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Original article

A PRELIMINARY STUDY ON THE EFFICIENCY OF ULTRA SLOW MOTION INTELLIGENT TRAINING (USMIT) IN RHYTHMIC GYMNASTICS TECHNICAL TRAINING

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Abstract.
Aim. The aim of this study was to test a new, complementary training method for maximizing the technical preparation through the stimulation of central nervous systems.

New requirements of the FIG Code of points require the execution of high difficulty elements, both body and apparatus.Ultra slow motion intelligent training is a method where the athlete performs predefined upper limb movements with a very low velocity, thus activating the frontal lobe, which is involved in the control of complex voluntary conduct, attention processes, and emotional states - essential aspects for the technical execution in rhythmic gymnastics.

This study involved 13 gymnasts who are part of the Junior National team, aged between 13 and 15 years, with a sport experience of 7 - 9 years. The research procedure required performing 3 ultraslow-motion routines. The first routine was performed with visual guidance, while the following 2 without any form of guidance. The routines required the gymnasts to maintain a constant speed on both the ascending and descending trajectory of the arms, in a controlled extension movement. The parameter measured by means of USMIT equipment was represented by the speed (mm/s) for each segment - left-right. The central tendency statistic indicators were calculated, along with the quartile. While similar studies, exploring the efficiency of USMIT are extremely rare, we used some reference values from other sports, such as biathlon, provided by the author of this equipment/method. Consequently, these findings need to be tested in the context of rhythmic gymnastics and its particularities.

This type of research, applied for the first time in rhythmic gymnastics, will be of significant relevance for specialists in the field, especially if the data collected will be encouraging.
Keywords: rhythmic gymnastics, USMIT, control capacity.

Introduction

Rhythmic gymnastics, a sport of high complexity, which combines the attributes of technique and physical abilities such as power and explosiveness (Kezic et al., 2018) with the aspects of body esthetics and expressiveness, has experienced impressive transformations in recent decades, primarily due to the increase in the level of technical skills, by permanently reviewing the requirements imposed by the FIG Code of points.

These new requirements highlight the importance of achieving elements with a high degree of difficulty, which requires the development of adequate physical support to sustain the motor performance of gymnasts (Ávila-Carvalho, et al., 2012). The degree of difficulty and virtuosity of an exercise can be obtained by correctly performing original handling elements with an unusual technique, synchronized with body elements that provide spectacularity to the exercise (Titov & Jastrjembaskaia, 2016).

Starting from these considerations, the increase in neurophysiological and psycho-emotional stress due to the increase in the difficulty of competition exercises, led us to consider the appropriate use of USMIT equipment as an evaluation and training equipment to increase the ability to control movement, on the coordinates imposed by the FIG Code of points 2020-2024.

Studies in the literature highlight the fact that slow, very slow and super slow exercises are often used for the development of muscle strength and endurance.

The one who first proposed these types of exercises was Ken Hutchins, who in the 80s and 90s imagined exercise systems in which the execution speed was about 100 mm/s, and neuromuscular strain and control were at a high level. Westcott (1993, 1999, 2012) confirmed Hutchins' approach, according to which super slow movements lead to approximately 50% increases in muscle strength, compared with training with traditional loads.

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According to these authors, the key to ultra-slow training is not to give the muscles the opportunity to relax, by eliminating the impulse generated by traditional dynamic work. In this way, the capacity for muscle contraction, respectively, the force increases significantly.

In terms of the ability to control movements, through ultra-slow requests, the literature does not present enough identifiable benchmarks in the databases. Although the issues of neuromuscular control and accuracy are analyzed in the bibliographic references, they are not approached from the perspective of this type of training, in which the performer becomes aware at each moment of the intermediate positions of the movement and his own actions according to the visual feedback.

This type of training predominantly stimulates the cerebral cortex, namely the frontal lobe, as an instance of control of voluntary movements, through the primary motor cortex, but is also responsible for managing attention, impulse control, memory or some emotional characteristics of the subject. According to Kenney, Wilmore and Costill (2015), the primary motor cortex contains the detailed representation of the whole body, and the areas that require fine control of movement, have the widest representation; thus, they benefit from a more important neural "allocation" in all the learned motor actions. Therefore, the primary motor cortex is responsible for controlling fine and discrete movements. Neurons at this level, known as pyramid cells, facilitate the control of the actions performed by skeletal muscles, which is generated by the decisional impulse regarding voluntary movements performed (Kenney, Wilmore, Costill, 2015). According to McArdle (et al. 2007) in response to internal and external stimuli, hundreds of millions of beats of sensory input automatically synchronize to be processed almost instantaneously through central nerve mechanisms. The input thus becomes perfectly organized, processed and transmitted with high efficiency to muscle effectors. Motor cortex fatigue occurs before the fatigue of muscle effectors (Cunningham et al. 2016). Some specialists from the U.S. Center for Neuroskills, quoting Kolb and Milner (1981), Blumer and Benson (1975) consider this area to be the centre of emotion control and our "personality headquarters."

Recently, authors such as Rădescu (2018) have conceptualized training with ultra-slow movements, integrating it into the following taxonomy:

- slow and very slow exercises, executed with speeds exceeding 15 cm / s and coordinated with a complete breath (an inspiration and an exhale);
- super slow exercises, performed at speeds between 8 - 10 cm / s, coordinated with several respiratory cycles;
- ultra-slow exercises, performed at speeds between 0.5 - 2 cm/ s, coordinated with several respiratory cycles.

The author was particularly interested in the opportunity of using ultra-slow exercises in performance sports by stimulating cerebral neuroplasticity and delaying the loss of concentration in pregnancies that involve fine regulation of motor actions. In other words, one can speak of specific endurance in maintaining the accuracy of movements. This objective involves adjustments at the level of three components: the muscular peripheral, neurological central and central psyche.

The aim of this preliminary study was to identify the efficiency of the USMIT complementary training method in maximizing the technical preparation in rhythmic gymnastics.

Objectives

The research approach will focus on identifying and improving some parameters related to the subject's ability to perform precise movements, with a focus on eliminating the oscillations of the segments and thus the deviations from the established trajectory and their dynamics through computerized training of USMIT type.

Methods

Participants

The research was conducted on junior gymnasts belonging to CS UNEFS Bucharest and CSM Arad, members of the Romanian National Group Team in rhythmic gymnastics. They started centralized training sessions on March 2022 at the National Olympic Junior Training Centre in Arad and Bucharest.

The 13 gymnasts included in the research were aged 13-16 and had between 7 and 10 years of experience in rhythmic gymnastics.

All gymnasts are clinically healthy. They were informed about the purpose of this research, which they found interesting for their preparation process. Under these conditions the participants expressed curiosity and interest in participating in this research. The parents of these athletes signed the informed consent.

Procedure

The research procedure required performing 3 ultraslow-motion routines, from a sitting position. The first routine was performed with visual guidance, while the following 2 (with 5 minutes break window), without any form of guidance. The routines required the gymnasts to maintain a constant speed on both the ascending and descending trajectory of the arms, in a controlled extension movement. The parameter measured by means of USMIT equipment was represented by the speed (mm/s) for each segment - left-right.

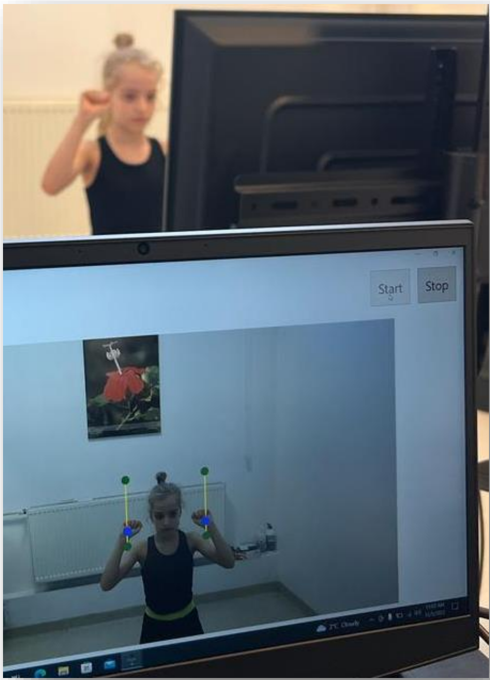

Figure. 1 Testing procedure - first routine with visual guidance

Study of the literature

The literature included recent scientific articles regarding trends in the current FIG Code of points and ultra-slow motion training, as well as issues related to specific rhythmic gymnastics training and scientific research methodology.

The first stage in outlining the research problem is documentation through the analysis of the bibliographic sources of reference for the approached topic. The sources of information consisted on one hand in the FIG Score Codes and on the other hand in the specialized works in the field of rhythmic gymnastics, but also in sport science in general. We were primarily interested in aspects of neuroanatomy, neurophysiology, psychology and the methodology of scientific research.

We mention that the literature has very few references to USMIT training in performance sports except for the method for developing force through ultraslow movements. The lack of specific knowledge in this area is an important gap that we will have to fill in the near future.

Experimental method

In this study, a psychopedagogical experiment with a single variable was used. The experiment we focused on was one of the determining types, but also one of the ameliorative types, which improved some parameters involved in a specific technique.

In the experiment, USMIT12 computer equipment was used for the tests, which included the Kinect X Pro 1.0 system (computerized system of Cartesian motion analysis, on Kinect 2.0 support, developed in collaboration with 73 Brains Software and the Foundation for Medicine and Health R Barn), tripod and linear meter. The equipment records movements at the level of the distal extremities of the upper limbs, in smooth movement, with constant, reduced speed, up to the lower limit of the execution speed.

Results

Table 1 presents information on the descriptive statistics detached from the first repetition, made according to the routine, with a visual landmark designed to understand the movement. The average speed of movement was measured simultaneously, for both the right and left hands, and statistical interpretation was approached from the same perspective.

Analyzing the coefficient of variation we identified a high level of homogeneity at the group level, both for the left hand (16%) and for the right hand (21%) in terms of the average speed of arm movement throughout the routine. This means that there are no differences at the group level.

Table 1. *Descriptive statistics for average speed movement (mm/s) – first routine*

No.	*Gymnast*	*Left hand (mm/s)*	*Right hand (mm/s)*
1	B.I.	8.71	7.92
2	C.A.	10.27	9.85
3	P.A.	12	11.42
4	V.E.	11.27	11.37
5	P.I.	12.9	12.76
6	C.C.	10.15	9.92
7	B.A.	9.16	15.81
8	B.C.	10.89	10.5
9	M.D.	10.59	13.01
10	M.C.	9.3	8.96
11	L.R.	8.68	8.55
12	T.I.	13.62	8.57
13	P.K.	14.04	13.7
	Mean	10.89076923	10.94923077
	Min	8.68	7.92
	Max	14.04	15.81
	STDEV	1.802116633	2.347656497
	CV	0.165471933	0.214412916
	Wilcoxon–Mann–Whitney test (U)	80	

Apart from the central tendency indicators, the Wilcoxon–Mann–Whitney test was applied to identify the significance of mean differences between the two hands/arms, in terms of average speed.

Table 2. *Wilcoxon–Mann–Whitney test – Average speed movement left hand vs. right hand – first routine*

	Left hand	***Right hand***	***Left & right Combined***
Sum of ranks	180	171	351
Mean ranks	13.85	13.15	13.5
Expected sum of ranks	175.5	175.5	
Expected mean of ranks	13.5	13.5	
U-value	80	89	
Expected U-value	84.5	84.5	
Standard deviation			19.5

The results of the Paired *Wilcoxon–Mann–Whitney test* for the two hands show that (Table 2):

- The U-value is 80. The critical value of U at p<.05 is 45, and there are no statistically significant differences between the left and right hands regarding the speed movement in the first routine.
- The Z-score is 0.20. The p-value is 0.83, and the result is not significant at p<0.50

Cohen's d = (10.94 – 10.89)/ 2.09 = 0.02 (weak size effect)

For the second routine, performed 5 minutes after the first, we noticed that for the left hand the average speed was 10.19 mm / s, very close to the value of the target speed, which is 10 mm / s.

Applying the coefficient of variation at the group level, both for the left hand (16%) and for the right hand (0.15%), we notice that homogeneity at group level is high.

Comparing the first and second routines, we notice that for the second routine the level of homogeneity was higher in the right hand.

Table 3. *Descriptive statistics for average speed movement (mm/s) – second routine*

No.	*Gymnast*	*Left hand (mm/s)*	*Right hand (mm/s)*
1	B.I.	7.71	7.92
2	C.A.	10.27	9.85
3	P.A.	9.87	9.01
4	V.E.	11.96	11.96
5	P.I.	10	12.75
6	C.C.	10.02	10.24
7	B.A.	8.35	8.3
8	B.C.	13.95	10.3
9	M.D.	12.2	11.39
10	M.C.	8.85	8.12
11	L.R.	10.06	9.83
12	T.I.	9.08	8.7
13	P.K.	10.19	10.1
	Mean	10.19307692	9.882307692
	Min	7.71	7.92
	Max	13.95	12.75
	STDEV	1.684856001	1.494044588
	CV	0.165294151	0.151183776
	Wilcoxon–Mann–Whitney test (U)	75.5	

Table 4. *Mann Whitney U Test – Average speed movement left hand vs. right hand – second routine*

	Left hand	***Right hand***	***Left & right Combined***
Sum of ranks	184.5	166.5	351
Mean ranks	14.19	12.81	13.5
Expected sum of ranks	175.5	175.5	
Expected mean of ranks	13.5	13.5	
U-value	75.5	93.5	
Expected U-value	84.5	84.5	
Standard deviation			19.5

The results of the Paired *Wilcoxon–Mann–Whitney test* for the two routines show that (Table 4):

- The U-value is 75.5. The critical value of U at p<.05 is 45, and there are no statistically significant differences between the left and right hands regarding the speed movement in the second routine
- The Z-score is 0.43. The p-value is 0.65, and the result is not significant at p<0.5

Cohen's d = (9.88 – 10.19)/ 1.05 = 0.29 (weak size effect)

The coefficient of variation calculated from the average speed of the movement of the arms on the ascending and descending routes provides information about the smoothness of the movement throughout the routine.

We consider that the closer the value of the coefficient of variation is to 0, the smoother the movement of the arms will be reaching the optimal level of neuromuscular control. Thus, in this first repetition we identify a coefficient of variation with values between 0.39 and 1.72, with an average of 0.49 (49%) for the left hand and 0.57 (57%) for the right hand, which emphasizes low homogeneity.

Table 5. *Descriptive statistics coefficient of variation (Variability of the movement) – first routine*

No.	*Gymnast*	*Left hand*	*Right hand*
1	B.I.	0.51	0.44
2	C.A.	0.53	0.53
3	P.A.	0.45	0.48
4	V.E.	0.51	0.53
5	P.I.	0.45	0.46
6	C.C.	0.42	0.41
7	B.A.	0.49	1.72
8	B.C.	0.4	0.36
9	M.D.	0.51	0.86
10	M.C.	0.39	0.39
11	L.R.	0.41	0.38
12	T.I.	0.92	0.45
13	P.K.	0.42	0.41
	Mean	0.493077	0.570769
	Min	0.39	0.36
	Max	0.92	1.72
	STDEV	0.136954	0.368
	CV	0.277754	0.644745
	Wilcoxon–Mann–Whitney test (U)	78.5	

Table 6. *Mann Whitney U Test – Coefficient of variation left hand vs. right hand – first routine*

	Left hand	***Right hand***	***Sample 1 & 2 Combined***
Sum of ranks	181.5	169.5	351
Mean ranks	13.96	13.04	13.5
Explected sum of ranks	175.5	175.5	
Expected mean of ranks	13.5	13.5	
U-value	78.5	90.5	
Expected U-value	84.5	84.5	
Standard deviation			19.5

The results of the Paired *Wilcoxon–Mann–Whitney test* for the two routines show that (Table 6):

- The U-value is 78.5. The critical value of U at p<.05 is 45, and there are no statistically significant differences between the left and right hand regarding the coefficient of variation in the first routine.
- The Z-score is 0.28. The p-value is 0.77, and the result is not significant at p<0.5
  Cohen's d = (0.5708 – 0.4930)/0.277 = 0.279 (weak size effect)

In the second routine, the coefficient of variation was between 0.39 and 0.7

Table 7. *Descriptive statistics coefficient of variation (Variability of the movement) – second routine*

No.	*Gymnast*	*Left hand*	*Right hand*
1	B.I.	0.46	0.48
2	C.A.	0.48	0.4
3	P.A.	0.41	0.41
4	V.E.	0.46	0.45

5	P.I.	0.43	0.43
6	C.C.	0.43	0.42
7	B.A.	0.43	0.43
8	B.C.	0.7	0.36
9	M.D.	0.7	0.62
10	M.C.	0.39	0.39
11	L.R.	0.4	0.39
12	T.I.	0.64	0.49
13	P.K.	0.44	0.43
	Mean	0.49	0.438462
	Min	0.39	0.36
	Max	0.7	0.62
	STDEV	0.111952	0.0653
	CV	0.228474	0.14893

Table 8. *Mann Whitney U Test – Coefficient of variation left hand vs. right hand – second routine*

	Sample 1	***Sample 2***	***Sample 1 & 2 Combined***
Sum of ranks	202	149	351
Mean ranks	15.54	11.46	13.5
Expected sum of ranks	175.5	175.5	
Expected mean of ranks	13.5	13.5	
U-value	58	111	
Expected U-value	84.5	84.5	
Standard deviation			19.5

The results of the Paired *Wilcoxon–Mann–Whitney test* for the two routines show that (Table 8):

- The U-value is 58. The critical value of U at p<.05 is 45, and there are no statistically significant differences between the left and right hand regarding the coefficient of variation in the second routine.
- The Z-score is 1.33. The p-value is 0.18, and the result is not significant at p<0.5

Cohen's d = (0.438 – 0.49)/0.09 = 0.56 (medium size effect)

Conclusions

This type of training predominantly stimulates the cerebral cortex, namely the frontal lobe, as an instance of control of voluntary movements, through the primary motor cortex, but is also responsible for managing attention, impulse control, memory or some emotional characteristics of the subject.

Studies in the literature highlight the fact that slow, very slow and super slow exercises are often used for the development of muscle strength and endurance. The key to ultra slow training is not to give the muscles the opportunity to relax, by eliminating the momentum generated by the traditional dynamic work. In this way, the capacity of the muscle contraction, respectively, the force increases significantly. We expect that this type of mechanism will also operate within the central nervous system.

After performing the two routines and collecting the data using the USMIT equipment, the data resulting from the statistical analysis showed no significant differences between the right and left hands in terms of the speed and smoothness of the predefined movement. We can consider that the athletes were closer to the target speed (10 mm /s) at the second repetition, because of their familiarity with the specific USMIT movement.

We believe that the use of USMIT equipment and ultra slow movements can lead to increased neuromuscular control and enhanced accuracy of movements specific to rhythmic gymnastics.

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