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Original Article

Effect of Functional Strength Training on the Skill Performance Level on the Vaulting Table for Juniors in Gymnastics

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Abstract

This study aimed to design a functional strength training program and evaluate its impact on the skill performance level of junior gymnasts on the vaulting table. Six gymnasts were 11–12 years old, participated as an experimental group. The findings revealed that implementing functional strength training positively influenced the skill performance level on the vaulting table, enhancing the gymnasts' execution and overall performance. Additionally, the program contributed to significant improvements in muscle strength, which is essential for gymnastics skills. The study highlights the importance of incorporating functional strength training as a core component in gymnastics training programs for juniors. Based on the results, the author recommends adopting the proposed program and its detailed implementation steps in training to enhance junior gymnasts' performance and physical abilities. This study provides a foundation for future research and practical application in gymnastics coaching and training.

Keywords: *Functional Strength, Junior Gymnasts, Handstand*

Introduction

The tremendous scientific and technological progress that the world is witnessing today is the distinctive feature of the current era, as it contributes to finding scientific solutions to many problems in various fields in general and the field of physical education in particular. Scientific progress in the use of sports training technology in developed countries, starting from preparing young people until they reach high levels, does not come randomly or by chance, but rather through sound scientific planning of training programs and reliance on the results of studies by authors and specialists in the fields of sciences related to the fields of physical education.

Gymnastics is of great importance in the field of various sports because of its features that make it at the forefront of sports. This sport also requires physical and skill development, so it requires great effort and greater energy expenditure. Since the vaulting table is one of the artistic gymnastics devices for men, and the number of jumps based on it is more than one hundred types that the player performs during competitions from childhood to international competitions, and the degree of difficulty of the jump increases with the change in its shape according to the place of support with the hands or performance with rotations before or after the push with the hands, so the performance criteria on this device are represented in the speed of approach and the strength of the rise with the legs and the push with the hands on the device (contact with the surface of the device and the angle of release). (Amin, M, 2000)

The skills on gymnastic equipment can only be developed and mastered by developing various physical abilities such as strength, endurance, agility and flexibility. Muscular strength is considered one of the important elements of physical fitness in the sports field, which affects the level of motor performance specific to the type of sports activity. Strength requirements differ from one activity to another. Muscular strength is divided into three main types: maximum strength - strength endurance - strength characterized by speed (muscular capacity). Muscular capacity is defined as the ability of muscles to overcome resistance that requires a high degree of speed in muscle contractions. (Amin, M, 2000)

Abdul Aziz Al-Nimr and Nariman Al-Khatib (2005) explain that performance in all sports activities depends on how the body moves, and the body moves through muscles, which contract and pull the limbs from one position to another. The stronger the muscles, the more effective these contractions are, and thus increasing strength enables the player to jump higher, run faster, and in short, it will enable him to perform better athletically. In addition, the path to preventing injuries begins with balanced development of strength on both sides of the body's various joints between the moving muscles and the opposing muscles. Perhaps the most prominent factors leading to injuries are due to the lack of balanced development of strength on both sides of these joints. (Al-Abyawi, N. ,2021)

Scott Gaines (2003) points out that the importance of functional strength training lies in the fact that it has indirect effects on the muscles by converting the increase in force produced from movement that can be used to improve the performance and integration of the nervous system. Therefore, all training programs must include functional strength training. (Gaines, S. ,2003)

"Ejlal Ibrahim, Nadia Darwish" (1994) explain that the muscles working for strength training are in the center or mid-body area, which includes the abdominal, back and side muscles, which is the main physical and muscular center for distributing movement in the human body because if we draw a longitudinal line from the head to the legs, and a transverse line from the middle, the two lines meet at a point in the middle of the body, which is the

abdomen and the corresponding area, the back and sides. The evidence for this is that if the player moves the arms or legs, he feels the movement of the abdominal, back and side muscles, and thus feels his physical muscular center, which leads to ease of controlling movement. Therefore, centering is considered the basis for good motor performance. (Ibrahim, E. M., & Darwish, N. M.,1994)

Functional Strength Training: Defined by Fabio Comana (2004) as "integrated, multi-dimensional movements (frontal, transverse, sagittal) involving acceleration, stabilization, and deceleration. These movements aim to enhance motor ability, core strength (referring to the spine and mid-body), and neuromuscular efficiency."

Core Stability: The ability to control the position and movement of the trunk relative to the pelvis to achieve optimal positioning for force production, transmission, and movement control until the completion of sports activities.

Canter Muscles: Refers to the muscles of the trunk and pelvis, which are responsible for maintaining the stability and balance of the spine and pelvis. These muscles also assist in generating and transferring force from larger body parts to smaller ones. (Operational Definition)

Fabio Comana (2004) points out that balance in muscle action is a key element in functional training, not only between strength and flexibility or working and non-working muscles, but also what we might think of as means used, for example standing on one foot and being able to move other body parts without falling, this is an important interactive feature in functional training. (Comana, F., 2004)

The vaulting table is one of the gymnastics devices with a special nature that depends on basic technical stages, which are the approach, the final step, the ascent, the first flight, the support and push, the second flight, and the landing. The incorrect performance of any of these previous stages affects the proper performance of the jumps in their entirety. The movements on the vaulting table require physical qualities such as speed, strength, agility, etc. Learning difficult skills on this device is also linked to learning basic skills, which represent the basis for mastering more difficult skills. The vaulting table is also considered one of the important devices that require a high degree of attention, in order to save effort and time and raise the level of skill performance. (Amin, M., 2000)

Through the author's work as a gymnastics coach and reviewing many scientific references and previous studies specialized in the field of training in general and gymnastics in particular, he noticed that performance on the vaulting table depends on the muscles of the lower limb in addition to the muscles of the upper limb. It is known that the amount of muscles in the lower limb to perform skills on the vaulting table produces a large amount of strength

and ability, but it does not reach the upper limb completely due to the weakness of the muscles of the core area, which is responsible for transferring strength from the lower limb to the upper limb. This prompted the author to try to find a way to treat this problem. Functional strength works to strengthen the core muscle area, which helps to fully transfer the force produced from one limb to another and be completely fluid while maintaining the loss of strength from the core area, in addition to generating strength in the core area, which increases the amount and quantity of force transferred from the lower body to the top.

This prompted the author to design a training program using functional strength training (throw medical functions 3 kg - strength and stability of body muscles - muscle strength (20 seconds) - muscle strength (20 seconds) - on handstand (stability) and test its effect on job performance and performing skill of vaulting table.

Study Hypotheses:

1- There are statistically significant differences between the averages of the pre- and post-measurements of the experimental group in functional strength (throw medical functions 3 kg - strength and stability of body muscles - muscle strength (20 seconds) - muscle strength (20 seconds) - on handstand (stability) in favor of the post-measurement.

2-There are statistically significant differences between the averages of the pre- and post-measurements of the experimental group in the level of skill performance (somersault skill - roundoff skill) on the vaulting table device, in favor of the post-measurement.

Materials and Method

The author used the experimental method of one group with pre- post measurement design.

Participants

They were (6) athletes, from (11 to 12) years old, playing for Juba Club, Saudia Arabian. They were registered in Saudi Gymnastics Federation. Adding to (4) juniors from the same age category and the same club, for the pilot study. Then the whole athletes were divided into two equal groups each of (5) athletes: a distinguished group, and a non-distinguished group.

Table (1) shows the homogeneity among the participants in all variables, as the value of the skewness coefficient is l between (+3, -3), which indicates the moderation of the distribution among the experimental group members.

Pilot Studies

For testing the validity of the used **Functional strength tests**, the author tested the two groups of participants (the distinguish and the non-distinguish). The used functional strength tests are Strength test for abdominal muscles and hip flexors, Muscular strength test for back

muscles, Muscular strength test for shoulder and arm muscles, Handstand test (stability) for shoulder and arm muscles, throwing 3 kg medicine ball, Strength and stability of trunk muscles.

Table 1 Characteristics of the participants (n=6)

Variables		unit	mean	SD	Skweness
Growth Rates	Age	Year	11.50	1.20	0
	Training age	Year	5.50	0.53	0
	Height	cm	148.75	5.63	0.132
	Weight	kg.	43.70	4.54	0
Functional Strength Tests	Broad jump	cm	165.35	5.42	0.328
	Vertical jump	cm	20.51	2.36	-0.195
	Medicine ball throw 3 kg	m	4.224	4.12	-0.192
	Strength and stability of the core muscles	sec	90.13	6.08	-0.18
	Abdominal strength (20 sec)	rep	21.6	3.18	0.188
	Back strength (20 sec)	rep	35.80	5.84	1.071
	Handstand (stability)	cm	13.60	3.18	0.188
Vaulting horse Performance	Front somersault skill	degree	6.254	0.51	1.142
	Roundoff skill	degree	6.211	0.42	0.447
	Performance level	degree	6.235	0.32	1.654

Table 2. Arithmetic mean and standard deviation for both the distinguished and non-distinguished groups In functional strength tests (n= 10)

Variables	Featured Group		Non-Featured Group	
	mean	SD	mean	SD
Broad Jump	47.551	1.87	39.698	3.807
Vertical Jump	164.354	4.46	162.354	5.425
3kg Medicine Ball Throw	4.724	3.184	4.284	4.174
Trunk Strength and Stability	89.13	6.08	85.134	6.682
Abdominal Strength (20s)	21.224	0.836	17.642	1.14
Back Strength (20s)	34.445	1.673	29.625	1.1401
Handstand (Stability)	22.436	1.816	18.355	1.581

Table (3) shows that there are statistically significant differences between the distinguished and non-distinguished groups in all tests, which indicates the validity of these tests in distinguishing between groups.

The author cooperated with committee of judges that accredited by the Gymnastics Federation to evaluate the performance. The participants were asked to perform Handspring and Round-off. Each performance was evaluated by degree of 10.

Table 3. Significance of differences between the distinguished group and the non-distinguished group in functional strength tests using the Mann-Whitney test to calculate the validity of the tests (n= 10)

Variables	Group	N	Mean of ranks	Sum of ranks	Mann-Whitney	Cohen's d
Broad Jump	Featured	5	8.00	40.00	0	2.63
Vertical Jump	Non- Featured	5	3.00	15.00		
3kg Medicine Ball Throw	Featured	5	8.00	40.00	0	2.64
Trunk Strength and Stability	Non- Featured	5	3.00	15.00		
Abdominal Strength (20s)	Featured	5	7.80	39.00	1	2.44
Back Strength (20s)	Non- Featured	5	3.20	16.00		
Handstand (Stability)	Featured	5	8.00	40.00	0	2.63
Broad Jump	Non- Featured	5	3.00	15.00		
Vertical Jump	Featured	5	7.90	39.50	0.5	2.52
3kg Medicine Ball Throw	Non- Featured	5	3.10	15.50		
Trunk Strength and Stability	Featured	5	7.90	39.50	0.5	2.55
Abdominal Strength (20s)	Non- Featured	5	3.10	15.50		
Back Strength (20s)	Featured	5	7.90	39.50	0.5	2.56
	Non- Featured	5	3.10	15.50		

Tabular value of "D" at 0.05 significance level = 1.96

Table (3) shows that there are statistically significant differences between the distinguished and non-distinguished groups in all tests, which indicates the validity of these tests in distinguishing between groups.

Training Program

1- Objective of the program

This program aims to develop the level of skill performance for juniors on the vaulting table (Handspring – Roundoff).

2- Principals of the training program:

a. Using all support methods and techniques (directed - preventive - leadership - leadership - leadership and motor guidance).

b. Scientific selection of special functional strength training that serves skill performance.
c. The proposed training program was implemented over a period of (8) eight consecutive weeks, at a rate of (3) training units per week, so that the total number of training units would be (24) twenty-four training units.
d. The author used low-intensity interval training (50 - 70%) of the player's maximum, as it is suitable for the intensity and nature of performance in gymnastics and is compatible with the time of the sports season.

3- The content of the training program

- The total training time during the proposed program was determined according to the following:
- Number of weeks of the proposed functional training program: (8) weeks for two months.
- Number of training units for all devices per week (6 devices) x 5 units.
- The number of training units on the vaulting table per week is 3 units.
- The number of training units on the functional strength per week is 3 units.
- Number of devices in the training unit = three devices
- Training unit time = 240 minutes, as shown in table (4)

Table 4. time distribution of the unit duration among the devices

Training session parts	Duration
Preparation and warm-up	45 minutes.
First device	45 minutes.
Second device	45 minutes.
Third device	45 minutes.
Special physical preparation	60 minutes

Training time on the vault table device during the program period is calculated as follows:
- Skill training time on the device (45 minutes) x Number of days training the device per week (3) x Number of weeks (8) = 45 x 3 x 8 = 1080 minutes.
- Physical training time on the device = 60 minutes on the number of devices (6) = 10 minutes in the training unit.
- The time of the functional training program (physical - skill) was distributed over the time allocated to the program.

Main Study

Pre- measurements

The author conducted pre-measurements for the research sample players in the variables of functional strength and skill performance in the period from 5/26/2023 to 5/27/2024 in order to identify the level of the research sample players in the physical variables and skill

performance through standardized physical tests and evaluating the level of skill performance through a group of international gymnastics judges.

Training Program

The content of the proposed cross-training program attached (4) was applied to the members of the basic research sample (one group) during the period from 1/18/2024 to 3/17/2024 for a period of (8) weeks, at a rate of (4) training units per week.

Post measurements

The author conducted post-measurements, evaluated the level of skill performance, and compared it with the pre-measurement to determine the extent of improvement for the players in the research sample during the period from 7/29/2022 to 7/30/2024.

Tools and devices

- weight scale in kg.
- Restameter to measure height in cm.
- Jumping table.
- Platform with a height of (1 m).
- Stopwatch.
- Mini trampoline device
- Divided box.
- Wall Bar .
- Elastic bands.

Statistical Treatments

According to the objectives and hypotheses of the study, the author used the following statistical treatments:

Mean - Standard Deviation Stdev.- Median - Skewness - Test (Wilcoxon Signed-Rank Test) - Improvement percentage.

Results and Discussion

Table (5) shows that there are statistically significant differences between the pre- and post-measurement in the post-measurement direction in the functional strength tests, as the arithmetic mean of the post-measurement was greater than the pre-measurement.

Table (5) shows an improvement in all variables, where the largest variable in the improvement rates was the strength of the leg muscles, with a percentage of 37.967%, and the least was the strength of the arm muscles, with 1.23%.

The results of the statistical analysis from Table (5) and (6) indicated that there was a noticeable development in the level of muscle strength of the legs and arms and an improvement in the strength of the abdominal, back and side trunk muscles. The author attributes this improvement in the level of muscle strength to the functional strength training under study,

which contains exercises directly directed at developing and improving muscle strength, which is considered one of the special physical qualities required for performance.

Table 5. Significance of differences between pre-measurement and post-measurement in functional strength tests using Wilcoxon test (n = 6)

Variables	Rank trend	n	Average Rank	Total ranks	Cohen's D
Broad Jump	Negative ranks	0	0	0	-2.121*
	Positive ranks	5	3.00	15.00	
Vertical Jump	Negative ranks	0	0	0	-2.060*
	Positive ranks	5	3.00	14.00	
Throwing a 3 kg medicine ball	Negative ranks	5	3.00	15.00	-2.030*
	Positive ranks	0	0	0	
Strength and stability of the core muscles	Negative ranks	0	0	0	-2.050*
	Positive ranks	5	3.00	12.00	
Strength of the abdominal muscles (20 sec)	Negative ranks	0	0	0	-2.060*
	Positive ranks	5	3.00	13.00	
Strength of the back muscles (20 sec)	Negative ranks	0	0	0	-2.070*
	Positive ranks	5	3.00	16.00	
Strength of the shoulder muscles (20 sec)	Negative ranks	0	0	0	-2.236*
	Positive ranks	5	3.00	14.00	

*Tabular value of "D" at 0.05 significance level = 1.96

Table 6. Arithmetic mean and improvement percentages for both pre- and post-measurement of functional strength tests

Variables		Pre		Post		Improvement
		mean	std	mean	std	
Muscle strength of legs	**Broad Jump**	164.354	1.87	184.321	1.572	37.97%
	Vertical Jump	47.551	4.465	87.551	4.321	40%
Muscle strength of arms	**3kg Medicine Ball Throw**	4.724	3.184	5.954	3.124	1.23%
Muscle strength of trunk	**Trunk Strength and Stability**	89.13	6.081	96.17	6.085	7.04%
Muscle strength of abdomen	**Abdominal Strength (20s)**	21.224	0.836	29.254	0.821	6.03%
Muscle strength of back	**Back Strength (20s)**	35.255	1.643	44.255	1.665	13.19%
Muscle strength of arms	**Handstand (Stability)**	13.436	1.816	17.442	1.854	4.01%

The results of this study are consistent with the results of the study of Allawi, M. H., & Radwan, M. N. E. (2001), Hassan, A. A. (2018), which showed that the core power, which is one of the elements of functional programs, includes movements characterized by producing force and converting it into immediate speed, and this is an important interactive feature in functional training. This is what was mentioned by El Nemr, A. A. A., & El Khatib, N. A. (1996) that performance improves better if the training is specific to the type and nature of skill performance and is in the directions of muscle work and at the same speeds of movements required for competition, as the best method for improving muscle capacity is the method in which the neuromuscular path during training is similar to the neuromuscular path during competition.

The author attributes these differences between measurements to the type of exercises performed in the functional strength training program using free exercises, and using elastic resistances such as elastic ropes and Swiss balls, which focus their work on the center area (the middle of the body), which had a positive effect on improving balance, and thus helps improve the different motor performance of the skills under study that require the quality of balance in order to show the performance in a good and increasing image.

The results of this study are consistent with the results of the study of Abdel Hafeez, R. S. (2011)**,** Mohamed, M. O. (2012), Al-Abyawi, N. H. A. A. (2021), where they concluded that strengthening the abdominal muscles and thus the corresponding back muscles (muscle balance), i.e. creating a balance between strengthening the front muscles (abdominal muscles) and the corresponding back muscles (back muscles) in an effective way depends to a large extent on choosing a set of exercises that suit each sport, and what this sport includes in terms of different skills and movements, as well as with the age group that will perform this set of exercises. Allawi, M. H., & Radwan, M. N. E. (2001) confirm that many sports activities depend mostly on the quality of balance, and it is also necessary to maintain the center of the body's transfer above the base of support during performance, so that the body becomes more stable and balanced, especially when performing various motor skills.

As is clear from the results of Table (5), there is a noticeable development in the level of strength endurance, stability of the trunk muscles, and strength of the abdominal muscles. The author attributes this improvement in strength endurance to the author’s use of some functional strength training exercises, which depend in their content on increasing the volume of training at the expense of intensity, which consequently had a positive impact on developing the strength endurance element in the research sample. In addition, this improvement is because of functional strength training, as the author considering the use of exercises with simple loads, which gives the opportunity to repeat the performance many times and with high efficiency, which leads to an improvement in endurance in addition to increasing the number of repetitions during performance.

Table (6) shows that there are statistically significant differences between the pre- and post-measurement in the post-measurement direction, as the calculated Z value (1.890) was less than the tabular value (1.96)

Table 6. Significance of differences between the pre-measurement and post-measurement in the level of skill performance on the jumping table device using the Wilcoxon test

Jumping Table device	Rank Direction	N	Average Rank	Total ranks	Cohen's Z
Handspring	Negative ranks	0	0	0	-2.060*
	Positive ranks	5	3.00	15.00	
Round off	Negative ranks	0	0	0	-2.070*
	Positive ranks	5	3.00	15.00	
Performance Level	Negative ranks	0	0	0	1.890
	Positive ranks	4	2.50	10.00	
	Negative ranks	5	3.00	15.00	

*Tabular value of "**Z**" at significance level 0.05 = 1.96

Table (7) shows an improvement in all variables, with the largest variable in the improvement rates.

Table 7. Significance of differences between the pre- and post measurement in the level of skill performance on the vaulting table device using the Wilcoxon test

Variables	Pre		Post		Improvement
	mean	std	mean	std	
Handspring	6.400	1.1408	8.400	0.894	31.25%
Roundoff	6.200	0.836	8.000	1.581	29.03%
Performance level on the device	6.800	0.976	8.400	0.547	23.53%

The results of Table (6) and (7) show a noticeable development and improvement in the skill aspect represented in the results of the performance level of the vault table skills.

The author attributes this improvement in the skill variables under study for the members of the experimental group to the positive impact of functional strength training on the level of skill performance on the vault table device as a result of using functional strength training, and taking into account that physical training using functional strength is very similar to muscular work in the vault table skills, as well as focusing these trainings on the basic muscle groups and assisting in performing skills.

The author was interested in developing muscular strength through functional strength training, which included many exercises that were developed in a functional style that allows

the possibility of considering the correct time division of the path of muscular strength exerted during performance and in a manner that calls for appropriate responses in developing and improving the muscular system in the direction of skill performance.

The results of this study are consistent with the results of the study of Tomlianovic, M., et al. (2011), Abdel Hafeez, R. S. (2011), which concluded that functional strength training programs had a better positive impact than traditional functional strength training programs in some physical and skill variables.

This is what both Allawi, M. H., & Radwan, M. N. E. (2001) indicate that muscle strength is highly positively correlated with athletic performance in some motor activities and that motor performance in the field of sports activity depends to varying degrees on muscle strength.

The author believes that the improvement in muscle strength, ability and skill level is due to the effect of the training program using functional strength training, as the skill level is affected by several factors, including physical factors, and the player's speed is affected by the frequency of the step, which results from the strength of the muscles that cause this movement, and strength is also related to strength endurance, as the greater the strength of the muscles, the greater their ability to endure.

Comana, F. (2004) that one of the most important features of functional strength training is the focus on the core muscle group (abdominal and back muscles) as the strong core muscles connect the lower limb to the upper limb, which makes them one of the best exercises used to improve the core muscle strength (mid-body) and balance.

This is consistent with what the author has concluded that good training of the trunk area leads to all the muscles in it working together and executing more powerful and effective movements and a more balanced body and tight internal and external muscles with good control of the limbs.

The author believes that functional strength training contributed to increasing the strength of the core muscles and directing them, which contributed to increasing the level of both strength and ability for the legs and arms, and the core muscle group depending on the process of motor transfer from the lower limb to the upper limb passing through the core area, which led to improving the level of skill performance on the jumping table device, as a result of functional strength training containing a group of directed exercises that work to strengthen the core muscle groups (back - abdomen - sides).

The author believes that the special strength of the trunk plays an important role in performing skills on the vaulting table, as it contributes to achieving the required horizontal speed and acceleration to reach the maximum possible height and contributes to the stability of

the body during flight and performing rotation in the air. The author considered the interest in stretching exercises for the muscles and flexibility for the joints so that the muscles and joints become fully prepared to perform functional strength exercises efficiently without injuries. The proposed exercises also led to improving the muscular capacity of the arms. The author attributes this to the functional strength exercises that the author developed to improve the muscular capacity of the legs, trunk and arms, and due to the principle of kinetic transfer, the player was able to collect the force used from the legs to the trunk to the arms, as the human body is a kinematic chain that contributes to the required kinetic transfer, which increases the amount of muscular capacity of the arms, which in turn led to improving the level of skill performance on the vaulting table.

The second hypothesis is achieved, which states: "There are statistically significant differences between the averages of the pre- and post-measurements of the experimental group in the level of skill performance on the jumping table device, in favor of the post-measurement."

Conclusion

According to procedures and results of the research, the author has reached to the following conclusions:

1- The training program had a positive effect on improving the muscle strength of gymnasts.
2- The percentage of improvement in functional strength variables was (leg muscle strength 37.967% in the broad jump test, 40% in the vertical jump test - arm muscle strength 1.23% in the 3K medicine ball throwing test - trunk muscle strength 7.04% in the trunk muscle strength test - abdominal muscle strength 6.03% in the abdominal muscle strength test - back muscle strength 13.19% in the back muscle strength test - arm muscle strength 4.006% in the handstand test).
3- The training program had a positive effect on improving the level of skill performance on the vaulting table.
4- The percentage of improvement in the performance level on the vaulting table device (front somersault on hands 31.25% - side somersault with a quarter turn 29.03%) and the percentage of improvement in the performance level on the vaulting table device 23.53%.

Recommendations

Based on the results of the research and the resulting conclusions, the author recommends the following:

1. The necessity of directing the attention of those in charge of the training process to the importance of using functional strength training.
2. The necessity of developing guiding training programs to guide trainers and enhance their training knowledge.
3. Conducting more studies in the field of gymnastics considering the amendments to the arbitration law and considering the compulsory requirements.

4. The gymnastics trainers must include some functional strength training in their training programs.
5. It is recommended to apply the same methodology on differe age groups, gender, and other sports activity.

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