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**ORIGINAL**

# The effect of specific strength training on the quality of gymnastic elements execution in young gymnasts

**Authors' Contribution:**
**A** Study Design
**B** Data Collection
**C** Statistical Analysis
**D** Data Interpretation
**E** Manuscript Preparation
**F** Literature Search
**G** Funds Collection

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## abstract

**Background** The aim of the study was to determine the effect of specific gymnastics strength training on the quality of technical indicators of gymnastic elements in young gymnasts.

**Material/Methods** The study involved 24 gymnasts aged 12-13 years (n = 11) and 13-15 (n = 13). Among the participants were the winners and medalists of the Polish Championship competitions. The duration of the gymnasts' sports training was 5-8 years. We evaluated the impact of changing the strength capabilities by using a specific strength training program in order to improve the quality of the performance of selected gymnastic elements. Indicators of maximum static strength (isometric) and dynamic strength were established on the basis of the system torque Ergo and Ergo Power Meter (Globus, Italy).

**Results** The data show that the technique can improve performance not only by the overall increase in strength, but also at the expense of mastering the specific strength forms required to perform a specific gymnastic element. This can be done by the specialization of dynamic characteristics of the development of muscle tone and its various varieties: intramuscular, intermuscular coordination and probably the economization of motor units requirement.

**Conclusions** The collected data also indicate that the realization of strength abilities of young gymnasts is closely linked to education and improvement of skills and motor habits. Various aspects of strength abilities gymnasts according to the nature of their content are also characterized by high specificity of their mutual relations.

**Key words** Strength training, artistic gymnastics, young gymnasts

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## INTRODUCTION

Physical preparation (PP) is an inherent part of the development process of elite athletes in virtually every specialization. In recent years, considerable success in deepening the essence of PP as the basis for technical excellence sports and individual components of the training loads in sport has been achieved [1, 2, 3, 4, 5]. It should be emphasized that among various sports, defining the contribution of PP is a very complex task. Especially in sports that consist of a plurality of competition requiring different properties in a movement structure [6, 7, 8, 9]. Artistic gymnastics is a such sport. Moreover, in such sports development of a high technical level requires PP that ensures a broad and comprehensive basis for the implementation of diverse and different in terms of structure exercises in each competition [10, 11, 12]. The concept of PP in gymnastics should firstly take in account meeting certain conducive conditions that improve the capacity of coordination carried out in of the technical preparation [12, 13, 14, 15, 16]. Mastering individual elements and gymnastic routines, which are based on precise coordination of movements of the whole body and its parts, requires a considerable degree of realization of individual potential strength and strength endurance [5, 17, 18, 19, 20]. Besides, it is known that an increase in the cross-sectional surface area of the muscle is fundamental for the maximal improvement in strength in young and adults [19, 21, 22]. The main demands in artistic gymnastics are related to muscle power and strength with significantly mobilizing coordination possibilities. In terms of strength, gymnasts are amongst the strongest athletes when strength is measured (relative strength) in relation to the body weight [18]. This has being demonstrated by their ability to support and move their body mass through various dynamic or static positions [16]. Especially the muscle strength of upper limbs is very important for vaulting, pommel horse, parallel bars, and rings especially for static hold elements, e.g. iron cross, inverted cross and swallow. The muscle size is important for strength, but gymnastics conditioning must not become body building [17, 18, 23]. Therefore, strength improvement is ultimately limited by the muscle size and the muscle cross-sectional area. Training to increase the muscle size and strength is important, but the maximum strength from the minimum size is the most important training goal in gymnastics [17, 18, 24]. Hypertrophy must be kept within strict limits to keep the power-to-body-mass ratio of the gymnast as high as possible [19, 25, 26].

Therefore, sports activities should not be conducted at the limit of strength, in order to get the highest level of technique, even if the gymnast mastered it very well. This implies the need to create specific potential of strength capabilities in the PP process to meet proper requirements of training and competition activities [1, 5, 10].

When securing specific preparation for the implementation of motor skills in technical elements of the different structure of movement, there are some restrictions determined by the insufficient examination of this matter. Currently, with the help of the PP measures within performance techniques of various elements and gymnastic exercises can eventually be guided only by preparation of motor skills due to the limited number of indicators used. To assess the participation of motor skills in the indicators of gymnastic elements of technical performance, the importance of specific directions of strength development possibilities is analysed. In the process of physical preparation in

gymnastics, achieving the necessary level of strength abilities can be realized, provided that the proper measures affecting the necessary level of each type of ability are taken, which are indicated by specific requirements of exercises included in gymnastic routines. These abilities can be formed only with a high similarity of contents and levels of strength in special preparatory exercises in the training process.

### AIM

The aim of the study was to determine the effect of specific strength training on qualitative technical indicators of gymnastic elements in young gymnasts.

## METHODS

### PARTICIPANTS AND STUDY ORGANIZATION

24 young male gymnasts aged 12–13 years (n = 11) and 13–15 (n = 13) years participated in the study. They were multiple medallists in gymnastic competitions. Each gymnast had 5–8 years of training experience, and they all initially trained according to a similar PP program. More details about both groups of gymnasts participating in the study are presented in the description of the organization of the research.

The study included athletes from the University Sports Association at Gdansk University of Physical Education and Sport. In addition, part of the research was conducted at the University of Physical Culture and Sports in Kiev. The study aimed to determine the effect of specific training of different characteristics of strength abilities on the quality of selected exercises in gymnastics. This was applied to gymnastic exercises, in which there is an increased demand for specific strength capabilities. Therefore, the study consisted of four parts. In each part, individual gymnastic elements and their strength determinants were evaluated. The description of each part is presented individually further in this section.

Expert evaluation (judges' score) of each exercise was made by three judges at the national level using a scale of 1 to 5 points [15, 27]. The final result of the performance was the average rating of three judges.

### HANGING SCALE REARWAYS ON THE RINGS

We evaluated the importance of correction of strength capabilities by using the program of specific strength training for the quality of performance of hanging scale rearways (back lever) on the rings. To learn such an exercise, a sufficient level of isometric strength is necessary. For this purpose a group of young gymnast aged 12–13 years (n = 11) implemented a program of specific strength training for 4 weeks (8 training sessions) [5, 17, 18]. One of the main exercises was similar in the structure of movement to this essential element. The execution of this exercise was as follows: gymnasts lied prone on a gymnastic bench with arms arranged along the body. The bench was set under a device for weight training with a suspended load on the pulley lines. The participant grabbed the lines and lowering his arms raised the suspended weight simultaneously elevating legs and maintaining such a position for 4–8 s. The load was about ¾ of the maximum force required to adopt such a position, and amounted from 3 to 7 kg. In each of the eight training sessions

about 3–5 attempts in two series with small rest time were performed (7–15 s). The assessment of the strength level of the involved muscle groups was evaluated as well.

## IRON CROSS ON STILL RINGS

We also evaluated the importance of static strength endurance needed to perform a quality iron cross on still rings. We compared the performance of the two groups of young gymnasts aged 14–15 years (n = 10). Initially, all participants underwent a similar strength preparation program. Grouping was based on the ability to perform the iron cross on still rings, and the relative strength value (normalized by body weight) was also evaluated. The first group included athletes who could perform this element (group 1 – n = 4), while the second group did not have this skill (group 2 – n = 6).

## UPRISE BACKWARD TO HANDSTAND ON THE RINGS

In order to determine the meaning of the effectiveness of different types of preparatory exercises, their impact with an emphasis on strength, speed components (explosive strength) and its slower execution were compared. Two groups of gymnasts aged 13–15 years implemented the following preparatory exercises: (1) on parallel bars – press to handstand with bent arms and the straight trunk with 1/2 toward turn; (2) backward upraise to handstand; (3) on the vaulting box set next to wall bars – a gymnast was lying prone (with contact only with his chest) grabbing the ladder at the height of the chest and performing explosive backward swing of the legs and hold them at full height.

The first group (n = 7) performed the mentioned exercises, emphasizing speed components, and the second group (n = 6) focused their attention on the manifestations of strength with relatively slower execution of movements. Participants performed sets of the mentioned exercises of special PP during 5 weeks of training (17 training units). In both groups, each exercise was performed in 2–4 sets of 2–3 repetitions at different (alternating) order.

Finally, the influence of special preparation on the quality of back uprise to handstand on rings performance as well as on the preparatory exercises was evaluated.

## PRESS TO HANDSTAND

In the execution of many gymnastic elements it is not possible to designate a sufficient number of factors determining the specific training effects during exercises demanding complex strength. If the structure of the exercise is characterized by relatively individual components, the structural and logical mutual relationship between the factors of priority character should be taken into account. In this case, an example would be the difference in the execution of the press to handstand with straight arms, when in the first phase hips rise is followed by legs and press to handstand with the straight trunk. The differences in their execution clearly affect the character of the relations of strength and their specific technique. To characterize these differences, evaluation of performance (technique) of both types of handstand in a group of 13–15-year-old gymnasts (n = 11) was evaluated, along with the assessment of the strength level of involved muscle groups.

## BACK UPRISE CROSS ON RINGS

From the practice of the process of gymnasts' preparation, the greatest physical difficulty is caused by gymnastic elements in which explosive actions (movements) rapidly change into static positions, requiring large muscle tone. To test the significance of a high level of specialization to adapt to the specific nature of changes in levels of muscle work, a number of (8) experimental training units were performed. In this respect, we evaluated the execution quality of back uprise cross on rings. This part of the study was conducted in two groups of gymnasts aged 13–15 years. The first group (n = 5), in a series of special 4-week training, implemented a special program of exercises focused on explosive force preparation. The second group (n = 6) primarily implemented exercises whose aim was to develop muscle strength of the arms and the shoulder girdle in a static load as well as exercises developing static strength endurance. In this analysis the relative strength value (normalized by body weight) was also evaluated.

After observation of the world's elite gymnasts in several European, National, and World Championships events, it was shown [18] that elite gymnasts have accented the usage of the following muscles: elbow extensors (movement: straightening the elbow joint; typical exercise: bar dips or handstand push-ups); shoulder (hyper-) flexors (movement: lifting the arms above and behind the head; typical exercise: press to handstand); sternoclavicular joint elevators and depressors (movement: lifting or pushing down the shoulders and arms; typical exercise: straight arm lat pulldowns or incline bench press); hip extensors (movement: kicking the thigh back; typical exercise: cast to handstand); shoulder extensors (movement: pushing the arms down and behind the back; typical exercise: Manna).

In addition, the male gymnast must have hypertrophied: shoulder adductors and horizontal adductors (movement: end of front giant in rings, cross; typical exercise: flys); elbow flexors (movement: bending the elbows; typical exercise: initial pull up to Asarjian on rings). Many of the muscles that participate in these movements also participate in other movements important for technically perfect gymnastics, for example by stabilizing joints (stabilizers).

## DYNAMOMETRIC ANALYSIS

In gymnastics considerable emphasis in selection of tests of specific motor skills are those which enable an assessment of different types of strength abilities. Indicators of maximum static (isometric Fmax peak) and dynamic (peak of force) strength was established on the basis of the Ergo Meter and Ergo Power dynamometric system (Globus, Italy) according to Bosco [28]. The Ergo System consists of a powerful central unit, which enables interfacing different modules in order to create personalized assessment in sports fields. An isometric dynamometer was used in order to measure the maximum isometric force of the body by means of an electronic sensor. Data coming from the transducer allow quantifying and representing the average and the peak force movement parameters. The dynamic force assessment enabled evaluating a peak of force achievement, rebuilding the natural pattern of muscular activation in the special type of dynamic work of athletes, as prescribed by Bosko [28] and designated earlier by Menkhin [1], Zasada [5] and Sawczyn et al. [29].

The maximum values of three measurements were used for analysis. Strength endurance measurements were carried out on the basis of holding time of isometric effort.

### STATISTICAL ANALYSIS

Research material was analysed using "Statistica 5.0 PL" package. Research material was analysed using t-student test. The significance of tests was considered at $p \leq 0.05$. According with the objectives, authors attempted to describe and interpret a relationship between variables describing strength and the quality of technical performance of gymnastic exercises. For this purpose Pearson's correlation coefficient, which is used to quantify the linear relationship between various parameters, was used. In the study the characteristics increments of strength and the score for the execution of exercises were analysed. One of the directions of the analysis was to check the informative value of tests used for the assessment of indicators of strength in gymnasts of all ages and levels of qualifications. In this analysis, the data of previous studies was used [1, 2, 3]. The level of informative value of trials and strength testing in relation to gymnastic elements was assessed based on empirical criteria and logically structured knowledge.

## RESULTS

### HANGING SCALE REARWAYS ON RINGS

In the first part of the study the impact of special strength preparation (4-week strength training) on the quality of execution of hanging scale rearways on rings was evaluated. The study results for this experiment are shown in Table 1.

Table 1. Indicators of increase in the technical level of performing hanging scale rearways on still rings (judges' score) and the strength capabilities of the muscle groups involved in its execution (after a 4-week program of special strength training) in adolescent gymnasts aged 12–13 years (n = 11)

| Variables and indicators | | Baseline mean ±SD | After training mean ±SD |
|---|---|---|---|
| Hanging scale rearways | score [points] | 1.65 ±0.21* | 2.35 ±0.38* |
| | holding time of the maximal force [s] | 3.75 ±0.90* | 5.75 ±1.41* |
| Arms flexors | relative strength (normalized to body weight) | 0.39 ±0.03* | 0.49 ±0.04* |
| | holding time of the maximal force | 1.19 ±0.64* | 3.44 ±0.72* |
| Trunk extensors | relative strength (normalized to body weight) | 1.89 ±0.09* | 2.15 ±0.07* |
| | holding time of the maximal force | 20.4 ±3.7* | 26.9 ±5.2* |
| Hips extensors | relative strength (normalized to body weight) | 0.27 ±0.07 | 0.34 ±0.09 |
| | holding time of the maximal force | 1.38 ±0.17* | 3.01 ±0.21* |

* Significant differences between baseline and afterwards at $p \leq 0.05$.

As results of strength training show, a significant increase in the relative muscle strength of arms flexor, torso and hip extensors can be noticed. It should be noted that the largest increase was observed in the holding time of maximum effort of the involved muscle groups. The impact of the training program was even more marked in the increase in indices of the quality of performance of hanging scale rearways on still rings and its maximum holding time. Therefore, a significant increase in both muscle strength and their static strength endurance were observed. This pattern refers to the muscles of the upper limbs, the latissimus dorsi muscle and trunk flexors and static strength of hip extensors.

Correlation analysis between an improvement in the technique performance (judge score) and its holding time in relation to the increase in strength indicators shows that the assessment is highly related to the static strength endurance, as the sum of all holding times of the maximal force in respective muscle groups ($r = 0.69$ at $p \leq 0.05$).

## IRON CROSS ON STILL RINGS

In order to determine the effect of the level of development of static strength endurance to perform iron cross, the results obtained by the two groups of adolescent gymnasts aged 14–15 year were compared. The characteristics of the numerical analysis are shown in Table 2.

Table 2. Impact of the development level of static strength endurance on the quality and holding time of iron cross on still rings including the relative strength level in two groups of young gymnasts (mean ± SD)

| Gymnastic groups | Relative strength (normalized to body weight) | Assessment of the level of static strength endurance (iron cross on still rings) | |
|---|---|---|---|
| | | judges' score [points] | holding time [s] |
| Group 1 – able to properly perform the iron cross (n = 4) | 0.897 ±0.151 | 4.38 ±0.38* | 7.98 ±1.94 |
| Group 2 – unable to properly perform the iron cross (n = 6) | 0.817 ±0.022 | 1.65 ±0.46* | 5.47 ±2.13 |

* Significant differences at $p \leq 0.05$.

The data show that in the absence of differences in the relative strength (0.897 ±0.151 and 0.817 ±0.022) the differences in strength endurance (holding time of the maximal force: 7.98 ±1.94 and 5.47 ±2.13 s) are minor and insignificant. In contrast, significant differences between groups, in favour of the first group were observed in the case of the quality of execution (judges' score) – at $p \leq 0.05$. In addition, the obtained data testify that the level of relative muscle strength is not the only determinant of the performance of the power element, iron cross on still rings.

## BACK UPRISE TO HANDSTAND ON RINGS

Correlation between an increase in the quality values of back uprise to handstand on rings and preparatory exercises obtained after a series of special strength training are shown in Table 3.

Table 3. Indicators of an increase in the score for back uprise to handstand on rings and applied preparatory exercises after 5 weeks of strength oriented training in 13–15 years gymnasts (mean ± SD)

| Gymnastic groups | Back uprise to handstand on rings | Preparatory exercises | | |
|---|---|---|---|---|
| | | 1 | 2 | 3 |
| Group 1 (n = 7 ) explosive strength oriented | 1.95 ±0.17** | 1.34 ±0.12* | 0.75±0.06 | 0.98 ±0.07* |
| | | r = 0.63* | r = 0.52 | r = 0.59* |
| Group 2 (n = 6) static strength oriented | 1.02 ±0.19** | 0.93 ±0.08* | 0.57 ±0.04 | 0.57 ±0.05* |
| | | r = 0.50* | r = 0.41 | r = 0.48 |

Significance of correlation at *$p \leq 0.05$; r – Pearson's correlation coefficient; 1 – press to handstand with bent arms and straight trunk with 1/2 toward turn; 2 back uprise to handstand; 3 – on the vaulting box set next to the wall bars – a gymnast was lying prone grabbing the ladder at the height of the chest and performing explosive backward swing of the legs and hold them at the full height.

It has been shown that application of special preparatory exercises in training resulted in an increase in the quality of performing back uprise to handstand on rings in both studied groups as well as in their technical quality of special preparatory exercises.

It should be noted that in results of comparative analysis, level of increase in the quality of the main exercise was found significantly higher in group 1.

## PRESS TO HANDSTAND

Pearson's correlation coefficient between the performance quality of two forms of press to handstand and the strength indicators of the involved muscle groups in these exercises are shown in Table 4.

Table 4. Correlation of the performance quality (score) of two forms of press to handstand and strength indicators of the involved muscle groups

| Quality score of exercises | Strength indicators of the involved muscle groups | | | |
|---|---|---|---|---|
| | trunk extensors | hips extensors | shoulder flexors (movement of the trunk) | shoulder flexors (movement of arms) |
| Press to handstand with straight arms and bent body | 0.623* | 0.502 | 0.348 | 0.217 |
| Press to handstand with bent arms and straight body | 0.355 | 0.857* | 0.335 | 0.104 |

* Significance of correlation at $p \leq 0.05$.

As Table 4 shows, the quality of performance of both types of handstand depends on an adequate level of strength capabilities. During the execution of the press to handstand with straight arms and bent body, the quality of performance was significantly related to strength indicators of trunk extensors, while the relationship with strength indicators of other muscle groups was insignificant. On the other hand, the quality of press to handstand with bent arms and straight body was determined by a significant high level of strength of the hip extensor muscles. The analysis showed that for the proper implementation of each of these types of elements not only a clearly defined group of skeletal muscles is used, but also some of their individual special capabilities.

### BACK UPRISE TO CROSS ON RINGS

In order to determine the effect of the specialized strength training on the ability of transition from dynamic gymnastic elements into static ones, the quality of back uprise to handstand on rings before and after implementing two forms (explosive or static) of exercises were evaluated. Results are shown in Table 5.

Table 5. Influence of training consisting of specialized exercises directed at explosive (group 1) and static (group 2) strength on the quality of back uprise to handstand on rings in gymnasts aged 13–15 years (mean ±SD)

| Measurement | Group 1 (n = 5) | | | Group 2 (n = 6) | | |
|---|---|---|---|---|---|---|
| | body weight | strength (normalized to body weight) | increase in score | body weight | strength (normalized to body weight) | increase in score |
| Baseline level | 56.3 ±1.2 | 83.2 ±3.1 (1.48) | 0 | 57.8 ±1.00 | 78,0 ±3.1 (1.35) | 0 |
| After special training | 56.2 ±1,1 | 85.1±3.3 (1.51) | 3.6 ±0.4* | 57.9 ±0.9 | 85.4 ±2.0 (1.47) | 1.2 ±0.2* |

* Significant differences between baseline and after at $p \leq 0.05$.

Higher mean quality results in learning back uprise to handstand on rings were achieved in gymnasts from the first group, who during the observation period implemented explosive exercises. The obtained intergroup difference was significant. At the same time, it must be noted that there was no significant increase in the relative muscle strength. Gymnasts in the second group, with static strength training, had a greater increase in both the relative muscle strength and static strength endurance. In this case preparation which was aimed both at the development of a rapid production of static muscle tension and at increasing its ability to quickly process the different levels of activity of muscle work gave the best results in this regard.

## DISCUSSION

The study evaluated an influence of directed training of different characteristics of strength abilities on the quality of chosen gymnastic exercises. These were exercises incorporated in gymnastic routines in the learning of which there is an increased need for specific strength abilities.

Results showed that, to achieve a high technical level, PP should mainly focus on increasing the strength characteristics and the ability to resist specific for the whole body manifestations of fatigue. As shown in previous studies, the technique of execution can be improved not only by an increase in absolute strength, but also by mastering specific strength characteristic corresponding to a specific gymnastic element [4, 9, 13, 15]. This can be done by specialization of dynamic characteristics of muscle tone development and its varieties: intramuscular, intermuscular coordination and economization of the motor units requirement [14, 17, 18, 22]. The existing data primarily indicate the need to improve strength to effectively perform gymnastic elements [6, 14, 17]. Specific data on the importance of quantitative and qualitative characteristics of strength causing an effective and lasting implementation of individual gymnastic elements is very scarce. Usually, there are only general statements, but little on combining strength with the quality of executing gymnastic elements and their combinations [11, 12, 18]. Well-trained 12-year-

old boys commonly show comparatively high values of relative strength. But as teenagers become heavier, their relative strength should decrease. In the case of the pubertal male gymnast, the problem is due to a relative strength that cannot keep up with the increase in body mass due to growing body height [22].

The results indicate that the impact of a specialized training program is largely visible in increased rates of the execution quality of hanging scale rearways on still rings and its maximum holding time. Thus, a significant increase in both muscle strength and the static strength endurance occurs. This pattern applies to the upper limbs muscles, the latissimus dorsi muscle, trunk flexors and static strength endurance of the hip extensors. Judges' scores for the execution quality are clearly dependent on the summary indicator of static strength endurance. This is connected with the fact that for certain strength indicators there is no significant increase in strength. However, in all cases, there is an increase in static strength endurance. These data may indicate the existence of other factors which can raise the level of technique in that gymnastic element.

Results more than enough show that the level of relative muscle strength is not the only determinant of the performance of a strength element, such as iron cross on still rings. The level of relative muscle strength in gymnasts is related to a small extent (it did not reach significance) to the summary indicator of static strength endurance of muscles involved in the execution of this gymnastic element. Results also highlight the importance of the impact of specific static strength endurance for gymnasts' strength capabilities important to perform a number of important and required gymnastic elements.

A high significant relationship between specific characteristics of strength and the execution quality of gymnastic elements during implementation of preparatory exercises at various speeds of execution was observed. This type of impact on technical elements of explosive strength can be seen in gymnastic elements such as: back uprise to handstand on parallel bars. Although the relative efforts are not large, their concentration over time has high requirements for the gymnasts' preparation of explosive strength. During such movements, high requirements are posed, for example, achieving the maximum effort in a very short time of movement (in the range of 10–22 m/s), and this can be seen only at certain times of the movement. In the absence of the possibility to designate a sufficient number of factors determining the specific training effect during learning complex strength movements, the structural and logical mutual relationship between the factors of priority character should be taken into account [9]. Such analysis well illustrates the differences in the nature of the relationship between strength "quality" and result of the technical implementation of movement at a time when the structure of the exercise has relatively independent components.

## CONCLUSIONS

Based on the obtained data, it can be assumed that improvement in highly specialized speed-strength components of motor performance, which are key links of many gymnastic elements and combinations, are a decisive factor of increasing the technical level of their execution. This can be confirmed by the

highest and statistically significant relationships between the quality increase in auxiliary exercises of PP characterized by the same type of movement components. This proves the thesis that in sport disciplines of complex movement coordination, especially in artistic gymnastics, the basic nature of the movement which takes place during a competition and the auxiliary exercise of PP used for this purpose should be analogous to their strength and speed characteristics.

One of the specific features of gymnastics is that even with the conformity of the characteristics of basic and preparatory exercises, during the implementation of a gymnastic routine, this rule is often not fulfilled. This indicates existence of other necessary factors of a comparable nature that should be included in the determination of the content of specific preparatory exercises within PP. Especially, this concerns the strength potential needed in various body positions. For example, the strength indicators during the execution of back and forward uprise clearly differ.

Conditions in which the quality of components is related with the strength of trunk extensors and with varying levels of other muscle groups create high demands on the specific components of coordination, manifesting in different characteristics of muscle tension and the level of their work. The difficulty of such relationships is especially conditioned by both the speed of static tension developed by major muscle groups and by high ability to change explosive work into static one with high movement compatibility of various parts of the body. Coordinated changes (in a specific moment of gymnastic combinations) of dynamic speed-strength nature of the work from the outgoing to the overcoming, or vice versa, also cause difficulties. Even a small delay or acceleration of such a change could lead to failure of the static posture or the appearance of significant technical errors.

The above results demonstrate a need for a differentiated approach in the selection of specific forms of PP while improving complex strength demanding exercises. For proper implementation of each of the mentioned types of elements not only defined muscle groups are used, but also capabilities of single involved muscle. It is also worth noting that at the time of their execution, an evident change in the level of muscle work takes place. This is a result of permanent changes to the relationship between movements or their feedback and the static body positions. Each of the elements requires a high level of speed-strength capabilities and the ability of their implementation in the form specific to the element.

Results could suggest that such a situation may be related to insufficient mastery of a high-speed level of muscle work at its implementation during transition into static conditions (in the overall execution of the exercise). In this case, only the sufficiently highly specialized strength preparation to different levels of muscle work may be the most effective in learning the exercise. Preparation that is directed both at the development of static strength and quick adjustment of strength levels gives the best results in technical preparation to most exercises and routines. The conducted study clearly indicates guidelines for training programming to achieve designated effects aimed to master the quality of the mentioned gymnastic exercises. It should be noted that taking into account such guidelines in improving many

other elements, characterized by a similar, complex structure of movement with similar characteristics of usage of various forms of strength activity, may constitute an important part of specialized gymnastic preparation. The observed data also have a direct relationship with the tasks of PP, because they allow for qualitative selection of the most appropriate effective measures in the optimization of their range. They also help determine the necessary levels of development of the basic aspects of motor skills to the tasks of technical preparation. The obtained data provide additional information on the properties of the manifestation of different aspects of motor skills consistent with the specifics of their implementation within the performance techniques of various gymnastic exercises, as well as the determination of functional state and symptoms of fatigue. Analysis of the collected material draws attention to the general regularity of usage of special physical preparation in terms of their priority orientation. It is based on the fact that at different stages of long-term gymnastic training, when gymnastic mastery is developed, specialized development of various groups of forms of motor abilities to their rational interdependence is the basic task of special physical preparation. Special training is necessary to develop strength and power in an athlete sufficient for correct technical performance of skills [30]. Repetition of the skill alone will not guarantee even a minimum level of strength to perform the skill correctly.

The collected data also indicate that the realization of strength abilities of young gymnasts is closely linked to education and improvement of skills and motor habits. Various aspects of strength abilities in gymnasts according to the nature of their content are also characterized by high specificity of their mutual relations.

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