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Retention Process of Gymnastics Skills in Young School-Aged Children

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Abstract

The assessment of the level of motor skills in the retention phase is done to determine the impact of the process of motor learning on the process of memorization, and thus on the automation of motor skills. This study aimed at determining the differences in the levels of some gymnastics skills in retention points after different retention intervals. The sample of respondents consisted of a total of 56 first-grade pupils (6.5 years±6 months). The sample of variables consisted of 12 simpler gymnastics skills that were assessed by three independent judges on a 5-point Likert scale. After an experimental gymnastics treatment lasting for 9 months, the subjects were tested two months, and four years post treatment. Trends in the quality of skills retention can be organized into several groups: the first group of skills did not show the differences between different measurement points; however, in the second group, a significant deterioration in performance between measurement points was noted. The third group of skills, structurally the most complex one, showed the differences only after 4 years of the retention period. It can be concluded that no link between the skills has been established, which would precisely define the causes of different trends regarding the decrease in the level of skills. Namely, for some skills, a retention period of two months was sufficient to determine the actual level of acquisition, while some skills required a significantly longer time, in our case 4 years, to determine the actual level of their acquisition.

Keywords: *artistic gymnastics, motor skills, motor learning, automation of skills, acquisition*

Introduction

Participating in gymnastics from a younger age is important for multiple reasons. Besides the fact that it helps build self-morale, determination, and better communication skills, it improves focus and concentration necessary in the school environment (Kerr & Gross, 1997). From the physical aspect, gymnastics training emphasizes bodyweight strength to improve core strength, reflexes, whole-body muscle extension, flexion, as well as balance (Madić, Popović & Tumin, 2009; Akin, 2013). Gymnasts are some of the strongest athletes in the world, and gymnastics strength training can help tone all muscles and assist in decreasing chronic muscle soreness and pain (Kochanowicz, Niespodziński, Mieszkowski, Kochanowicz, & Sawczyn, 2017). Basic gymnastics elements are a combination of fundamental movement skills that are proven to play a vital role in the development of a child and later involvement in sports activities (Burton & Miller, 1998; Gallahue & Ozmun, 1998; Jurimae & Jurimae, 2000; Karabourniotis, Evaggelinou, Tzetzis & Kourtessis, 2002). Basic gymnastics skills include movements that appear throughout a gymnast's development and across various apparatus, and their mastery is crucial for advancement in the sport as well as for better everyday functioning since it develops coordination skills (Vandorpe et al, 2011). Participating in gymnastics programs results in motor proficiency improvement (Culjak, Miletic, Kalinski, Kezic, & Zuvela 2014).

According to Schmidt and Lee (2005), the success of the learning process can be assessed in different ways: 1) the method of calculating the differences in the achieved skills at a certain checkpoint (initial, transitive and final point of the

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learning process) concerning the previous point, and 2) the method of relative retention and the calculation of differences in the achieved skills which makes it possible to determine the "amount of lost knowledge" during the retention interval. The stated "amount of lost knowledge" is the difference between the level of skills at the final point of the learning process and one of the retention points. In this case, the term retention point is considered to be a checkpoint that follows a certain time of the non-repetition of the motor skill. According to Arthur, Bennett, McNelly, and Stanush (1998), forgetting the motor skill refers to the loss or deterioration of acquired skill after a period of non-use. Classical definitions of retention emphasize that retention is the degree to which people can remember (or perform) some previously practiced motor skills after a certain period without repeating them (Magill, 2011). The assumption is that the feedback on motor skills in the retention phase presents the formed motor programs that are, or are not, adopted at the automation level (Carroll & Bandura, 1987). Accordingly, the goal of assessing the level of learning motor skills in the retention phase is to determine the impact of motor learning on the process of memorization, and thus on the automation of the motor skill (Magill & Schoelfender-Zohdi, 1996). Skills are considered mastered if their retention level is the same as and/or similar to the level determined at the final point of the learning process (Schmidt & Lee, 2005).

Since the retention interval is the period in which a certain motor skill was not practiced, the length of this interval is positively related to the level of their decline (Magill, 2011). It is expected that longer retention intervals result in a greater decline in the level of skill compared to shorter retention intervals. The reasons for reducing the level/quality of performance of a particular motor skill are considered to depend on several variables: length of retention period or length of a period without motor skill practice, type of motor skill, and various disruptive activities before or during retention interval (Arthur et al., 1998). Several studies have concluded that the results of the retention test became progressively worse with increasing retention interval and that, to reduce forgetting skills, it would be necessary to increase the level of learning of analyzed motor skill if the length of retention interval increases (Gawron, 2019). It is considered that the level of acquisition of motor skills is one of the most important factors that determine the amount of "retained" knowledge or the estimated level of knowledge at the retention point. To determine as high a level of knowledge as possible in the retention point of projection, the available literature links the concept of "overlearning", and is defined as continuing learning, although those who learn have reached a certain level of skill (Stothard & Nicholson, 2012). The learner continues to practice even when the skill is learned and thus encourages the achievement of the highest levels of acquisition of skills or their automation. Achieving automated performance reduces cognitive requirements when performing this skill, and enables better long-term functioning. Following the above, a higher level of the acquisition of certain skills (preferably automated performance) defines higher retention or determination of higher levels of analyzed motor skills in the retention point. This is the reason why gymnastics skills should be regularly monitored in retention periods; this could also be used as guidance in future planning and programming of the training process.

Researches on retention in gymnastics are rare and mostly focused on the effect of a model of feedback on retention results (Shafizadeh & Shaban, 2018; Frikha, Chaâri, Elghoul, Mohamed-Ali & Zinkovsky, 2019). However, a few of the studies did focus on investigating the period for gymnastics skills retention and researchers have found no decline in the performance of simple gymnastics skills after two weeks of retention (Baudry, Leroy, Thouvarecq & Chollet, 2006; Proios, 2019). A retention period of more than two weeks has not been investigated; hence, this research is very important because it will make a great contribution to the understanding of the proces of long retention when it comes to gymnastics skills. To investigate the period in which the learned basic gymnastics skills are retained, this study aimed at determining the differences in the acquisition levels of some gymnastics skills at retention points after different retention intervals in first-grade pupils.

Methods

Participants

The sample of respondents in this research consisted of a total of 56 students (20 male and 36 female) of the first grade (chronological age 6.5 years±6 months). The male students averaged 126.9 cm in height and 26.7 kg in weight, while the female students averaged 125.9 cm in height and 25.7 kg in weight. The same sample was tested after four years when they attended fifth grade (10.5 years±6 months). According to their preferences, both during and after the experimental treatment, students were involved in extracurricular activities, except in gymnastics. All students who participated in gymnastics programs outside the experimental program were not included in the research. All of them gave verbal assent and their parents gave written informed consent. The Ethical Committee of the Faculty of Kinesiology – University of Split verified that this investigation complied with all ethical standards for scientific investigations involving human participants (approval number 2181-205-02-05-22-0040, 30.12.2022.).

Measurements

Gymnastics skills that were used in this research were chosen according to their structural complexity (simpler and more complex gymnastics skills): bridge, candlestick, forward roll, backward roll, cartwheel, beam walking, jump off the small beam, jump off the high mat, passes from the front bar hanging to the rear bar hanging and back, mount pullover on the bar, wall handstand and straddle sit on the vault. These skills are a part of the begginers school of gymnastics, and were therefore selected for this research. To avoid any subjective assessment, three independent judges (gymnastics experts) evaluated the subject's performances and were previously instructed on the criteria in performing gymnastics skills, which were rated on the Likert scale. Likert scale was used to assess the quality of performance according to the following criteria: (5) performance without technical and/or aesthetic mistakes; (4) performance with small technical and/or aesthetic mistakes; (3) performance with medium technical and/or aesthetic mistakes; (2) performance with large technical and/or aesthetic mistakes; (1) performance was not made at all.

The study was conducted over 35 weeks (23 weeks of treatment, 7-week retention period, and 5 weeks of performance assessment), with the addition of one week for the performance assessment after a 4-year retention period. Boys and girls practiced together three times per week for 45 minutes, during the PE class led by the same teacher. Totally, children practiced during 104 classes in 10 months' time. The classes consisted

of an introductory part of the class (warm-up), a preparatory part of the class (stretching), the main part of the class in which gymnastic skills were practiced, and the final part of the class (cool-down). Initial- and acquisition levels of performance have been assessed during the learning process, the final level of performance was assessed at the end of the experimental program, and the retention levels of performance have been assessed after the PE learning process. Overall, the quality of the performance was assessed five times, with the first retention point done two months after finishing the learning process, and the second retention point done four years after finishing the learning process. For this research, only the final level of performance and two retention points will be taken into analysis.

Statistics

Data were analyzed using the Statistica for Windows 14.0 (TIBCO Software Inc, USA) and statistical significance was set at $p<0.05$. Basic descriptive statistics were calculated for all gymnastics skills each measurement point (mean values and standard deviations (SD), minimum (Min), and maximum (Max) result). For determining the between-subject reliability of the gymnastics skills, Cronbach's alpha coefficients (α) and inter-item correlation coefficients (IIR) were calculated. Analysis of variance (ANOVA) with repeated measures for time with post-hoc Bonferroni test was used to check for differences in the acquisition level of gymnastics skills at retention points compared to the final point of measurement.

Results

The reliability of each analyzed gymnastics skill was checked by calculating inter-item correlation and Cronbach alpha coefficients (Table 1). A review of these coefficients in the final measurement point revealed mostly satisfactory values: IIR ranges from 0.70 to 0.90; Cronbach-alpha coefficient values range from 0.91 to 0.98. In the second measurement point (first retention point), which was conducted 2 months after the end of the teaching process, and during which the analyzed skills were not repeated, the following reliability parameters were determined: IIR ranged from 0.59 to 0.92; Cronbach-alpha values ranged from 0.86 to 0.98. In the third measurement point (second retention point), which was conducted 4 years after the end of the teaching process, and during which it was assumed that analyzed skills were not repeated since most of them were not a part of official curricula in physical education, the following reliability parameters were identified: IIR ranged from 0.60 to 0.94; Cronbach-alpha values ranged from 0.85 to 0.98. Due to satisfactory metric characteristics, most of the analyzed skills will be taken into further analysis, except for straddle sit on vault element, where poor reliability parameters were identified in the third checkpoint.

Table 1. Reliability Analysis (IIR, α) and Descriptive Statistics (Mean, Min, Max, SD) of Analyzed Gymnastics Skills in All Measurement Points

	IIR	α	Mean	Min	Max	SD
Candlestick F	0.76	0.93	3.81	1.40	5.00	0.86
Candlestick 1R	0.81	0.95	3.53	1.00	5.00	0.92
Candlestick 2R	0.88	0.97	3.52	1.00	5.00	1.18
Bridge F	0.75	0.92	3.99	1.50	5.00	0.89
Bridge 1R	0.76	0.93	3.48	1.60	4.80	0.87
Bridge 2R	0.87	0.96	3.39	1.00	5.00	1.15
Forward roll F	0.71	0.92	3.84	1.00	5.00	0.76
Forward roll 1R	0.69	0.91	3.31	1.70	4.80	0.72
Forward roll 2R	0.81	0.94	3.21	1.75	5.00	0.83
Backward roll F	0.83	0.95	3.79	1.00	5.00	0.84
Backward roll 1R	0.81	0.95	3.35	1.00	5.00	0.87
Backward roll 2R	0.85	0.95	2.82	1.00	5.00	0.98
Cartwheel F	0.89	0.97	3.20	1.40	5.00	0.97
Cartwheel 1R	0.76	0.93	2.96	1.10	5.00	0.96
Cartwheel 2R	0.84	0.95	3.12	1.00	5.00	1.08
Beam walking F	0.78	0.93	2.72	2.00	4.70	0.68
Beam walking 1R	0.75	0.93	2.80	1.50	4.70	0.61
Beam walking 2R	0.87	0.96	2.83	1.75	5.00	0.96
Jump-off the small beam F	0.70	0.91	2.97	1.00	4.70	1.03
Jump-off the small beam 1R	0.59	0.86	2.60	1.00	4.90	0.91
Jump-off the small beam 2R	0.72	0.90	3.13	1.50	5.00	0.87
Jump-off the high mat F	0.71	0.91	3.85	2.30	5.00	0.62
Jump-off the high mat 1R	0.70	0.91	3.36	1.20	4.90	0.81
Jump-off the high mat 2R	0.70	0.89	3.40	1.75	5.00	0.82
Passes hanging on the bar F	0.90	0.98	2.90	1.00	5.00	0.85

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Table 1. Reliability Analysis (IIR, α) and Descriptive Statistics (Mean, Min, Max, SD) of Analyzed Gymnastics Skills in All Measurement Points

	IIR	α	Mean	Min	Max	SD
Passes hanging on the bar 1R	0.85	0.96	2.74	1.00	4.90	0.92
Passes hanging on the bar 2R	0.94	0.98	2.08	1.00	5.00	1.41
Mount pullover F	0.90	0.98	3.23	1.00	5.00	0.90
Mount pullover 1R	0.91	0.98	3.21	1.00	5.00	0.88
Mount pullover 2R	0.94	0.98	2.06	1.00	5.00	1.36
Handstand F	0.85	0.96	3.62	2.00	5.00	0.84
Handstand 1R	0.92	0.98	3.45	1.00	5.00	1.00
Handstand 2R	0.94	0.98	2.42	1.00	5.00	1.36
Straddle sit on vault F	0.84	0.96	3.07	1.00	5.00	0.90
Straddle sit on vault 1R	0.81	0.95	3.09	1.00	5.00	0.86
Straddle sit on vault 2R	0.60	0.85	3.13	1.75	5.00	0.78

Legend: F – final measurement, 1R – 1st retention point, 2R – 2nd retention point

The level of acquisition of each analyzed skill was determined by the method of summation, i.e., calculation of the mean value for each skill at each checkpoint (Figure 1). The highest level of acquisition in the first checkpoint (at the end of the teaching process) was determined for the bridge element (3.99), while the beam walking element had the lowest level of acquisition (2.72). Levels of acquisition of other skills were within the range of the two mentioned skills. When observed through the assessment criteria, some skills were performed for the school grade good (3), i.e., performed with medium technical and/or aesthetic flaws. Other analyzed skills were performed at the level of school grade very good (4), and generally had performances with minor technical and/or aesthetic errors.

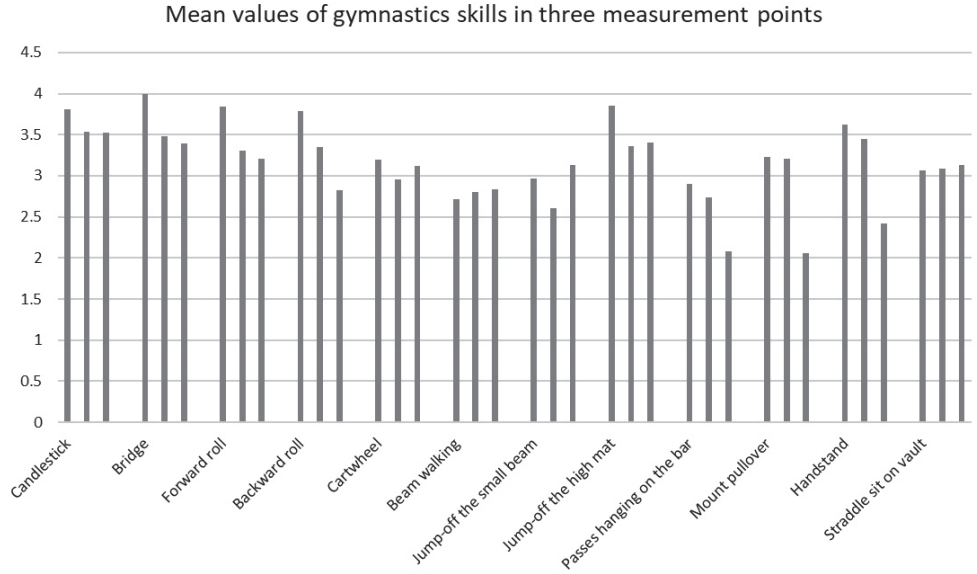

FIGURE 1. Comparison of Mean Values of Each Gymnastics Skill (Element) in Three Measurement Points (Final Point, 1st Retention Point, and 2nd Retention Point)

In the second checkpoint, which followed 2 months after the end of the program, the level of almost all the skills corresponded to the school grade good (3), or represented performances with medium technical and/or aesthetic errors. An exception to the above was the element of candlestick whose performance level was the highest, even after 2 months of non-repetition (3.53).

The level of the most of the analyzed skills after four years of retention continued to correspond to the school grade good (3). As in the second checkpoint, the candlestick element remained the best element performed (3.53). In addition, three elements that were categorized as structurally more complex skills (mount pullover, passes hanging on the bar, and handstand) had numerically much lower values than at the second checkpoint.

The differences between the levels of acquisition of the analyzed skills at different checkpoints were analyzed by ANOVA with the Bonferroni post-hoc test (Table 2). Trends in their values can be organized into several groups. Despite a certain numerical decrease in values between the checkpoints 1–3, they were not found to be statistically significant for the following elements: candlestick, cartwheel, and beam walking. Contrary to mentioned skills, the backward roll is the only skill whose level of performance has been constantly decreasing in the re-

tention period, so much that there are significant differences in the levels of mastery of this skill between all checkpoints. Some skills experienced a significant decrease in value from the first to the second, and the first and third checkpoints (bridge, forward roll, and jump-off the high mat). Although there was some further decline between the second and third measurement points, this decline was not found to be significant. The last group of skills is represented by structurally more complex skills: mount pullover, passes hanging on the bar, and handstand. The trend of their values is identical: despite a certain numerical decrease, no significant difference was found between the first and second checkpoints. Significant decreases in value occurred between the second and third, and consequently between the first and third checkpoints.

Table 2. Results of Analysis of Variance (ANOVA) With Post-hoc Bonferroni Test

	ANOVA		Bonferroni post-hoc		
	F value	p	F/1R	1R/2R	F/2R
Candlestick F					
Candlestick 1R	3.01	0.05	0.12	0.10	1.00
Candlestick 2R					
Bridge F					
Bridge 1R	13.00	<0.001	0.00*	0.00*	1.00
Bridge 2R					
Forward roll F					
Forward roll 1R	23.49	<0.001	0.00*	0.00*	1.00
Forward roll 2R					
Backward roll F					
Backward roll 1R	30.04	<0.001	0.00*	0.00*	0.00*
Backward roll 2R					
Cartwheel F					
Cartwheel 1R	1.18	0.31	0.40	1.00	0.97
Cartwheel 2R					
Beam walking F					
Beam walking 1R	0.33	0.72	1.00	1.00	1.00
Beam walking 2R					
Jump-off the small beam F					
Jump-off the small beam 1R	7.92	<0.001	0.02*	0.73	0.00*
Jump-off the small beam 2R					
Jump-off the high mat F					
Jump-off the high mat 1R	9.15	<0.001	0.00*	0.00*	1.00
Jump-off the high mat 2R					
Passes hanging on the bar F					
Passes hanging on the bar 1R	11.44	<0.001	1.00	0.00*	0.00*
Passes hanging on the bar 2R					
Mount pullover F					
Mount pullover 1R	26.17	<0.001	1.00	0.00*	0.00*
Mount pullover 2R					
Handstand F					
Handstand 1R	22.32	<0.001	1.00	0.00*	0.00*
Handstand 2R					

Legend: F – final measurement, 1R – 1st retention point, 2R – 2nd retention point; *p < 0.05

Discussion

The main goal of this paper was to determine the level at which some gymnastics elements can be "remembered" after a period of non-exercise. The information about the level of retained skill is the basis of its vertical and horizontal progress, but also the basis for planning and programming the learning process.

Analyzing the structural complexity of skills that were at a lower or higher level of acquisition at the first checkpoint, one can not draw a general conclusion that structurally simpler skills reach a higher level of acquisition, and structurally more complex skills reach a lower level of acquisition (Neljak,

2009) after six months of training. Namely, some presumably structurally simpler skills reached a higher level of acquisition, and vice versa. The first retention point generally revealed a certain decrease in the level of performance of gymnastics elements. However, reducing the level of skills acquisition at the time of non-repetition is an expected result of forgetting the performance of skills (Arthur et al, 1998). Although a period of 4 years elapsed from the second checkpoint to the third checkpoint, during which the analyzed skills were not repeated in physical education classes (according to the information obtained from the respondents' teachers), the third checkpoint yielded results very similar to the second checkpoint. The similarity of these results in most of the analyzed skills, regardless of the values of that level, confirm the actual level of their acquisition. Additionally, it can be concluded that a period of 6 months was enough for the structurally simpler gymnastics skills to reach a stable level of acquisition, which generally corresponds to performances with medium technical and/or aesthetic errors. An exception to this was found for three skills that were categorized as structurally more complex skills (mount pullover, passes hanging on the bar, and handstand), where they had numerically lower values than at the second checkpoint. Based on the obtained data, it can be concluded that the mentioned skills were acquired at a lower level. Furthermore, it is confirmed that a longer retention period is required to conclude the actual level of acquisition of certain structurally complex skills, since the level of their performance after a short retention period may lead to false information.

Results showed that the level of performance of some gymnastics skills (candlestick, cartwheel, and beam walking) didn't show a significant difference in retention points when compared to the final measurement point. Since such a result leads to the conclusion that these skills were less forgotten, the opposite assumption can be that those skills are acquired at a higher level compared to other skills, regardless of the values of these levels. Contrary to the mentioned skills, the backward roll was the only skill whose level of performance has been constantly significantly decreasing in the retention period. The reason for this can probably be found in the demands for certain motor abilities. In the time of non-repetition of this skill, motor abilities that children developed during the process of learning probably decreased, thus increasingly "spoiling" the performance of this skill. Such a decline in ability can be partly attributed to the growth of children in which the level of ability, achieved to enable the performance of the backward roll to the final point of the learning process, clearly decreased or was insufficient for increased limbs. All of the above is further related to the level of acquisition of this skill since it was found that motor abilities affect the level of performance of motor skills only during the first phases of motor learning, and with the automated phase of the acquisition of skills, they become insignificant (Delaš Kalinski, Jelaska, & Atiković, 2011). This skill was not acquired at a sufficient level compared to the other analyzed skills. Some skills suffered a significant decrease in value from the first to the second, and between the first and third checkpoints (bridge, forward roll, and jump-off the high mat). The obtained result could be analyzed from the point of the importance of determining the ideal length of the retention period to determine the actual level of acquisition of certain skills. Namely, it is likely that the period of two months (between the first and the second checkpoint) was long enough to significantly reduce the level of this skill's performance and that, after that time, the actual level of the acquisition of this skill is defined. The structurally most complex group of skills (mount pullover, passes hanging on the bar and handstand) was characterized by nonsignificant differences between the first and second checkpoint. Significant decreases in value occurred between the second and third, and consequently between the first and third checkpoints. Given that these are structurally complex skills, and that their level of acquisition decreased only after 4 years of non-repetition, it is assumed that, in addition to forgetting, some other factors caused this result, such as growth and maturation, which remains to be determined by further research.

Since retention tests are one of the strategies to determine the level of skills acquisition, based on the results of this research, it can be concluded that no link between skills has been identified. Namely, for some skills, a retention period of two months was enough to determine the actual level of acquisition, while some skills required a significantly longer period; in this case, a period of 4 years. Further research is needed to detect the factors that affect the length of the retention period as accurately as possible since some research suggest that different learning strategies define the successfulness of the retention period itself (Maleki, Nia, Zarghami, & Neisi, 2010; Shafizadeh, & Shaban, 2018; Frikha, Chaâri, Elghoul, Mohamed-Ali, & Zinkovsky, 2019).

The limitations of the current study can be found firstly in the lacking of the control group of subjects, and following investigations should include such a sample for more accurate and more valid results. Secondly, it is very difficult to interpret the results from this study since there is a lack of similar research with which we could compare them. Due to the fact that researchers suggest using the electronic programs and integrating them in the educational process because this enhances the level of retention among learners, especially in the basic school stages (Shatnawi & Al-Saeedin, 2021), this could be really helpful for future research of the retention of gymnastics skills.

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Conflict of Interest
The author declares that there is no conflict of interest.

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