's movement is fully controlled and protected by a physiotherapist, up to the pain limit; its intensity is assessed with VAS scale.

During all tests, generally accepted research methods for musculoskeletal examination should be followed [17], and special attention should be paid to: correct settings and careful placement of the Wiva® Science Sensor, pelvis stabilization, knee extension, appropriate conditions during the test (room temperature 20-22°C, adequate lighting, minimum room area of 20 m²), adherence to the research methodology recommended by the device's constructor and generally accepted principles and structures for conducting physical examination in accordance with the recommendations of the Polish Society of Physiotherapy, Polish Society of Family Medicine and the College of Family Physicians in Poland in the field of physiotherapy of spinal pain syndrome [5].

RESULTS

The examination of joint range of motion consists of determining the angular value of the maximum possible deflexion from the so-called intermediate zero position. The assessment of physiological norms of spinal mobility may follow the guidelines of the constructor of the Wiva® Science sensor or the American Academy of Orthopedic Surgeons [21] and Magee [22]. Correct ranges of spine motion in individual sections are presented in Table 1.

According to Kapandji [23], the range of axial rotation of the whole spine between the pelvis and the skull may reach or even slightly exceed 90˚. The cervical spine is the most mobile section of the entire vertebral column [24]. While extending, the forehead should be in a horizontal plane, parallel to the ground; during bending to the side it should reach an approximate angle of 45˚, and during rotation 90˚ [25]. Subject-matter literature presents disparate data on the parameters listed in Table 1. According to some researchers [23], the total range of flexion-extension movement in C0-C7 segments is as much as 100-125˚, with the lower section (C2-C7) contributing to 80-110˚. Between the ages of 30 and 70, the range of movements in individual joints is reduced by 20-50% [26]. Limited mobility in the joints leads to major difficulties in many everyday activities. Reduced range of motion in the joints usually accompanies severe spine pain [27, 28].

TABLE 1. Correct ranges of spine mobility in the cervical and lumbar section [20, 21, 22]

Active motion	Normative ranges of spine mobility			
	by Wiva® Science Sensor producer		by Magee (2002) * and the American Academy of Orthopedic Surgeons **	
	1	2	1	2
Neck: Flexion-Extension	45	55	80-90*	70*
Neck: Bending to the side	45	45	20-45*	20-45*
Neck: Rotation	70	70	70-90*	70-90*
Spine: Flexion-Extension	90	30	80**	80**
Spine: Bending to the side	30	30	35**	35**
Spine: Rotation	40	40	45**	45**

Interpretation of results always requires consideration of the following elements: sex, age, body posture, pathologies or injuries (if any), individual's physical activity, ambient temperature. Physical activity is an independent factor which determines flexibility better than gender, age and body type [29, 30, 31, 32]. Flexibility may be developed with special stretching exercises (*stretching program*) [33], yoga [1, 34, 35], as well as through dance [36], *tai-chi* [1], Pilates [37], and exercises in the water [38].

CONCLUSIONS

Practical verification confirmed a great potential of the Wiva® science sensor computerized functional diagnostic system. The Wiva® science sensor Joint Mobility computerized functional diagnostic system, combined with Biomech software, may be used for objective and precise functional analysis of joints and spine in active and passive examinations. It is consistent with research on objectivization of rehabilitation results, including spinal pain syndrome. It may also be used in physiotherapy, orthopedics and neurology, in the activation process, as well as in multidirectional and objective assessment of motor performance in children, adolescents, the elderly, and athletes. It is an excellent aid in developing rehabilitation programs.

The computer functional diagnostic system with the Wiva® science sensor is an appropriate tool for widespread clinical applications as well as other uncontrolled environments. The Wiva® Joint Mobility protocol is a simple, fast, accurate and reliable tool used to monitor progress of treatment/rehabilitation of patients with joint or spine mobility disorders; hence, its usefulness in clinical practice is high. The development of objective diagnostic methods used in monitoring the progress of treatment will undoubtedly contribute to further improvements and higher effectiveness of the implemented therapeutic programs.

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