Medicine and Medical Sciences 7(7): 087-091, July 2019
DOI: 10.15413/mms.2019.0113
ISSN 2682-5759

Research Paper

Kinematic analysis of lesions in lower parts of the spine during breaststroke swimming - implications for physiotherapists organizing therapy in water

Accepted 26th July, 2019

ABSTRACT

Swimming is clearly recommended for people with lower back pain. Usually, however, front or the back crawl is recommended for patients with lower back pain. However, the electromyographic research on abdominal muscles shows that exercises with resistance of a symmetrical effect prevent pain in the lumbar spine. Swimming breaststroke rarely is consistent with medical ordination. It was assumed that in patients with posterior derangement (McKenzie classification), swimming back extension (hyperextensions) can serve as supportive treatment. The aim of this study was to determine the actual range of motion of the hyperextended spine while swimming in recreational breaststroke style. The study involved 15 people. The film method and the SIMI Motion software were used to monitor the movement of the spine in the water. Six active markers in the form of light-emitting diodes reflecting spine were placed on the side of the subject's body. Markers formed a line connecting the axis of the hip with the axis of the glenohumeral joint. The purpose was to cross backstroke stretch of 25 m. The evaluation of the degree of the spine hyperextension during recreational swimming breaststroke was based on the value analysis of the angles included between the markers. Analytical procedures consist in calculating extremes and average standard deviation for each angle. Five repetitions of the measurement were adopted for every person tested , which in further procedure allowed to calculate that the average standard deviation of the angle values at each point in time is within the range of ABC <1.7; 9.7>, BCD <1.2; 5.5> and CDE <2.6; 8.0> in order to obtain the actual value of the angle for each individual arithmetic mean value of the angle for successive time points after five attempts was calculated. The study showed that in all patients, hyperextension was contained within the range of 14° to 19.4°. The maximum range of hyperextended motions obtained during the test is within the physiological limits. Hyperextensions can be considered as a supportive treatment of the posterior derangement at which the treating motion under the land conditions is hyperextension in both supine and standing position.

Key words: Kinematics; Lumbar spine, Range of movement, Lower back pain, McKenzie method, Aquatherapy.

Grzegorz Konieczny[1*], Krystyna Antoniak-Lewandowska[2], Daria Rudnik[2] and Piotr Synowiec[3]

[1]Faculty of Health Sciences and Physical Education, Witelona State University of Applied Sciences in Legnica, ul. Sejmowa 5A, 59-220 Legnica, Poland.
[2]Unit of Swimming, University School of Physical Education, Wroclaw, Poland.
[3]Faculty of Mechanical and Power Engineering, Wroclaw University of Technology, Poland.

*Corresponding author. E-mail: gkonieczny@wp.pl.

INTRODUCTION

The buoyant force operating in the aquatic environment allows motion exercises to be much easier to perform in water than on land. The movement in water, especially warm, leads to reduction of muscle tension and stretching of contracture fascia (Adstrum et al., 2017; Schleip et al., 2005; Stecco and Schleip, 2016). The mentioned factors are the reasons that kinesitherapy in water is preferred even by people with low swimming skills. However, the maximum

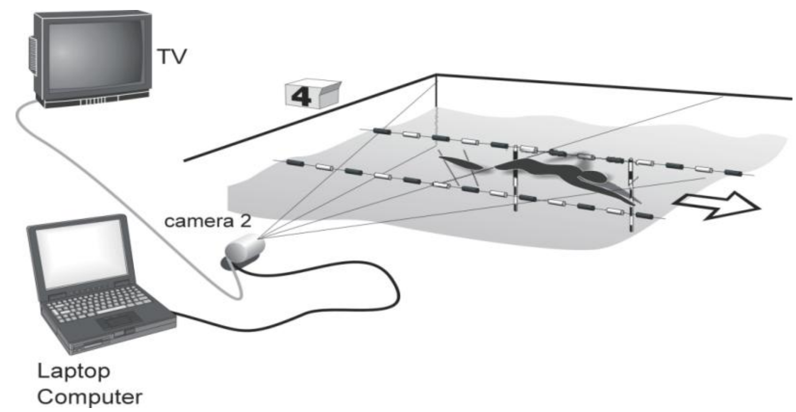

Figure 1: The track measurement scheme.

use of the aquatic environment for therapeutic purposes is allowed, when the human body is completely relieved and has no contact with the bottom. Therefore, the locomotion in water in a horizontal position is the optimal solution, even for people who can swim only in breaststroke commonly called a "frog style". In the breaststroke style, the movements of upper and lower limbs are performed simultaneously under the water surface (Sanders et al., 2015). We distinguish at least three ways to solve the same motion task in water: the professional breaststroke, rescue breaststroke with a head above the water, and the recreation breaststroke. The breaststroke in a professional version has a very complex structure and coordination of movements, which is determined by the FINA swimming rules (Mills et al., 2015; Conceição et al., 2014). At the professional level with a very fast swimming, a large hydrodynamics resistance is generated, which can overload the motion system, mainly due to the wavy motion of the human torso and strong dynamics of the motion cycle, which allows to obtain significant acceleration (Seno et al., 2013; Strzala et al., 2015).

The popular recreational "frog style", has relatively little to do with a modern technique of the breaststroke. This way of swimming is characterized by the arrangement of the body at a slight angle with respect to the level of water and the movements performed at low speed. Due to a high popularity of this method of movement in water by people that use swimming in their rehabilitation or recreational purposes, we decided to look more closely at this problem. For persons with a back pain in the lumbar section, swimming is clearly recommended in the literature (Cole and Herring, 1997). However, in the majority of cases, it is advisable to swim in the so called "long axis" styles, that is, front crawl or backstroke. Breaststroke and butterfly are not recommended due to its rotation in the transversal axis of the body (Cole and Herring, 1997). However, the electromyographic testing of the abdominal muscles showed that exercise with a resistance of a symmetrical characteristic, which without doubt is breaststroke style, prevents the pain effect in the lumbar section of the spine (Szpala et al., 2014; Rutkowska-Kucharska et al., 2009). Swimming breaststroke is rarely consistent with the medical ordination, therefore it was assumed that the occurrence of back extensions (hyperextensions) while swimming is not harmful for persons with posterior derangement (by McKenzie classification) (McKenzie, 2003; McKenzie, 2006), and can serve as supportive treatment.

Therefore, the aim of this study was to determine the actual range of hyperextension motion of the spine while swimming breaststroke.

MATERIALS AND METHODS

The research comprised 15 people, 6 women and 9 men (aged 21.94±3.47, average weight 61.88±8.25, average height 165.63±9.62) who swim breaststroke at the non-professional level. The criterion for inclusion in the research group was a lack of faulty posture.

The research was conducted in the indoor swimming pool with dimensions of 25 m × 16.5 m and depth of 1.4-1.8 m. To monitor the way the motion task is performed in the water, a filming method was used with a specialist software - traffic analysis computer system SIMI Motion. The research was conducted using a Sony digital video camera that records with a frequency of 50 frames/s. The camera was mounted on the wall of a swimming pool basin on a fixed tripod. The optical axis of the camera was perpendicular to the subject. The camera had a system that allows constant monitoring from under the water. The calibration system was represented by a rigid rectangle with dimensions of 1 × 2 m with a contrasting, black and white tags of a length of 20 cm each. These tags supported the calibration control of a video camera during the video footage editing (Antoniak-Lewandowska, 2007) (Figure 1). The prototype of the test apparatus belongs to the laboratory of The Department of Swimming at University School of Physical Education in Wroclaw, which holds a Quality Management System certificate No. 1374-d / 2/2009, PN - EN ISO 9001: 2001.

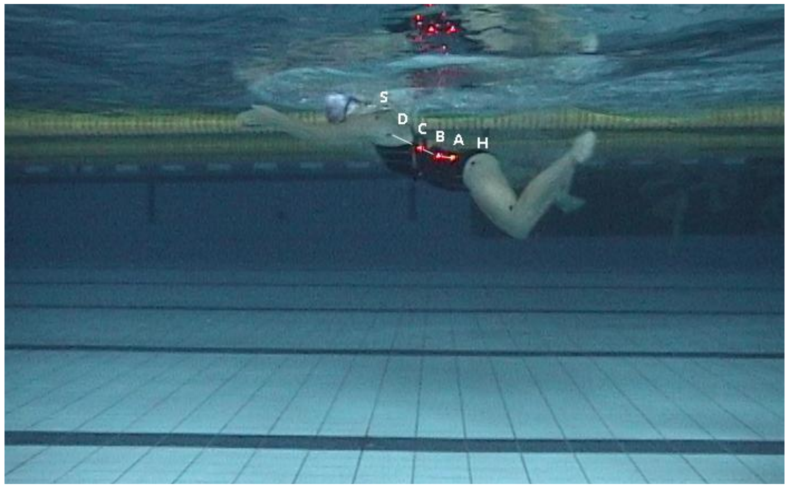

Figure 2: Method for placing markers on the subject's body.

The research material was recorded by filming people while swimming breaststroke. For measuring purpose, 6 markers were set with a diameter of 5 mm, at a distance of 10 cm each on the side of the subject's body from the camera view. The active markers with LEDs were used in the research (Renschmidt, 1997). Markers are indicated by the letters H (hip), A, B, C, D, S (shoulder), and form a line connecting the axis of the hip joint with an axis of the shoulder joint. The number and positioning of markers provided an optimum level of the recorded data (Figure 2).

The task of the examined person was to leisurely swim breaststroke on a distance of 25 m. Each examined person performed five attempts. The results of the experiment were drawn down during measurement. The information boards indicating the number of attempts and the number of the examined person were filmed in each attempt. One complete cycle was recorded exactly perpendicular to the optical axis of the camera and chosen for further analysis in SIMI software. Such procedure has excluded the parallax error, that is, object deformation associated with its remoteness from the axis of the lens. Biomechanical measurements based on the filming method should take into account the uncertainty of measurement of the video recording. The random error of the marker placing and moving it to other biomechanical parameters is largely difficult to quantify; therefore in further proceedings, smoothing procedure for marker path during time was applied. The degree of the compensation of this error depends on these procedures. Taking into account factors that are included in the measurement error, which results from the designation of the image and the precision of the marker placing on the body of a subject, an angle measurement error in the sagittal plane was 4° (Karlsson and Lundberg, 1994).

Since the measurement of the curvature of the spine in an upright position may differ from the corresponding measurement in the water (due to lack of a point of support), it was assumed that the position of the person examined in the water during so-called slip - that is a part of the movement cycle - is a neutral position for each examined person for all observed points. Therefore, every change of angle values for each angle was measured from zero point, which determines the reliability of the measurement. Under this assumption, the flexion movements had positive angle values, and straightening movements had negative values. The negative signs were omitted during calculations of the angle range.

RESULTS

The evaluated degree of the retroverted spine during breaststroke was based on the analysis of the angles between markers located on the side of the subject's body. Markers formed angles ABC, BCD, CDE in the sagittal plane and reflected a spine projection in the following sections: lumbar, lower and upper thoracic. The analytical procedures involved the evaluation of extremes and the average standard deviation for each angle. For each examined person, there were adopted series of five repetitions of the measurement, which in further procedure allowed to calculate that the average standard deviation of the angle values at each point in time is within the range of ABC <1.7; 9.7> BCD <1.2; 5.5> and CDE <2.6; 8.0>.

To maintain the accuracy of the statistical analysis, the following activities were performed:

a) The initial position of the spine was assumed at t = 0 s for each examined person

b) No repeatability was assumed for any element of the movement in the cycle

c) It was calculated the average value of the angle for the same point in time when Δt=0.02 s from among the five trials of each examined person (Ryguła, 2005).

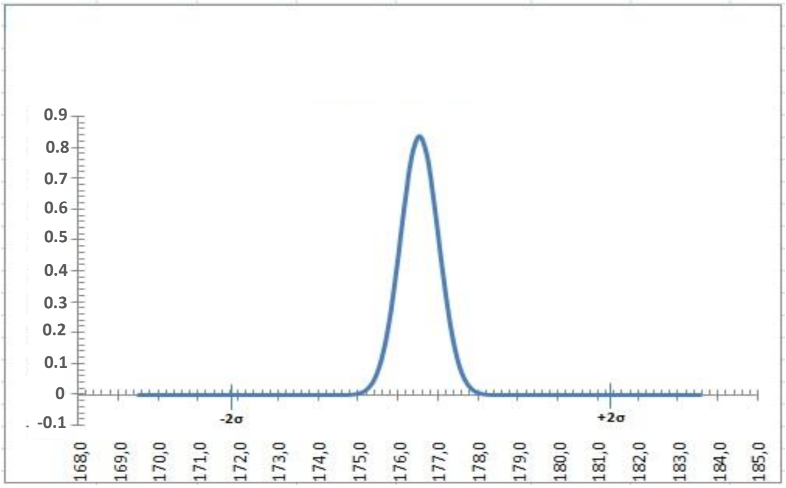

Figure 3: The density of the normal distribution for average ABC angle N(176.5°; 0.48].

To obtain the actual value of the angle, the arithmetic mean of angle values was calculated for each individual in successive time points in five attempts. The obtained values were used to calculate the arithmetic mean of the angle values for all examined persons.

The second table contains the mean of extreme values of the measured angles and range of motion in the individual sections of the spine, which may provide the basis to the creation of standards for the retroverted spine for considered age group with the applied calculation procedure.

An analysis of measuring uncertainty confirmed the correctness of the performed measurement procedures and allowed to eliminate gross errors related to the truncation error and random errors. All the results obtained in calculations are within range of expanded uncertainty with the confidence level P (t) = 0.9545.

The density of the normal distribution determines the probability of the occurrence of the angle value within a specified period (Figure 3). Marked points ± 2σ are the boundary with more than 95% confidence level of the occurrence of a given range. This does not preclude the occurrence of values outside the range of ± 2σ. Each average angle value for a particular unit of time, where Δt = 0.02s in a cycle is consistent with the assumptions $2\bar{\sigma}$ for a normal distribution of the expanded uncertainty analysis. This means that the probability of the occurrence of a result outside the concerned range is equal to 1-P (t), therefore at a finite number of measurements, the probability of obtaining false results is approx. 4.5% (Taylor, 1982).

DISCUSSION

The conducted research showed that the hyperextension was included with a range from 14° to 19.4° for all examined persons. This means that during recreation breaststroke, the motion range in observed segments of spine is with the physiological motion range of the lumbar spine with a ratio of 60˚ for flexion movement, 25° for straightening movement, 25° for lateral flexion and 30° for rotation movement (Ng et al., 2002).

The confirmation of the validity of our research is similar to the observations by a team of Belgian researchers who used a video-digitizing system for evaluating the different options for breaststroke swimming (Colman and Persyn, 2000). Filming underwater supplemented by a computer animation allowed to determine which aforementioned variant of breaststroke is exposed the most to the occurrence of pain in the lower spine. The analysis of a breaststroke technique at professional level which provides large hydrodynamics resistance confirmed the occurrence of a pain in the lumbar spine, with a hyperextended reaching 30°, that is, above normal physiological. The same research showed that the effect of a pain also occurs when swimming rescue breaststroke with the hyperextended in the range of 21˚do 26˚. This occurs in the situation such as during motion cycle when head is above the water and feet finish its movement over the long axis of the body. During professional swimming, the effect of pain can be generated by a dynamic, sinusoidal movement of the whole body when the spine is involved, and large hydrodynamic resistance resulting from high speed swimming with a very large range of motion. However, during the rescue swimming, when the head must be constantly above the water level, it also can occur temporarily, excessively and beyond the physiological limits in the hyperextension of the spine, which can cause pain effect resulting from a repetition of the motion cycle. The above-mentioned situations do not occur during recreational swimming, which has a long slip phase, during which the body position in the water coincides with the long axis of the body and results in the spine extension. Both research cited by us as well as our measurements confirm the fact that during recreational breaststroke in a group of healthy subjects the pain effect does not occur.

It has to be recognized that the hyperextension of the spine or extend in the sagittal plane occurs occasionally in everyday life, while in swimming, which is a cyclic activity, multiple hyperextension of the spine within the physiological limits are not harmful, and may even have a therapeutic effect.

The data shown in Table 2, which are result of a very thorough mathematical procedures, can be the basis for creating a standard of a retroverted spine while swimming breaststroke for the age group with a range of 18-25 years.

The authors of the present study have in mind the fact that the complete picture of the information confirming the therapeutic effects of swimming breaststroke will be obtained when the conducted research will be complemented by an electromyography of muscles involved in movement in the water. The desirability of such proceeding is indicated by research that combine muscle electromyographic recording with the measurement of the angular velocity of the knee during simple flexion and extension movement (Pöyhönen et al., 2001). The aim of this research was to assess the actual therapeutic effects commonly used in the aquatic environment during simple rehabilitation exercises. The research have shown that the effectiveness of the exercises in the aquatic environment depends on many factors such as the type of the task, method of its implementation, the water temperature and the fact whether it is either standing or flowing water. Therefore, planning the type of therapeutic exercises in water should take into account the desirability of performed tasks, which determines their effectiveness.

Conclusion

The obtained maximum values of the range of hyperextension motion while swimming breaststroke remain within the physiological limits - exceeding half of its value. The hyperextension that occurs while swimming breaststroke, due to a cyclical nature of movement, can be regarded as a supportive treatment of posterior derangement (by McKenzie classification), where hyperextension is a movement based therapy under land conditions for vertical and horizontal position.

REFERENCES

Adstrum S, Hedley G, Schleip R, Stecco C, Yucesoy CA (2017). Defining the fascial system. J. Body Mov. Ther. 21(1):173-177. doi: 10.1016/j.jbmt.2016.11.003. Epub 2016 Nov 16.

Antoniak-Lewandowska K (2007). Analysis of kinematic parameters of long distance swimming, Ann Univ Mariae Curie-Skłodowska Sect. D Med. 62: 35-9.

Cole AJ, Herring SA (1997). The low back pain handbook: a practical guide for the primary care clinician. Hanley &Belfus, Philadelphia.

Colman V, Persyn U (2000). Biomechanical Analysis of Low Back Pain in Breaststroke Swimmers, Int. Sport Med. J. 1 (4): 1-10.

Conceição A, Silva AJ, Barbosa T, Karsai I, Louro H (2014). Neuromuscular fatigue during 200 m breaststroke. J. Sports Sci. Med. 13(1): 200-10. eCollection 2014.

Karlsson D, Lundberg A (1994). Accuarcy estimation of kinematic data derived from bone anchored external markers. 3rd Int. Symposium on 3-D Analysis of Human Motion, Stockholm, Sweden. Pp. 4 - 8.

McKenzie R (2003). The lumbar spine: mechanical diagnosis and therapy. Spinal Publications New Zeland Ltd.

McKenzie R (2006). Comments on a systematic review of the McKenzie method. Spine (Phila Pa 1976), 31(22):2639; author reply 2639-40.

Mills C, Lomax M, Ayres B, Scurr J (2015). The movement of the trunk and breast during front crawl and breaststroke swimming. J. Sports Sci. 33(4):427-36. doi: 10.1080/02640414.2014.946951. Epub 2014 Sep 5.

Ng JKF, Richardson CA, Kippers V, Parnianpour M (2002). Comparison of lumbar range of movement and lumbar lordosis in back pain patients and matched controls. J. Rehabili. Med. 34: 109-13.

Pöyhönen T, Kyröläinen H, Keskinen KL, Hautala A, Savolainen J, Mälkiä E (2001). Electromyographic and kinematic analysis of therapeutic knee exercises under water. Clin. Biomech. 16 (6): 496-504.

Renschmidt C (1997). Tibiocalcaneal motion during running measured with external and bone marked. Clin. Biomech. 12: 8-16.

Rutkowska-Kucharska A, Szpala A, Pieciuk E (2009). Symmetry of muscle of activity during abdominal exercises, Acta Bioeng. Biomech. 11(1): 25–30.

Ryguła I (2005). Research process in sports sciences., AWF, Katowice.

Sanders RH, Fairweather MM, Alcock A, McCabe CB (2015). An approach to identifying the effect of technique asymmetries on body alignment in swimming exemplified by a case study of a breaststroke swimmer. J. Sports Sci. Med. 14: 304-14.

Schleip R, Klingler W, Lehmann-Horn F (2005). Active fascial contractility: Fascia may be able to contract in a smooth muscle-like manner and thereby influence musculoskeletal dynamics. Med. Hypotheses. 65(2): 273-7.

Seno T, Funatsu F, Palmisano S (2013). Virtual swimming--breaststroke body movements facilitate vection. Multisens Res. 26(3): 267-75.

Stecco C, Schleip R (2016). A fascia and the fascial system. J. BodywMov. Ther. 20(1):139-40. doi: 10.1016/j.jbmt.2015.11.012. Epub 2015 Nov 23.

Strzala M, Stanula A, Głab G, Glodzik J, Ostrowski A, Kaca M, Nosiadek L (2015). Shaping physiological indices, swimming technique, and their influence on 200m breaststroke race in young swimmers. J. Sports Sci. Med. 14(1):110-7. eCollection 2015.

Szpala A, Rutkowska-Kucharska A, Drapala J (2014). Electromechanical delay of abdominal musclesis modified by low back pain prevention exercise, Acta Bioeng. Biomech. 16: 3. DOI: 10.5277/abb140311

Taylor JR (1982). An Introduction to error analysis, University Science Books Mill Valley, California.

Cite this article as:

Konieczny G, Lewandowska KA, Rudnik D, Synowiec P (2019). Kinematic analysis of lesions in lower parts of the spine during breaststroke swimming - implications for physiotherapists organizing therapy in water. Med. Med. Sci. 7(7): 087-091.