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AN EVALUATION OF KINESTHETIC DIFFERENTIATION ABILITY IN MONOFIN SWIMMERS

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ABSTRACT
Purpose. The aim of this study was to compare the ability of monofin swimmers in reproducing the bending forces that act on a monofin's surface through the specific leg movement present in swimming as well as the forces that the swimmers generated on a kinesthesiometer as part of a dry-land simulation trial. **Methods.** Six men, members of the National Monofin Swimming Team, took part in the study. The level of the swimmers' kinesthetic response was defined by examining their repeatability in producing the bend forces that act on a monofin's surface as a reaction to water resistance and by investigation on the pressure force generated by a swimmer's lower limbs during dry-land tests on a kinesthesiometer. **Results and conclusions.** It was established that a high level of kinesthetic response, estimated in the group of monofin swimmers, was the result of an adaptation evoked from the specificity of their sensory stimulus perception, received in the form of feedback from the monofin's large surface area.

Key words: swimming, monofin, kinesthetics

Introduction

The term kinesthesis refers to the ability to perceive bodily movement as well as the movement of specific segments of the human body. Kinesthesis is associated with the concept of spatial attitude, it is generally understood as a lasting and unchanging attribute of healthy humans [1] and is considered to be an additional sense, whose use does not require conscious participation [2]. An analogy between kinesthetic and sensual perception is paradoxically inclined towards the opinion that the perception of position and spatial body movements are a process emanating from learned experience. An example could be the differentiation between scent and taste when recalling sensory impressions from the past. A similar basis exists in the development of balance through the perfection of various forms of locomotion during the ontogenetic development of a human being (from crawling to balanced walking). By accepting the above arguments, discussion can be permitted on the adaptive movement of the human being as a process that makes physical activity possible, i.e., through the engagement of individual motor abilities as well as the kinesthetic transformation of one's own body. Treating kinesthetics as an adaptive process, controlled by humans, is crucial in understanding the issue undertaken in this study.

Within the aspects of didactics (undertaken in the study herein) it seems crucial that attention be paid to the role of conscious and controlled kinesthetic perception within the process of learning and teaching motor skills. Kinesthetic perception, which occurs during changes of tension force and muscle length, as well as in the quickness of these changes, is treated herein as an indispensable, polysensoral element when encountering new movement activity. Peripheral receptors, which are central in the supply of information related to the positioning of specific body parts, are composed of proprioceptors, found in the structure of muscle, ligaments, fascia and joints (nero-muscular spindles), as well as mechanoreceptors and skin, which all react to pressure, touch and vibration (Meissner's corpuscles). As described in previous research, the mechanism for forming movement sensation in humans distinguishes receptors and single-track activity, being responsible for individual bodily perception and movement, as well as two-track control of both forms of information simultaneously [3]. It likewise demonstrates a dependency between the perception of touch and kinesthetic sense, as well as the individual ability to control these sensations [4–6]. Movement perception is then an undisputed factor regulating the process of control of movement behavior, whether within the confines of one joint or the complicated coordination of a series of sequential movements [5, 7].

A measure of the efficiency of kinesthetic sense is movement response – identified as kinesthetic sensitivity. Individual kinesthetic sensitivity is connected with the phenomenon of kinesthetic memory [8]. Kinesthetic memory is associated with the cerebellum, which is responsible for movement planning and muscle tension [9]. The role of the brain stem is also relevant in the formation of kinesthetic sense [10]. Thanks to kinesthetic memory, the peripheral and central nervous

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system controls the activity of the muscles and generates additional indicators that were collected in previous motor experiences [11, 12]. However, according to some physiologists, kinesthetic information is employed by humans as unconscious information. Some existing research implies that conscious orientation towards its perception (as a result of concentration and an adequate mindset) might trigger specific sensations. These sensations improve the efficiency of learning (the teaching process) [13, 14] because they are necessary in the formation of movement imagination, which itself is a necessary factor in constructing the program to perform it. On the other hand, kinesthetic interaction verifies the propriety of the movement structure when performed in natural conditions [15]. Such a statement can be confirmed by, for example, pointing to the the irrationality of learning/teaching swimming with only dry-land exercise. Therefore, through consciously received kinesthetic interaction, one can influence not only the efficiency of the learning process or teaching motor abilities, but also their improvement in sport [14]. In a large variety of sport activities, where motor activity is performed under specific environmental conditions, the colloquial meaning of the concept of equipment "feel" or "sense" (e.g. skis, skates), base (e.g. snow, ice) or environment (aerodynamics in ski jumping or feel of the water) seems not to be accidental. The subject of this study was to focus on swimming technique, in which the "feel of the water" defines a specific and multi-aspectual type of human adaptation involving the response sensitivity of movement feeling in a water environment as well as the modification of motor behavior by control and regulation in neuromuscular coordination processes [16].

The accuracy of movement reproduction is a measure of the quality of technique and is a factor that determines competitive performance in swimming as a cyclical sport [17]. Investigation into movement precision has brought the issue of the level of kinesthetic response ability to the forefront, for they determine an individual's ability to perform multiple repetitions of torque [14]. Previous studies have shown that higher levels of kinesthetic response have an impact on improved levels of movement control. These results are of great applicational significance in sport, which is confirmed by the dependencies between the level of kinesthetic response and the level of mastering a sport [13, 18]. As such, the study presented here was narrowed down to focus on the subject of modifying swimmers' movement behavior, specifically those equipped with a monofin, by considering the effective and economic employment of it being used as a source of propulsion.

Monofin swimming technique is, according to its rules, a water-based sporting activity aimed at the efficient and economical use of a single fin surface as the main source of propulsion [7]. Monofin swimming technique consists of performing undulatory movements with particular body segments, including the chest, in the sagittal plane. The scope of these movements, whose trajectory is similar to a sinusoid curve, increases from the pelvis towards the knee and then feet. The feet are bound together by the monofin, which transmits torque generated through the legs directly to the surface of the monofin, whose surface area can be up to 0.8 m^2. The two-dimensional structure of this propulsive movement and the surface area on which reactive forces are generated (in relation to water resistance) allows the monofin to be used as the main source of propulsion by the swimmer [19].

The necessity in overcoming the water resistance generated by the monofin's large surface area causes the swimmers to receive a powerful dose of kinesthetic stimuli. Thus, swimmers who excel in monofin swimming could be characterized by having a high level of kinesthetic response ability. Therefore, the main focus of this study was the verification of such a hypothesis. Its goal was to compare monofin swimmers' abilities in reproducing the bend forces that act on the monofin, caused by the lower limb movement present in swimming, as well as compare the forces generated by similar limb movement in laboratory dry-land conditions.

Material and methods

Six male swimmers agreed to participate in the study. As members of the National Monofin Swimming Team, all of the swimmers displayed a high level of monofin swimming proficiency. In the first stage of the study, swimmers were asked to swim a distance under water by using only twelve monofin strokes; this was the only task required of the swimmers in the first part of the trials. All swimmers used the same monofin, which was specially modified for measuring the monofin's bend as a reaction to water resistance. This fin was equipped with strain gauges glued to both sides of the fin's surface, mounted where the plate connects to the boots (Fig. 1). A connection cord was used to link the parts to the measuring equipment, which was shielded for protection. The raw data collected by the gauges was expressed as a voltage change in time function, defined by the moment of direction change by the monofin when it bends due to water resistance (Fig. 1). The results of previous studies justified treating the recorded forces as the result of propulsive force that determines swimming speed [19].

The second part of the study involved dry-land imitation of the propulsive downward leg movement similar to the movement structure enacted when swimming with a monofin. The task of each of the examined monofin swimmers was to use their thighs to press a resistant lever-arm of a kinesiometer. Similar to the in-water test, the participants were to complete twelve strokes by trying to generate exactly the same pressure force used when swimming. The kinesiometer used was a prototype device constructed on a bench (160 cm in

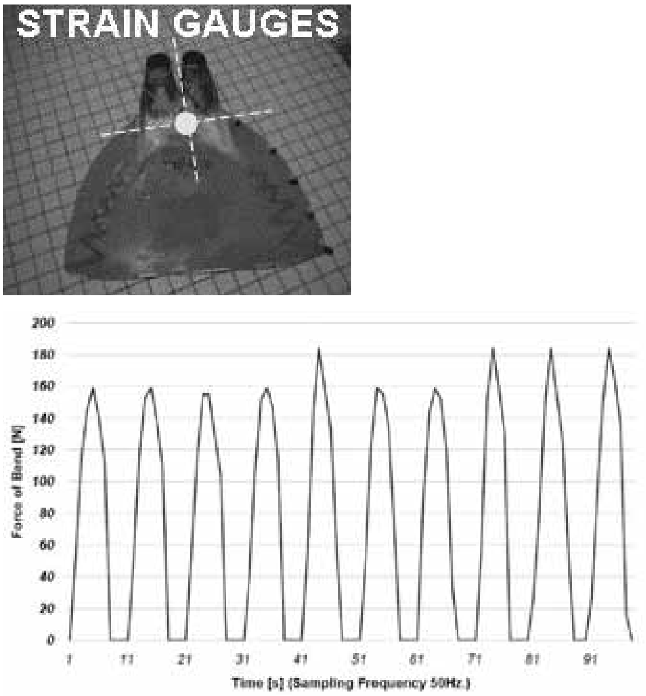

Figure 1. Pictured is the monofin used in the study, equipped with a set of strain gauges, as well as an example of the results recorded for the force (as a moment of time) that bends the monofin due to water resistance. Only the sections of the movement cycle that illustrated downward movements were analyzed; the forces registered during the upward movement phase were disregarded

length, 40 cm in width and 50 cm in height) and strengthened by a rigid permanent foot rest (Fig. 2). Strain gauges were mounted onto plates constructed of spring steel (50 HRC hardness; length 20 cm; width 5 cm; thickness 0.5 cm). The construction of the bench allows for the gauges and pulleys to be arranged in a specific position that permits the registration of the movement and forces of the particular joints of the lower limbs. Raw data was obtained in a time-dependent series, which was illustrated as a voltage change defined by the bend of the monofin's profile at the moment when pressure was registered on the measurement unit (Fig. 2). Previous studies allowed for the interpretation of these changes in the amount of torque, among a unit of time, as an effect of human consciousness on motor activity [20]. The individual ability expression to exhibit conscious response to kinesthetic sensation is based on an interpretation of the reproduction accuracy of the torque generated by the knee joint flexors, as this muscle group is of great significance when generating the propulsion used in monofin swimming [21].

All of the participants in the experiment assumed a lying position which stabilized the lower limbs (non-elastic belts attached to the bench were fixed at the hips in order to keep movement isolated to the axis of the knee joint) (Fig. 2). Stabilization of the thigh and calf allowed for the knee joint's bend angle to be precisely established, as well as eliminating any unnecessary movement other than the flexing and extending of the calf at the axis of the knee joint. All testing was carried out in static conditions. The knee joint's bend angle during the experiment was 70 degrees, which created optimal conditions to generate torque through the knee extensors [22]. Owing to the specific nature of monofin swimming, measurements were taken on both the left and right limbs. Before each measurement, three trials were carried out in order for the participants to become acquainted with the equipment.

With the aim of creating an objective premise in comparing the raw data obtained from the water and dry-land measurements, the following procedures were applied: the instructions given to the participants for both tasks consisted of only one requirement, which was to repeat each of the twelve repetitions in the in-water and dry-land tests as precisely as possible. Data that recorded the bend of the monofin during the upward movement phase (as a consequence of lower limb flexion at the knee joint) were excluded from analysis. In addition, in order to reduce random error, the first and last movement cycles were disregarded.

The original registered measurement of the moment when the monofin was bent (at a frequency of 50 Hz) was converted in order to obtain the same sampling frequency in the dry-land trials (at 100 Hz). The same strain gauges (HBM, 120 Ω K = 2.09) were used on the monofin and the arm of the kinesiometer in order to ensure a high reproduction accuracy and to maintain the shape and elasticity of the movements, regardless of the number of deformations. In both experimental trials, the stain gauges were connected in a half-bridge

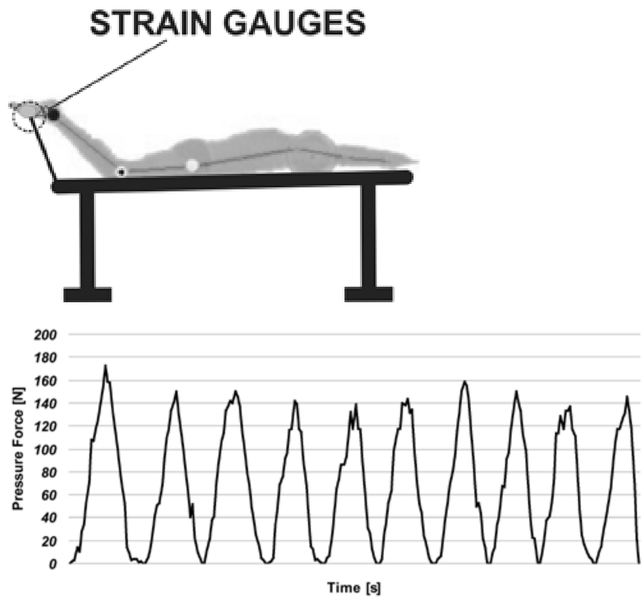

Figure 2. Pictured is the kinesiometer used in this study and an graphic example of the recording of pressure force (as a moment of time) triggered by the extensors in the knee joints of both legs

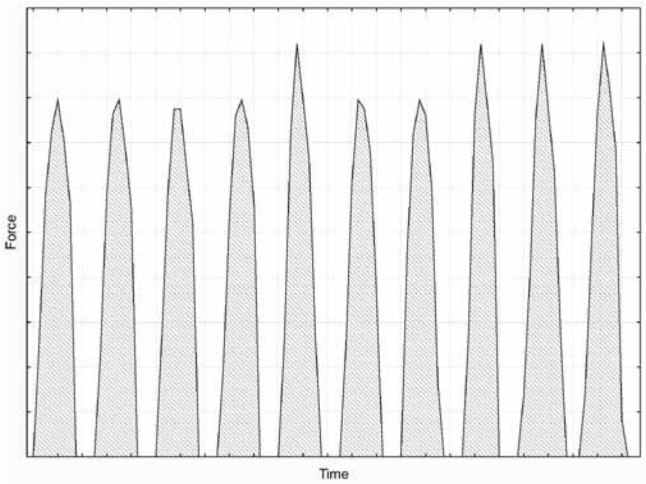

Figure 3. An illustration of the procedure quantifying the recorded forces as a function of time

configuration. The upper sensor was glued in a parallel symmetry axis to the monofin (or at the arm of the kinesiometer). The second sensor, glued at the opposite site of the measuring equipment, was perpendicular to the symmetry axis of the fin plate (or the arm of the kinesiometer). Compensatory strain gauges were used to avoid interference. During both procedures, the direct current impulses registered from the strain gauges were amplified, converted and recorded on a computer.

The following scaling procedures were employed: a five-point scale along the axis of symmetry of the fin was delineated (with the assumption that the fin plate is stiff in its longer dimension). The first point was located as near to the strain gauges as possible. The last point was placed at the rear edge of the fin. The distance between each point was found to be the same. A mass (1 kG = 9.81 N) was suspended from each scaling point separately. Next, the changes in the voltage values caused by the fin's bending at the different points were recorded. Then the mean values of the recorded voltage for each sample and scaling coefficient were calculated. The scaling procedure for the kinesiometer was carried out in the same way as mentioned above. Therefore, the recorded pressure applied to the kinesiometer and the bend force acting on the monofin are the effects of torque generated by the muscles as a function of time. In order to accurately evaluate the kinesthetic response, the values of the registered moments of time were quantified in the form of surface area, estimated from the values transcribed from the diagram of the recorded moments (Fig. 3).

On this basis, an evaluation of a swimmer's kinesthetic response abilities was carried out by using a Repetition Accuracy Factor (RA) at the moment of bend force acting on the monofin's surface during swimming, and similarly, the Repetition Accuracy Factor (RA) for moments of pressure acting on the kinesiometer [3], given by the equation:

$$RA = \sqrt{\frac{\sum_{i=1}^{10} (\bar{M} - Mi)^2}{10}} \qquad (1)$$

where:
M – is the mean value of the moments of the recorded forces and,
Mi – as the moment of the registered forces in the i sample.

The RA factor values were expressed by using a point-based scale describing error level. Lower RA values correspond to a higher level of kinesthetic response abilities. A RA equaling zero denotes a minimal accuracy error value in repeating the moments of pressure forces generated in the dry-land test and at the moment of bending the monofin's surface during real swimming. The RA factor (being dimensionless) used in this study defines the swimmer's individual ability in precisely repeating the force when generating propulsion during swimming [20].

In addition, the anthropometric parameters of the tested swimmers (body height and mass) were measured and found to have significant correlation with the results obtained during the trials. The value of the Pearson's correlation coefficient between body height and the value of the RA factor during the water trials equaled $r = 0.81$, while in the land trials it was found to be $r = 0.86$. The value of Pearson's correlation coefficient, between body mass and the RA value for the participants was the same ($r = 0.91$) on land as in water. The critical correlation coefficient for $n = 6$ amounted to $r = 0.81$ ($p = 0.005$). On the basis thereof, it can be assumed that the somatic parameters of the group of swimmers tested had no impact on the obtained results. This fact, when considered together with the overall high level of the participants (as being members on a national team) allows the group to be considered homogenous.

The information presented above leads to confidence in the reliability of the testing procedures as well as on the objective nature of this study's preliminary analysis. It was hoped that all the conditions for eliminating the risk of error during data collection were met. In addition, the construction of the measuring equipment, as well as its calibration, were done in such a way as to minimize the influence of error on the quality of the input data. This is especially pertinent as they served to analyze the process (the repetition of kinesthetic perception) and did not form a basis for analysis, in which the most relevant was the individual value of the main research parameter (as the RA value itself is non-dimensional). The entire study was conducted by using the employed research procedures fulfilled by ISO-9001–2001 quality standards, while the methods used in this study have attained the full acceptance of the scientific community, as confirmed in numerous publications [i.a. 20, 23, 24].

Results

The results in Figure 4 present a comparison of the RA values calculated for the study group (as well as the group mean) which gives the impression of an equal precision of movement repetition recorded in both of the trial measurements. Analysis of the RA value in dry-land tests reveals that four of the examined swimmers obtained similar values. These values fluctuated between 6 and 10 points. Interpretation of the abovementioned results, according to a point-based coefficient scale, finds that four swimmers are characterized by a high level of kinesthetic response. Swimmers numbers IV and VI obtained results exceeding 20 points, which translates into a lower level of kinesthetic response in dry-land conditions. Analysis of the RA value calculated on the basis of the bend force impulses acting on the monofin reveals that almost all of the examined swimmers show a high level of kinesthetic differentiation (except for one swimmer, with a RA of 13) during the actual propulsive movement performed in water, which exceeds the level of kinesthetic response performed in dry-land conditions.

A preliminary analysis of the Repetition Accuracy Factor (RA) suggests that, in the studied group of swimmers, the level of precision in the repetition of the force generated to bend the monofin is higher than the level of precision in the repetition of force generated in the dry-land exercise.

A graphic reproduction of the RA factor values (Fig. 5) shows a tendency within the swimmers who obtained lower results in the level of repetition precision in the dry-land trials to be able to better duplicate the force used to bend the monofin during real swimming.

The observed regularities were confirmed by ANOVA statistical analysis conducted on the measurement layout. Using the Wilks' Lambda Test (Fig. 6), a hypothesis on the homogeneity of variance was rejected, as the differences turned out to be relevant for $F_{(10,106)} = 40,56$ at $p < 0.001$. The stated lack of variance between the average values speaks to the existence of differences between the Repetition Accuracy Factor (RA) in the dry-land trials and the water trials. In order to definitively state that all of the measurements influenced the variability of the results, Tukey's Post-hoc Test was carried out several times. The results of this test confirmed the expected variability in terms of the RA values of both trials. Significant differences occurred within the compared groups (within the scope of the RA coefficient values obtained from the water and dry-land trials) as well as between them. Only two dry-land measurements (with swimmers II and III) had no significant variation. The largest difference between RA values were noted in the case of subject IV. The existence of a variance at $p < 0.001$ also confirms the average range (Fig. 6).

An objective analysis of the results leads to the conclusion that the level of precision in the repetition of

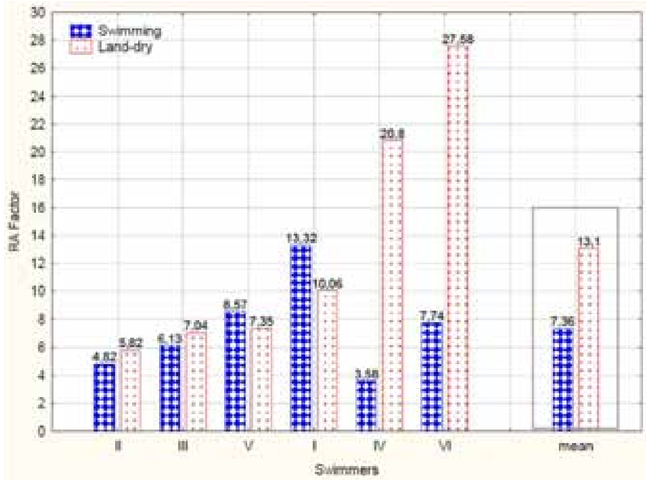

Figure 4. The value of the Repetition Accuracy Factor (RA) of force generated by the limbs in the dry-land trials and the bend forces acting on the surface of the monofin in water. The results are arranged not by the order of the swimmers but by ranking the RA values obtained in the dry-land trials

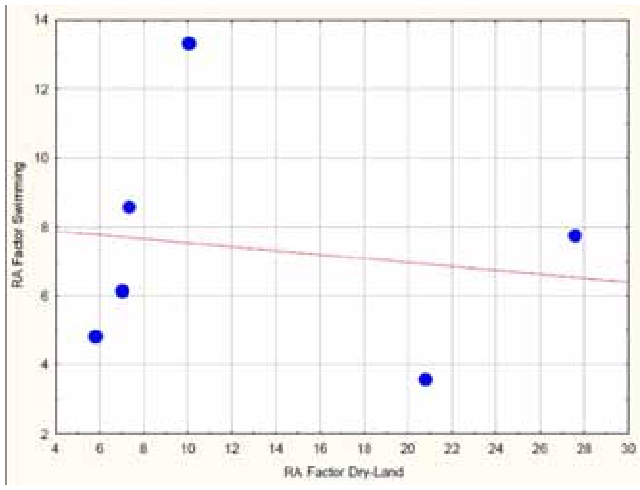

Figure 5. Line-graph showing the values of the RA factors registered during the dry-land and water trials

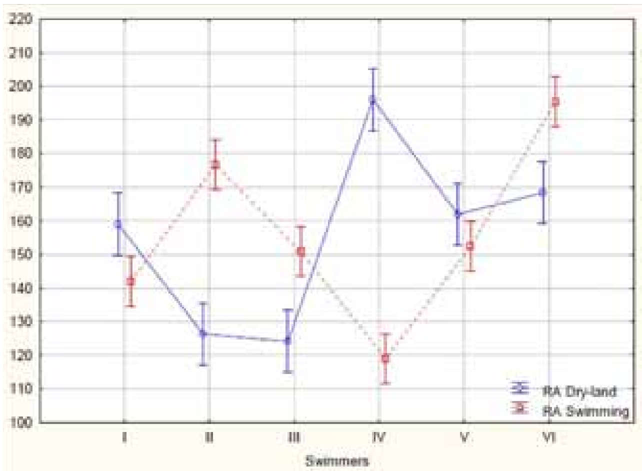

Figure 6. A graphic interpretation of the results of the analyzed variants (averages were not considered, only the Wilks' lambda). The vertical bar equals 0.95 confidence intervals

bend force on the monofin during actual swimming is greater than the one in dry-land simulation trials.

Discussion

The kinesthetic response level of the examined group was investigated by means of a method that evaluated torque/moment of time repeatability. The wide use of this method validates it as a tool for in-depth diagnosis of certain abilities in various kind of sport [13, 25]. The basis for the comparison of the torque generated under conditions of isometric (torque causing forces of pressure on the kinesiometer) and auxotonic (torque causing bend forces on the monofin) contraction has been emphasized in research [26]. The results provided by Klarowicz and Zatoń [20] proved the relevance of the application used in this study in the evaluation of swimmers' kinesthetic response abilities.

The applicational dimension of the established objective in this study manifests itself in the didactic premise resulting from an assumption that the measurement of an individual's ability to control movement is an error, defined as the conflict between the execution of a current movement task and its original intention [27]. A reduction of errors is of course possible, as are correctional changes during the process motor learning [13]. An error therefore, is treated as a chain, combining the objective measurement of precise movement with the application of actual active movement results, thus qualifying it as having an educational role. If one assumed that both trials in this study objectively determined the individual level of precision control in a movement system, this would quantify the level of kinesthetic response of the studied group. It would therefore fulfill a role as an educational tool aimed at improving swimming technique. The above context deepens the justification for comparing the values of repetition accuracy (RA) in trials performed in both natural conditions and as a dry-land simulation. This is regardless of the fact that both trials differed not only in the environment in which they were conducted, but also in the manner of executing the movement task.

The results indicate significant inter-group differences in terms of the range of the measured parameters. Differentiation among individuals in the level of kinesthetic response is a normal phenomenon and depends on individual human predisposition [13]. It may be then accepted that monofin swimmers exhibited characteristics of a high level ability in differentiating kinesthetic impression while executing tasks in "natural" conditions, and that the level of the tested ability was higher when compared to the results obtained while producing imitative movements on dry-land. The incidence of such a differentiation is, in itself, curious. As is the fact that two of the examined swimmers achieved a low level of kinesthetic differentiation on dry-land.

A subjective reason for this, which accentuates the results, may be a lack of concentration during testing. Such a cause was not considered in this study, as, aside from the precise instructions given on the tasks that needed to be executed and the regulation of how they were carried out in both the water and dry-land trials, there were no tools used for monitoring the swimmers' attitude and motivation in reliably executing the task. Therefore, the causes for such disparity must be considered.

The first reason may be related to a change in spatial orientation, brought on by the disparate conditions in completing tasks in water and on dry-land. The simulation of movement on dry-land is not a counterpart to the range of movement that a swimmer performs in the water [28]. Additionally, the dry-land trials consisted of measuring the force exerted while simulating the torque generated by extensor muscles of the knee joint in static conditions, while simulation of the torque generated in water involved the dynamic movement of the entire lower extremity. These in itself may have had an influence on the level of kinesthetic response, particularly in the dry-land trials, which only imitated the propulsion movements. In essence, the dissimilarity in the spatial orientation of movements executed in both trials may lie in the specific nature of the physical properties of water. Water density is 820 times greater and a thermal conductivity is 25 times greater than air [29]. For movement, in conditions where resistance is lessened, the receptors of a swimmer are very susceptible and sensitive to kinesthetic stimuli (a very similar reaction can be seen in an organism experiencing weightlessness). Research carried out by Lackner and DiZio [30] shows that an increase in movement precision can be summoned by a change of environment. In such an environment, the feeling of resistance perception is far more distinct when compared to similar activity on dry-land with regard to the flow of additional mass, which is far more precise when concerned with movement speed and the perception of the limbs' spatial positioning [3]. It can then be assumed that for these monofin swimmers it was this very feedback that eased the precise execution of the tasks in the study within the natural conditions of swimming in water.

Based on the differences of the repetition accuracy factor in the water and dry-land trials, another argument stemming from physiological aspects can also be presented. It has been found that maintaining muscle tension for longer periods of time can lead to a disruption of the muscle spindles' functioning [31]. Clearly this aspect would be the cause of a less precise differentiation of kinesthetic performance in static conditions than in the more dynamic conditions found in the water trials. One could likewise interpret the fact that effort placed on large muscle groups causes an individual decrease in movement precision and kinesthetic perception, which brings about a limit in the control of motion [32], particularly in conditions where the limbs are partially stabilized.

Other factors influencing the results (particularly in swimmers IV and VI) might also result from an interruption of the kinesthetic information flow that was present in the dry-land trial. As other studies have found [33], the foot and ankle joints, as the most distant parts of the biomechanical chain that make up the lower limbs, bear a very high overload caused by the monofin's large surface area resistance. As a result of this overload, structural and functional changes could occur in the feet and ankle joints, which in consequence might also lead to changes in the functioning of some receptors. Regardless of the negative nature that these changes may have, the swimmers' feet might individually differ in terms of kinesthetic perception. In the case of the present study, these differences might result from different feet and knee joint load when exerting the single-point pressure load on the kinesiometer in the dry-land trial.

During analysis of the results, it was noticed that there was also an apparent tendency in the swimmers who obtained the highest (negative) repetition accuracy factor values to precisely replicate the force used when bending the monofin during real swimming as they did in the dry-land simulation. Such high level kinesthetic response abilities (noted in the swimming trials) could be the result of the subjects' specialization in monofin swimming and experience gained over many years of training, giving them a greater edge in their ability to shape a conscious response of kinesthetic impressions. This learned form of ability has been defined as "stability of kinesthetic response" [34].

The errorless – efficient and economical – transfer of torque generated by the leg muscles to the monofin is one of the hallmarks of the practical usage of kinesthetic response abilities. From a kinesiological standpoint, the transfer of nerve impulses along the successive parts of the biomechanical chain (i.e., parts of the swimmer's body to the monofin) initiates feedback from this channel to the swimmer's proprioceptors and skin receptors. The ability to receive this sensual information through selective kinesthetic interaction is regarded as necessary to initiate the processes of movement control and regulation within the areas of the swimmer's consciousness as well as outside of it. This suggests that the quality of the described "kinesthetic dialogue" between the swimmer, the water and the surface of the monofin (as a source of propulsion) seems to determine swimming speed. In this context, a high level of kinesthetic response stability, obvious in its most advanced form – the stabilization of kinesthetic response – becomes indispensable in meeting the dynamic criteria of proper technique in monofin swimming [16]. These criteria include: 1) the high stability of the forces bending the monofin's surface as a response to water resistance and the consistency of the entire process throughout a period of time, 2) the equal proportions between the forces generated on the surface of the monofin during both upward and downward movements, 3) the intensification of upward fin movement in order to generate higher water resistance forces on the monofin's surface, 4) and the ability to perform monofin movement so that the distribution of the bend forces acting on the monofin is as close as possible to a sinusoidal curve. In the abovementioned context, the ability of having precise perception and kinesthetic response emerges as a key link in the process of improving technique of propulsive movement in monofin swimming.

Conclusions

The results of the comparison of the repetition accuracy of forces that act on bending the monofin, originating from lower limb movement during swimming, and the forces generated by limb movement in dry-land laboratory conditions did not entirely support the hypothesis that monofin swimmers would be characterized by a high level of kinesthetic response stability. However, what was confirmed was that, in the group of swimmers tested, the accuracy level in reproducing the force that bend the monofin during real swimming was greater than the accuracy displayed in the dry-land simulation trials. On this basis, it could be stated that the swimmers in the group exhibiting a high level of kinesthetic response only did so when executing actual propulsion movements in the water. What is more, the subjects who attained higher values of error (measured by the RA Factor) in the simulated dry-land trials also repeated the force used to bend the monofin during real swimming with lower precision. The presented conclusion can lead to the generalization that a high level of kinesthetic response in swimmers is due to individual attributes and it results from a specific adaptation in the perception and the creation of kinesthetic impressions in water based on the flow of precise stimuli from the large surface of the monofin.

The rather modest size of the group of swimmers does not allow for the drawing of explicit conclusions. The results rather pointed to a tendency that requires additional research on a larger group of monofin swimmers. Nevertheless, there are rational justifications for using individual kinesthetic abilities in technical monofin training, particularly in the case of raising the consciousness of swimmers and by encouraging them in the ability to feel the monofin working, as opposed to plainly controlling propulsive movements in order to obtain maximal swimming speed.

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