



# New Trends and Issues Proceedings on Humanities and Social Sciences

Volume 4, Issue 8, (2017) 126–135



ISSN:2547-8818

[www.prosoc.eu](http://www.prosoc.eu)

Selected paper of 8th World Conference on Learning, Teaching and Educational Leadership, (WCLTA 2017) 26-28 October 2017, Universidade Aberta, Lisbon, Portugal

## Progressive neuromuscular control improvement by using extrinsic feedback as learning tool, in swimming

Mihai Ilie <sup>a\*</sup>, University of Pitesti, Targu din Vale, Pitesti 110040, Romania

### Suggested Citation:

Ilie, M. (2017). Progressive neuromuscular control improvement by using extrinsic feedback as learning tool, in swimming. *New Trends and Issues Proceedings on Humanities and Social Sciences*. [Online]. 4(8), 126–135. Available from: [www.prosoc.eu](http://www.prosoc.eu)

Selection and peer review under responsibility of Prof. Dr. Jesus Garcia Laborda, University of Alcala, Spain.

©2017 SciencePark Research, Organization & Counseling. All rights reserved.

---

### Abstract

In this study, we started from the hypothesis that if we use the nautical sports simulator as learning mean and a tool to create visually extrinsic feedback, then we will be able to determine an effective change in the sensory-motor response at upper limb in order to improve progressive neuromuscular control. Using feedback as learning and optimizing mean of training is one of the desires of athletes training and, at the same time, an objective mean of raising the athlete's awareness of the way in which he manifests his motor behaviour. The importance of implementing feedback in the training of athletes is also highlighted by the achievement of valuable results both in individual sports and in sports games. The ways that feedback can be implemented in the training varies according to the purpose, the specificity of the sport, the way of interpretation and the approach of its results. The purpose of this research was to improve de capacity of the progressive neuromuscular control at the upper limbs level, in swimming, using extrinsic feedback. The experimental approach was carried out within the research centre for human performance from University of Pitesti, Romania and had four junior as participants with 7–10 years experience in this sport, national medalists and champions. External feedback was provided using a nautical condition simulator that provided graphical trajectories specific to how they managed to control the level of force exerted on the palm. The training plan involved 15–20 minutes training for each swimmer with a frequency of two sessions per week for 3 weeks for each technical aspect of the research. The results reflected how each athlete managed to correct the sensory response according to the given stimulus. During the study, the swimmers expressed varied ways of adapting to the stimuli, having the greatest difficulties of neuromotor reorganisation especially in the transition to the last level of force increase. In conclusion, the approach confirmed that extrinsic feedback is an objective mean of sensory-motor learning and reorganization and, implicitly, an improvement tool of progressive neuromuscular control in swimming, the logistic actuators having a decisive role in achieving the purpose of the research.

Keywords: Motor learning, nautical simulator, sensory response, strength, swimming.

---

\* ADDRESS FOR CORRESPONDENCE: Mihai Ilie, University of Pitesti, Targu din Vale, Pitesti 110040, Romania.

E-mail address: [ilie112004@yahoo.com](mailto:ilie112004@yahoo.com) / Tel.: +40-741-012-750

## 1. Introduction

Neuromuscular control represents an efficient, objective and determinative mean of sports training, which allows us to identify the need of feedback integration from its extrinsic perspectives. Its benefits are reflected in the adaptation of the sensorial response to stimuli that are as varied as possible, so that the motor answer of the athletes should emphasise the upgrade to a new performance step. Using feedback as a mean of training optimisation represents one of the athletes training desideratum and, in the same time, an objective mean of athletes' awareness about the way they are expressing their motor behaviour. The importance of the feedback implementation in the athletes training is also emphasised by the valuable performances that are achieved both in individual and team sports. The ways that feedback can be integrated in the training process varies depending on the purpose that is established to be achieved, sport specificity, the way that its results are interpreted and approached.

Swimming is the only sport that requires the implication of the whole body and bases itself on suppleness, equilibrium, namely, on rhythm. Rhythm is a quality to which the following are inherent: strength and magic. The rhythm is unitary and active. The rhythm's perceptibility bases itself on hearing, on the sense of touch and the sense of the muscles (Popescu-Bradicieni & Plastoii, 2014).

Swimming is the only sport that requires the implication of the whole body and bases itself on suppleness, candor, equilibrium, namely, on rhythm. Rhythm is a quality to which the following are inherent: strength and magic. The rhythm is unitary and active. The rhythm's perceptibility bases itself on hearing, on the sense of touch and the sense of the muscles.

Swimming is a highly complex motor skill and its acquisition or efforts towards any technical improvement require a specific procedure of bilateral information transmission between the swimmer and the coach. Indeed, specific environmental factors make it more difficult to exchange information (head immersed in water, swimming cap, ambient noise) and this leads to errors (Zaton & Szczepan, 2014). From this point of view, extrinsic feedback represents a very useful mean of interaction between swimmer and coach in order to provide the optimum stimulus of best performance obtaining.

According to Schmidt and Lee (2005) cited by Zaton and Szczepan (2012), extrinsic feedback plays important functions in the motor teaching and learning process. First of all, it provides the learner with information about the performed motor activity; this is an informative function. Secondly, it motivates or activates people through performing motor activity; this is a motivation function. Thirdly, it has a strengthening function, which inclines to repeat motor activity correctly, and a punishing function, which prevents actions incompatible with the motor activity model.

No matter what kind of feedback we are talking about, it is important to have in mind the physiological structure of the human memory which is approached from the two perspectives: short-term and long-term memory. In short-term memory, data are processed, but it can only contain a limited amount of information (Miller, 1956). The quantity of information conveyed to the learner must be limited. It is worth noting that unimportant data are not stored (sometimes permanently) within long-term memory, which gather in experiences and motor habits; hence, the necessity to provide the learner with real-time information and accurate instructions (Zaton & Szczepan, 2014).

We cannot speak about neuromuscular control and not making any reference to balance or sensory system as a structure element in achieving the optimum level of motor control. The focus of the training is to improve movement and respectable movement is based on a balance of mobility and stability. This balance requires effective proprioceptive communication between the muscles and joints. Improving this system should then create more effective movements. In order to improve the neuromuscular system's effectiveness in coordinating movement, proprioceptive neuromuscular facilitation concepts should be utilised (Burton & Brigham, 2013). In the same direction, I agree with the idea expressed by Miller & Hung (2016), Huxhold, Schmiedek, and Lindenberger (2006) and

Huxhold et al (2009), which underlines that balance activities take place in association with at least one concurrent task in daily activities, and cognitive function can have an impact on balance control. The impact of adding a cognitive loading on functional activities such as gait and balance control is inconclusive depending on many factors such as the difficulty of the primary/secondary tasks and subject conditions.

During goal-directed behaviour, such as picking up a box while walking, provisions must be made to adapt the motor program for walking to changes occurring in the external environment (uneven ground) and internal environment (change in centre of mass because of the additional load). These provisions are stimulated by sensory triggers occurring in both feedback (mechanoreceptor detection of altered support surface) and feedforward (anticipating centre-of-mass change from previous experience) manners (Riemann & Lephart, 2002).

Muscles are the motors responsible for limb movement. However, they are more than simple force generators. Their spring-like behaviour has been long recognised as a key element in the control of limb movement. One theory of motor control is predicated on the assumption that the central nervous system can control the equilibrium position established by the balance of force in these muscle springs (Hinder & Milner, 2003). Although some of the afferent information may be redundant across the three sensory sources (somatosensory, visual and vestibular), specific unique roles are associated with each source that may not be entirely compensated for by the other sensory sources (Riemann & Lephart, 2002).

In this research, we started from the hypothesis according which, if we will use the simulator that was designed for nautical conditions, as training tool and extrinsic visual feedback provider, then we will be able to determine an efficient shift of the sensory-motor answer at the upper limbs level in terms of improving progressive neuromuscular control.

This study aimed the improvement in the progressive neuromuscular control of the upper limbs, in swimming, using the extrinsic feedback.

To achieve this purpose, we focused our approach on the following targets:

- the identification of the dynamic and cinematic parameters from the data recording program (given by the simulator) according to the motor structure that is specific to the crawl arms technique;
- the calibration of the dynamic and cinematic parameters used as extrinsic feedback source and
- the execution (in real time) of some graphics made of lines that shall follow as precise as possible (from the perspectives of dynamic and cinematic parameters) the pre-established visualised model reflecting the traction strength that is specific to the crawl style, the length of the traction stroke, the trajectory of the way that the swimmer succeeded in achieving the tasks of the graphic model regarding the variation of the palm pressure strength.

## 2. Data and Methods

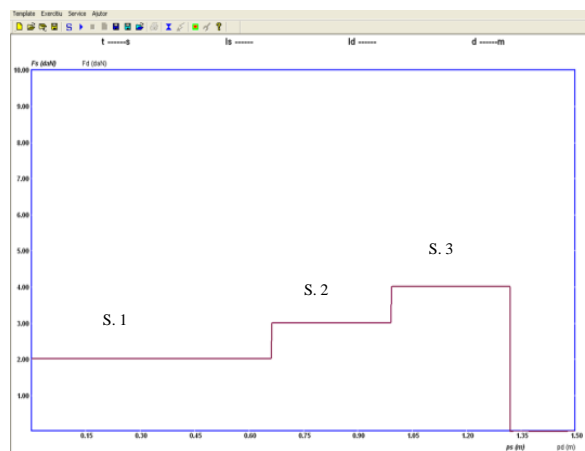
The experimental approach was carried out in the Human Performance Research Center of the University of Pitesti and had four female and two male as subjects with experience in practicing this sport between 7 and 10 years ( $F_{\text{mass}}$ : 56.5 kg  $\pm$  5.5 kg,  $F_{\text{height}}$ : 1.64 m  $\pm$  0.06 m,  $M_{\text{mass}}$ : 61.5 kg  $\pm$  6.5 kg,  $M_{\text{height}}$  1.69 m  $\pm$  0.04 m), national medalists and champions. External feedback was provided using the water sports simulator from the ERGOSIM-type apparatus. The recorded data were processed and analyzed according to the dynamic and cinematic parameters that were monitored, the appreciation being made from the perspective of how each athlete managed to follow the graphic model that was established.

The simulators' parameters that were aimed during this research were the following:

- the *release* (the length of the stroke)—(Rel);
- the *number of the steps* (the indicator of the strength increase)—(St no.);
- the *strength value for each step*—(S);
- the *length of each step*—(L<sub>s</sub>);
- the *number of executions per each set*—(Rpt/set);
- the *effective working time for each set*—(T<sub>set</sub>) and
- the *swimming distance that was covered during each set*—(D<sub>set</sub>).

### 3. Results and Discussions

The results were recorded and analysed according to experimental design, their values showing the way that each swimmer succeeded in readapt the sensorial response according to the working stimulus (Figure 1).



**Figure 1. The graphic model of the pre-established progressive sensorial response (S<sub>1-3</sub>—strength steps)**

Due to the large amount of data and graphs recorded for each swimmer during the research, we decided to present only those related to the definitive exercise in the progressive restructuring of the sensory-motor response, where the swimmers showed the greatest difficulties of neuromotor reorganisation, especially to the last level of strength increase (step 3). At the same time, we have also achieved a centralisation of parameters' values specific for the simulator, as shown in Tables 1–4.

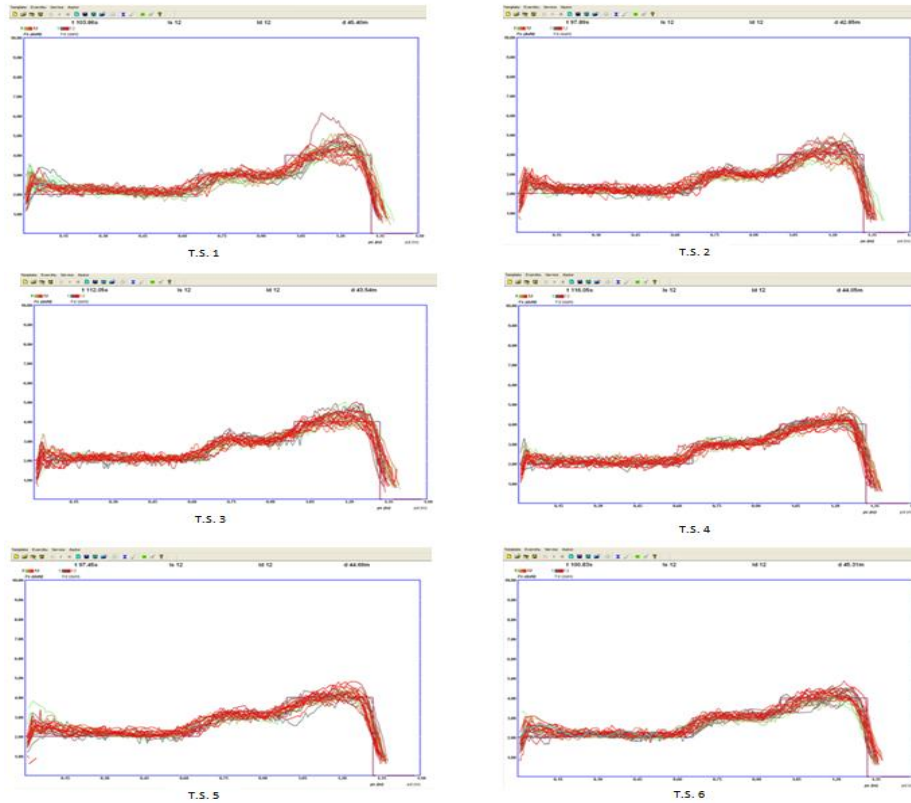


Figure 2. The graphical representation of the progressive sensorial response recorded by the  $S_1$  at the end of each training session (legend: T.S.<sub>1-6</sub>—training session)

Table 1. The parameters of the simulator for  $S_1$

$T_s$	Rel. (m)	St. no.	$S$ (daN)	$L_s$ 1/2/3 (cm)	Rpt/set	$T_{set}$ (s)	$D_{set}$ (m)
1	1.32	3	2/3/4	66/33/33	12	103.86	45.40
2	1.32	3	2/3/4	66/33/33	12	97.89	42.85
3	1.32	3	2/3/4	66/33/33	12	97.45	44.69
4	1.32	3	2/3/4	66/33/33	12	100.83	45.31
5	1.32	3	2/3/4	66/33/33	12	112.05	43.54
6	1.32	3	2/3/4	66/33/33	12	116.05	44.05

In Figure 2 and Table 1, we can see how  $S_1$  attempts to follow the proposed model, the feedback provided by the simulator actually helping her to correct the sensory response from one training session to another, so that at the end of the measurements the swimmer shall get closer to the model of the chart used as a neuromotor stimulus. From the values presented in Table 1, we can observe that the simulator-specific parameters ( $T_{set}$  and  $D_{set}$ ) show variations from one training session to another, whereas the Rpt/set remains the same. If in *the first training session*  $S_1$  made the 12 executions in 103.83 seconds, during which she did a 45.40 m displacement, in *the last two*, the  $T_{set}$  increased, reaching 112.05 seconds and 116.05 seconds respectively, while the  $D_{set}$  is below the first value, that is, 43.54 m and 44.05 m, respectively. Although the time required to achieve the 12 reps increased and the swimming distance diminished, the graphs shown in Figure 2 illustrate an improvement in the progressive neuromuscular control (in steps), the final assessment of the sensorial behaviour being of a visual-qualitative nature.

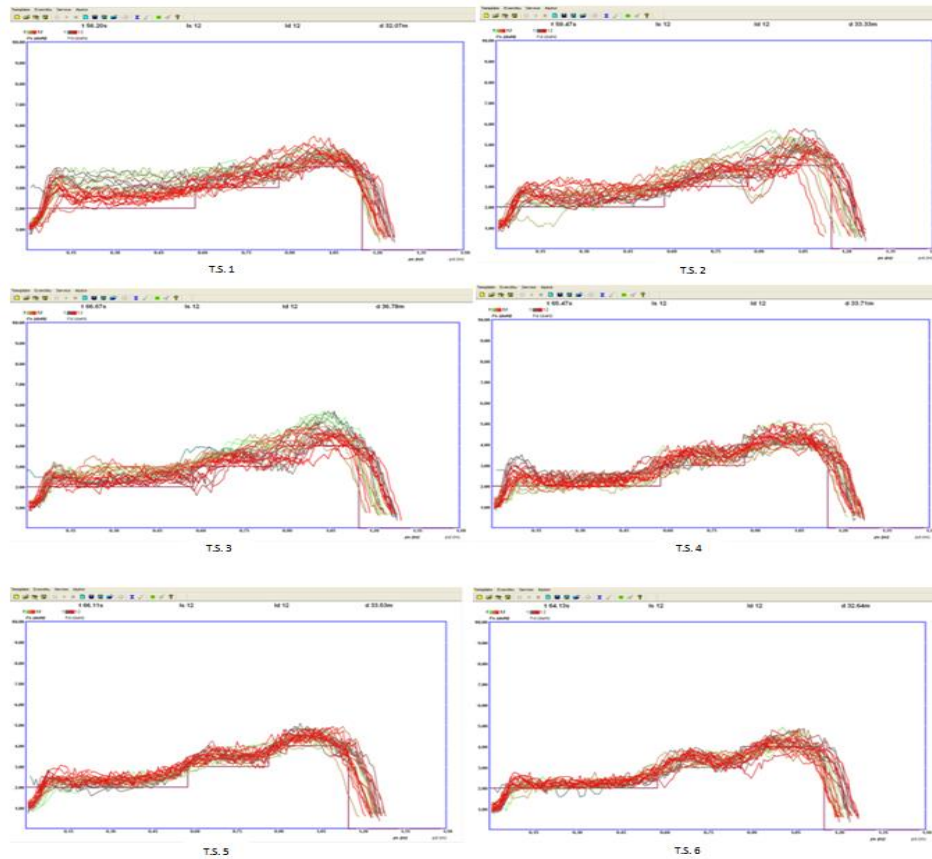


Figure 3. The graphical representation of the progressive sensorial response recorded by the S<sub>2</sub> at the end of each training session (legend: T.S.1–6–training session)

Table 2. The parameters of the simulator for S<sub>2</sub>

$T_s$	Rel. (m)	St. no.	$S$ (daN)	$L_{s\ 1/2/3}$ (cm)	Rpt/set	$T_{set}$ (s)	$D_{set}$ (m)
1	1.15	3	2/3/4	57.5/28.75/28.75	12	56.20	32.07
2	1.15	3	2/3/4	57.5/28.75/28.75	12	59.47	33.33
3	1.15	3	2/3/4	57.5/28.75/28.75	12	66.67	36.78
4	1.15	3	2/3/4	57.5/28.75/28.75	12	65.47	33.71
5	1.15	3	2/3/4	57.5/28.75/28.75	12	66.11	33.53
6	1.15	3	2/3/4	57.5/28.75/28.75	12	64.13	32.64

Table 2 and Figure 3 show how S<sub>2</sub> manages to adapt its sensory response based on the extrinsic feedback provided. Unlike S<sub>1</sub>, S<sub>2</sub> presents real difficulties in achieving the given graphical model in *the first three training sessions*, one of the causes being the performing of the movements without adapting the execution speed according to each step of force (neuromotor difficulties), which is revealed by the performing of the 12 repetitions in a shorter time compared to the last three training sessions. *In the last 3 trainings* she manages to improve her neuromotor behaviour by focusing more on the graphic task and being more careful, the charts reflecting in a more faithful way the shape of the proposed working model, which is also emphasised by a smaller difference of  $T_{set}$  between the latter (65.47 seconds, 66.11 seconds and 64.13 seconds).



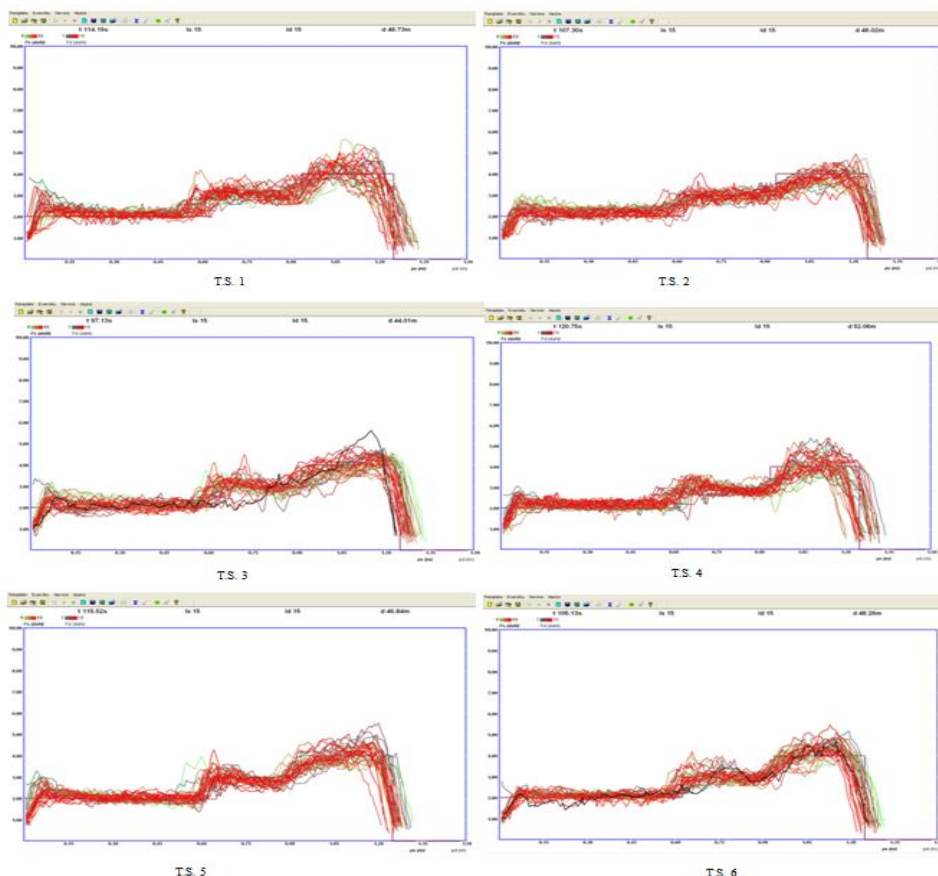


Figure 4. The graphical representation of the progressive sensorial response recorded by the  $S_3$  at the end of each training session (legend: T.S.<sub>1-6</sub>—training session)

Table 3. The parameters of the simulator for  $S_3$

$T_s$	Rel. (m)	St. no.	$S$ (daN)	$L_{s1/2/3}$ (cm)	Rpt./set	$T_{set}$ (s)	$D_{set}$ (m)
1	1.25	3	2/3/4	62/31.5/31.5	15	114.19	48.73
2	1.25	3	2/3/4	62/31.5/31.5	15	107.30	48.02
3	1.25	3	2/3/4	62/31.5/31.5	15	97.13	44.01
4	1.25	3	2/3/4	62/31.5/31.5	15	120.75	52.08
5	1.25	3	2/3/4	62/31.5/31.5	15	115.52	46.84
6	1.25	3	2/3/4	62/31.5/31.5	15	105.13	48.26

Figure 4 and Table 3 highlight how  $S_3$  adapts his sensory response to the extrinsic feedback given by the simulator used as a motor action tool. From the data presented in Table 3, we can see that the  $T_{set}$  parameter records values between 120.75 seconds and 97.13 seconds, and  $D_{set}$  ranges from 52.08 m to 44.01 m. We note that  $S_3$  presents a variation in the ability to adapt the sensory response to the proposed graphical model as shown in Figure 4 (T.S.<sub>1</sub>; T.S.<sub>3</sub>; T.S.<sub>5</sub>) each time in the first training session of the week. From the charts obtained in T.S.<sub>2</sub>; T.S.<sub>4</sub>; T.S.<sub>6</sub>, we can see a focalisation of the feedback curves, according the model, on the three progressive steps proposed to improve neuromuscular control. From the perspective of the  $D_{set}$ ,  $S_3$  managed to swim the longest distances in the same training sessions in which he performed closer to the proposed graphic model ( $D_{set} = 48.02$  m—T.S.<sub>2</sub>; 52.08 m—T.S.<sub>4</sub>; 48.26 m—T.S.<sub>6</sub>).

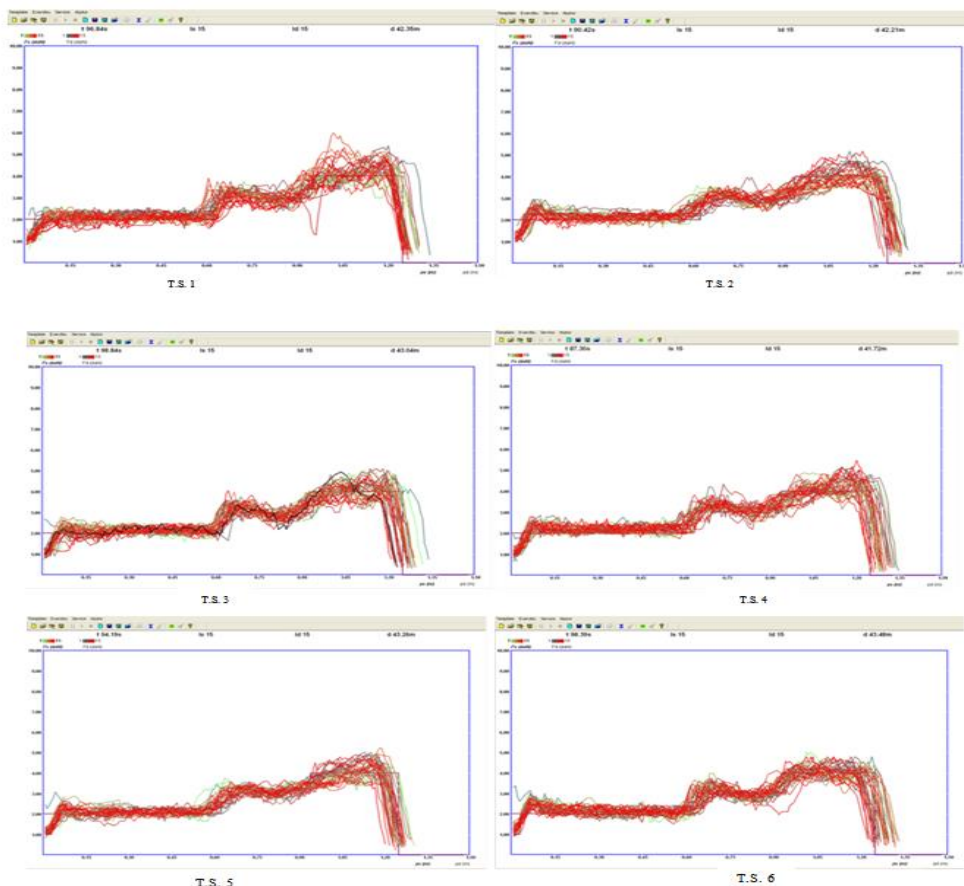


Figure. 5. The graphical representation of the progressive sensorial response recorded by the  $S_4$  at the end of each training session (legend: T.S.1–6–training session)

Table 4. The parameters of the simulator for  $S_4$

$T_s$	Rel. (m)	St. no.	$S$ [daN]	$L_{s1/2/3}$ (cm)	Rpt./set	$T_{set}$ (s)	$D_{set}$ (m)
1	1.25	3	2/3/4	62/31.5/31.5	15	96.84	42.35
2	1.25	3	2/3/4	62/31.5/31.5	15	90.42	42.21
3	1.25	3	2/3/4	62/31.5/31.5	15	98.84	43.04
4	1.25	3	2/3/4	62/31.5/31.5	15	87.30	41.72
5	1.25	3	2/3/4	62/31.5/31.5	15	94.19	43.26
6	1.25	3	2/3/4	62/31.5/31.5	15	98.39	43.48

The data presented in Table 4 and the charts illustrated in Figure 5 highlight the evolution of the sensory response that  $S_4$  has shown during the research. As it can be seen in Figure 5,  $S_4$  manages, from the *first training session*, to adapt its sensory system to the motor stimulus, the expressed neuromotor behaviour highlighting an increased capacity of neuromuscular control to progressive stimuli. The numerical values shown in Table 4 highlight small  $T_{set}$  differences from one training session to the next, with variations from 87.30 seconds to 98.84 seconds. As far as  $D_{set}$  is concerned, the results of the six training sessions have values ranging from 41.72 m to 43.48 m, fact that denotes a constancy of neuromotor behaviour from the point of view of adaptability.



#### 4. Conclusions

Although the same motor stimulus was used for all the subjects involved in the research, there were situations when the sensory-motor reorganisation had a different dynamics from one subject to another. Thus, with regard to the way of realizing the lines according to *the first step of the graphic model*,  $S_1$ ,  $S_3$  and  $S_4$  managed to respect its shape during the training sessions; instead,  $S_2$  had real difficulties adapting the sensory-motor response, so that she could achieve closer trajectories to the model in the first three training sessions, correcting in the last three, but below the level shown by the other subjects.

Regarding how the subjects respected *the second-step graph*,  $S_1$  and  $S_4$  came close to it.  $S_3$  had difficulties in the first training session of each week of the research,  $S_2$  being able to get much closer in the last training session.

The biggest impediment in adaptation was recorded in case of *the step no. 3*. Here, the subjects have had difficulties in increasing the response velocity of the motor response, so that the transition from the second to the third step being performed on a trajectory that respects the shape of this step. However, all subjects performed charts with progressive differences of strength from one step to the next, with the note that, in the case of the last increase, they did not maintain the same level of force over the entire length of the step. The most obvious adaptation from this point of view was shown by  $S_4$  who, in the last training session, succeed to perform a chart with a shape that was very close to that of the proposed model.

The results of this scientific approach entitle us to subscribe to the ideas expressed by the field specialists regarding the importance of feedback (in our case the extrinsic one) in improving neuromuscular control using exercise systems that involve both the motor system and the sensory system.

The dynamic and kinematic parameters used in the experimental approach provided useful information in the quantitative assessment of how the subjects of the research managed to adapt and improve their sensory response according to the used exercise stimulus, respecting the motor-specific structure of the crawl stroke technique. The calibration of these parameters proved to be consistent with the need for sensory reorganisation specific to each subject, which has helped to improve individual progressive neuromuscular control.

The possibility to have real-time visual extrinsic feedback had a fundamental meaning in the sensory-motor reorganisation of response to the stimulus that led to the improvement in the progressive neuromuscular control.

The experimental approach provided the optimal framework for confirming the utility of the nautical sports simulator in providing extrinsic feedback and, implicitly, improving progressive neuromuscular control.

The research confirmed that extrinsic feedback is an objective mean of sensorial-motor reorganisation and, implicitly, of the improvement in the progressive neuromuscular control in swimming, the logistic exercise elements having a decisive role in achieving the purpose of the research.

## References

- Burton, L. & Brigham, H. (2013). *Proprioceptive neuromuscular facilitation: the foundation of functional training*. Retrieved from [http://www.functionalmovement.com/articles/Screening/20130704\\_proprioceptive\\_neuromuscular\\_facilitation\\_the\\_foundation\\_of\\_functional\\_training](http://www.functionalmovement.com/articles/Screening/20130704_proprioceptive_neuromuscular_facilitation_the_foundation_of_functional_training)
- Hinder, M. R. & Milner, T. E. (2003). The case for an internal dynamics model versus equilibrium point control in human movement, *Journal of Physiology*, 549, 953–963, doi:10.1113/jphysiol.2002.033845. Retrieved from <http://www.mcgill.ca/edu-kpe/sites/mcgill.ca.edu-kpe/files/10953.pdf>
- Hung, Y. & Miller, J. (2016). Extrinsic visual feedback and additional cognitive/physical demands affect single-limb balance control in individuals with ankle instability. *World J Orthop*, 7, 801–807.
- Huxhold, O., Li, S. C., Schmiedek, F. & Lindenberger, U. (2006). Dual-tasking postural control: aging and the effects of cognitive demand in conjunction with focus of attention. *Brain Res Bull*, 69, 294–305.
- Popescu-Bradaceni, I. & Plasto, C. D. (2014). The technique that is specified for Swimming, Gymnastics and Handball game, hermeneutically transposed. In *Globalization and intercultural dialogue. Multidisciplinary perspectives. Section: Language and discourse* (pp. 688–689), Arhipelag XXI Press, ISBN 978-606-93691-3-5.
- Riemann, B. L., Lephart, S. M. & Bryan, L. (2002). The sensorimotor system, part II: The role of proprioception in motor control and functional joint stability. *Journal of Athletic Training*, 37, 80–84.
- Salavati, M., Mazaheri, M., Negahban, H., Ebrahimi, I., Jafari, A.H., Kazemnejad, A. & Parnianpour, M. (2009). Effect of dual-tasking on postural control in subjects with nonspecific low back pain. *Spine*, 34, 1415–1421.
- Schmidt, R. A. & Lee, T. (2005). *Motor control and learning. A behavioral emphasis*, 4th ed. Champaign, IL: Human Kinetics Publishers.
- Zaton, K. & Szczepan, S. (2012). The effect of immediate verbal feedback on the efficiency and the effectiveness of swimming. *Baltic Journal of Health and Physical Activity*, 4, 91–103.
- Zaton, K. & Szczepan, S. (2014). The impact of immediate verbal feedback on the improvement of swimming technique. *Journal of Human Kinetics*, 41, 143–154. doi: 10.2478/hukin-2014-0042