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INFLUENCE OF 12-WEEK ARTISTIC GYMNASTICS TRAINING ON CHILDREN'S STRENGTH AND BALANCE PERFORMANCE

VPLIV 12-TEDENSKEGA TRENINGA ŠPORTNE GIMNASTIKE NA MOČ IN RAVNOTEŽJE OTROK

ABSTRACT

The purpose of the present study was to investigate the influence of 12-week artistic gymnastics training on children's strength and static balance performance. A total of 32 children attending gymnastic club for kids with mean age 6.09 ± 7.45 years; height 106.81 ± 5.47 cm, body weight 17.00 ± 2.72kg and body mass index (BMI) 14.98 ± 2.57 kg/m2 were included in the study. A training program with 270-minute intensity at a frequency of 3 days a week for 12 weeks has been implemented for all participants. Hand grip strength test, stretched arm hanging duration on high bar and stork balance test for dominant and non-dominant legs were applied to the participants. SPSS 21.0 statistical program was used in the statistical analysis of the data and the statistical significance level was accepted as $p<0.05$. As a result of the study, while a statistically significant difference has not been observed between Non-dominant leg stork balance pre-test and the post-test ($p=0.06>0.05$), a statistically significant difference was observed between the Dominant leg stork balance pre-test and the post-test ($p=0.00<0.05$). However, a significant difference was found between both hand grip strength pre-test and post-test ($p=0.00<0.05$) and stretched arm hanging duration on high bar pre-test and post-test ($p=0.00<0.05$). There was a statistically significant difference between the participant's pre-test sit and reach and the post-test ($p= 0.00<0.05$). It can be said with this study that 12-week artistic gymnastics training increased children's forearm flexor muscle isometric strength and balance performance.

Keywords: Artistic gymnastics; balance; forearm flexor muscle; strength

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IZVLEČEK

Namen pričujoče študije je bil raziskati vpliv 12-tedenskega treninga ritmične gimnastike na moč in statično ravnotežje otrok. V vzorec smo zajeli 32 otrok s povprečno starostjo 6,09 ± 7,45 let; višino 106,81 ± 5,47 cm, telesno težo 17,00 ± 2,72 kg in indeksom telesne mase (ITM) 14,98 ± 2,57 kg / m2. Za vse udeležence je bil izveden program usposabljanja, trajajoč 12 tednov, 270 minut tedensko in 3 krat tedensko. Za udeležence so bili uporabljeni preizkus moči oprijema roke, vesa v zgibi in Storkov test ravnotežja štorklje za dominantno in nedominantno nogo. Statistična analiza je bila narejena v programu SPSS 21.0, raven statistične pomembnosti pa smo določili pri $p<0,05$. Med pre-testom in post-testom nedominantne noge pri Storkovem testu nismo zaznali značilnih razlik ($p = 0,06> 0,05$), smo pa opazili statistično značilne razlike v pre- in post- testu: i) dominantne noge Storkovega testa ($p = 0,00 <0,05$); ii) moči oprijema roke ($p = 0,00 <0,05$) in iii) veso v zgibi na visokem drogu ($p = 0,00 <0,05$). Pričujoča študija dokazuje, da 12-tedenski trening ritmične gimnastike pozitivno vpliva na povečanje izometrične moči rok in statičnega ravnotežja otrok.

Ključne besede: ritmična gimnastika; ravnotežje; fleksorska mišica podlakti; moč

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INTRODUCTION

Artistic Gymnastics (AG) is a traditional sport that has been included in Olympic program since Athens Olympics in 1896 (Molinari et al., 2010). AG requires artistic and balance skills as well as explosive movements such as jumping, pulling, pushing and sprinting. Coordination skill is one of the motor skills that should be at a high level (Gardasevic, & Vasiljevic, 2017) These components operate various muscle groups bilaterally and in a coordinated manner for force generation (Kutac, Jurkova & Farana., 2019). Hand grip strength is a good indicator of total muscle strength, endurance, and overall strength of the body (Erdogan et al., 2016). It is basically based on the maximal isometric strength produced by the hand and forearm muscles (Karataş, 2017). "The ability to grip is made possible by the fact that the thumb can move opposite to the other fingers the fingers and thumb act as a versatile pair of pliers" (Krejač, K., Žvan, M., Peharec, S Milan., & 2020, Čoh, Milan). Thus, hand grip strength is highly important while hanging and rotating movement routines are performed in parallel bars (Savucu et al., 2018). For this reason, it is recommended to be used in various motor ability measurement test batteries recommended for children. High bar is one of the competition equipment used by male and female gymnasts to perform their movement routines. Routines performed on the high bar include forward and backward circular movements (swing / full giant), releasing the high bar and holding it again and finishing movement (Yeadon & Hilley, 2020).

Balance is the ability to remain stable with minimal sway on the support base of the center of gravity of the body (Akşit & Cırrık, 2017). Gymnasts need to increase especially their dynamic and static balance performances in order to perform the somersaults and acrobatic movements at different levels successfully. Just like taekwondo players landing during kicking (Ipekoglu et al., 2018), as the number of somersault increases, the angular momentum in the long axis will increase, making it difficult for the gymnast to maintain balance during landing (Suchilin & Arkaev, 2004). Therefore, performing different techniques in gymnastics training improves the ability to control the body position in the air during the somersault movements and the ability to stay in balance while landing. Gymnasts perform static skills such as handstands in a slow position, in a controlled manner, and after a swing. For this reason, AG requires both static and dynamic balance. In this study, it was hypothesized that 12-week gymnastics training would increase the strength of the forearm flexor muscles and static balance performance of children.

METHODS

Participants

Totally (n=32) children, including 20 girls and 12 boys with an average age of 6.09 ± 7.45 years, average height 106.81 ± 5.47 cm, body weight average 17.00 ± 2.72 kg, body mass index (BMI) 14.98 ± 2.57 kg / m^2 were included in the study. All children were allowed to carry out a test only once by being verbally informed about the test in advance. All participants were right-handed gymnasts. All participants were asked not to participate in any sports activity in the last 24 hours to avoid fatigue before the test. The feedback of the performance was reported to the participants during the test in order to achieve maximal effort. All participants were given detailed information about possible risks that might occur during training before the test and they were asked to read and sign an informed consent form. The families of the participants were given detailed information about the study and asked to sign the family consent form. Thus, attention was paid to conduct the research in accordance with the Declaration of Helsinki.

Experimental procedure

12-week Training Program

A training program specific to the beginner level of artistic gymnastics was carried out for a total of 270 minutes at a frequency of 3 days for 12-week. A training unit was determined as a total of 90 minutes, on Monday, Wednesday and Friday (see below). Special care was taken for each training unit to include learning new technical skills and repetition of old technical skills. They trained only calisthenics without using any additional weight in any training unit.

Table 1. Training unit chart

The number of training (days of week M-W-F)	Total training duration volume/intensity/ (min.)	Warm-up section (min.)	Main section (min.)	Cool-down section (min.)
3	270	20	55	15

Abbreviation: Min= minute, M=Monday, W=Wednesday, F=Friday.

Warm-Up Section

Participants were randomly divided into 3 groups after a 5-minute jogging run on a 12x12 floor implement and performed sequentially animal walks, tiger crawl, bear walk (stretched leg), caterpillar walk, crab walk, frog and rabbit jump, side swing leg, tuck jump, scissor leap,

galloping and wheel barrow walk movements with voice commands. Each animal movements were performed one repetition.

Main Section

This section included backward roll (10 repetition), backward and forward roll with straight leg (10 repetitions), backward and forward straddle roll (10 repetitions), scissor leap (2 rounds), handstand work on the wall (10 repetitions), cartwheel (10 repetitions), round off prior exercise (10 repetitions), backward roll on incline mat (repeated and with helper), intermittent isometric body hold training, repetition of old technical skills, flexibility specific for gymnastics (side split, center split, back and forward bridge/arch/back bend), movements to increase the range of motion of the shoulder joint on the wall bars and repetition of learned skills.

Cool Down Section

This section consisted of games specific to gymnastics after 3-5 minutes of slow pace run, back extension roll, lower extremity static stretching exercises; bilateral side split, isometric stretching exercises for upper extremities; as combined neck, shoulder, wrist, elbow, and combined stretching exercises; back arch exercises.

Data Collection

Handgrip Strength Test

Camry digital hand dynamometer (Model EH101) was used to evaluate the grip strength of the dominant hand. The participants were asked to sit on a chair and hold the elbow joint at a 90° angle. After the dynamometer was adjusted according to the hand size of the participants, they were asked to grasp with their maximum power for three seconds. The test was repeated twice, and the best degree was recorded as grip strength (Le & Shim, 2019).

Stretched/Straight Arm Hanging Duration on High Bar Test

This test was implemented in order to evaluate the continuity of the strength especially by contracting the forearm muscles in an isometric type against a stable resistance. (Berisha & Çilli, 2016). Validity and reliability of the test was carried out by Sleeper, Kenyon, & Casey, 2012. Participants waited with their arms stretched/staright and the body suspended on the high bar. The test was terminated with a movement in body position or arms. The test was repeated once and the hanging on the high bar time was recorded in seconds.

Standing Stork Balance Test

This test was used to measure the balance of participant while standing on one leg. Each participant placed one foot on the inside of the knee on the other leg for support, with bare feet, hands on waist. The stopwatch was started when the participant lifted one foot off the ground. The test was terminated by stopping the recorded time when one or both hands were separated from the waist or the position of the support leg changed (when it was moved). The test was repeated three times and the best result was recorded according to the rating score (Castillo-Rodriguez, Onetti-onetti, Sousa-Mendes & Chinchilla, 2020) (see below).

Table 2. Stork Balance Scoring

Rating	Score (sec.)
Excellent	> 50
Good	40 - 50
Average	25- 39
Fair	10 - 24
Poor < 10	< 10

*Sec = Second; https://www.topendsports.com/testing/tests/balance-stork.htm

Flexibility

Sit and reach (S&R) stand with 32 cm. height and 35 cm. length placed on a flat surface was used to determine the flexibility of the participants. Participants were asked to reach as far as possible on the S&R table on the floor without bending their knees with their feet with their legs extended and without shoes. The furthest distance between the middle fingers and the point corresponding to the soles was measured. After repeating the test twice, the longest distance reached was recorded as the best degree (Şahin et al., 2019).

Data Analysis

SPSS 21.0 statistical program (SPSS INC, Chicago IL) was used in the statistical analysis of the data and the statistical significance level was accepted as $p < 0.05$. Paired sample T-test was used to control some variables, while Kolmogrov-Smirnov test was used for normal distribution analysis. Results were interpreted with the help of Cohen's d effect size value. Cohen' s d effect size is small values between 0.20-0.50; 0.50-0.80; shows a medium effect of 0.80 and a larger level (Cohen, 1988).

RESULTS

Table 3. Descriptive statistics of the participants' physical characteristics (mean ± sd).

Variables	Minimum	Maximum	Mean ± Sd
Age (year)	4.5	7.5	6.09 ± 7.45
Height (cm)	96	118	106.81 ± 5.47
Weight (kg)	13.0	22.5	17.00 ± 2.72
BMI* (kg/m^2)	10.05	19.95	14.98 ± 2.57

*Body Mass Index

Descriptive statistical data of the participants are given in Table 3. The average age of 32 participants took part in the study has been defined as 6.09 ± 7.45; mean height 106.81 ± 5.47; mean body weight 17.00 ± 2.72 and the mean BMI 14.98 ± 2.57.

Table 4. Paired sample t-test of the hand grip strength pre-test and post-test test of the participants.

Variables	Mean± SD	t	p	Cohen's d
Handgrip Strength pre-test	0.91± 0.41	-12.59	.00	0.43
Handgrip Strength post-test				

($p < 0.05$)

There is a statistically significant difference in the handgrip strength of the participants between pre-test and post-test ($p = 0.00 < 0.05$). (Table 4.)

Table 5. Paired sample t-test of stretched/staright arm hanging duration on high bar pre-test and post-test of the participants.

Variables	Mean± SD	t	p	Cohen's d
Stretched/straight arm hanging duration on high bar Pre-test	-3.19 ± 1.44	-12.53	.00	0.41
Stretched/straight arm hanging duration on high bar Post-test				

($p < 0.05$)

There is a statistically significant difference in the stretched/staright arm hanging duration on high bar between pre-test and post-test ($p = 0.00 < 0.05$). (Table 5.)

Table 6. Paired sample t-test of the stork balance (DL) pre-test and post-test of the participants.

Variables	Mean± SD	t	p	Cohen's d
Stork balance Pre-test (DL) Stork balance Post-test (DL)	-6.23 ± 3.41	-10.31	.00	0.41

(p <0.05) DL = Dominant Leg

A statistically significant difference has been found between the (DL) Stork balance pre-test and post-test (DL) of the participants (p = 0.00 <0.05). (Table 6.)

Table 7. Paired sample t-test of the stork balance (N-DL) pre-test and post-test of the participants.

Variables	Mean± SD	t	p	Cohen's d
Pre-Stork balance test (N-DL) Post-Stork balance test (N-DL)	-0.74 ± 2.15	-1.95	.06	0.11

(p <0.05) N-DL = Non-Dominant Leg

There is no statistically significant difference between the participants pre-test stork balance test (N-DL) and post-test (N-DL) (p = 0.06> 0.05). (Table 7.)

Table 8. Paired sample t-test of the sit and reach pre-test and post-test of the participants.

Variables	Mean± SD	t	p	Cohen's d
Pre-test sit and reach Post-test sit and reach	-1.62 ± 0.85	-7.76	.00	0.53

(p <0.05)

There is a statistically significant difference between the sit and reach pre-test and post-test of the participants (p = 0.00 <0.05). (Table 8.)

DISCUSSION

In this study, the effect of 12 weeks of artistic gymnastics training on forearm flexor strength and static balance performance was examined.

According to the results of the study, a significant difference was found between both hand grip strength pre-test and post-test (p = 0.00 <0.05) and stretched arm hanging duration on high bar

pre-test and post-test ($p = 0.00 < 0.05$). The reason for this difference may be due to the increase in forearm flexor muscle strength in the practice of hanging and swinging movements in the high bar for 12 weeks. In other words, it can be explained by the adaptation of the participants to the applied gymnastics training. Similarly, Genc, Cigerci & Sever, 2019 found a significant difference in the hand grip strength data as a result of their study investigating the physical and physiological effects of 8-week core training on female handball players. Ziyagil et al., 1996 found a significant difference between 11-year-old sedentary children and the children engaged in sports in view of grip strength. Berisha & Çilli, 2016 observed that there is a positive linear relationship between the time of hanging with stretched arms and gymnastic technique scores of 15-16-year-old children. Bayraktar, 2005 found the grip strength of swimming athletes to be significant ($p < 0.001$) compared to gymnastics and athletics athletes. As a result of the study on the relationship between the hand grip strength of elite shooters and their shooting performance conducted by Erdogan et al., 2016 while there was a positive and significant relationship between female shooters dominant hand grip strength and their shooting scores, insignificant relationship was observed between male shooters dominant hand grip strength and their shooting scores. In the study conducted by Yasemin, Tunçel & Harbili, 2020 which they examined the relationship between upper extremity strength, anaerobic power, speed and agility in young handball players, they found a high level of positive correlation between anaerobic power and medicine throwing, dominant and non-dominant hand grip strength values.

The fingers are generally the main joint that generates force for hand grip strength. (B-Razak et al., 2018) Muscle strength and muscular endurance develop in childhood (Koçyiğit, Akın & Şentürk, 2020). Hence, the increase in hand grip strength can lead to more force generation in finger movement. Therefore, they are considered to be extremely important during the combination of movements in gymnastic equipment (the high bar and the asymmetric bar) where movements such as hanging and swing are frequently repeated. As the body passes through a hanged position, it is subjected to both its own weight and the force of constantly changing acceleration.

These forces can cause the athlete to fall from the apparatus quickly to the ground. The hand and forearm muscles must generate a significant amount of force in order to perform a continuous routines of movements in the apparatus (Ruiz et al., 2006). Based on this information, a successful performance, especially in some apparatus, regardless of age and gender, may require hand grip strength. In this study, it was observed that there was no statistically significant difference between N-DL stork balance pre-test and post-test, but there

was a statistically significant difference between DL Stork balance pre-test and post-test. It was expected that there was no statistically significant difference in N-DL. According to the study conducted by Granacher et al., 2011, children aged 6-7 years were given a 4-week balance exercise to evaluate the effect of balance, leg strength, and balance training, but no statistically significant improvement was observed. Gymnastics is a sport in which aesthetic values are at the forefront and at the same time it is necessary to maintain balance (Choen Whiting & Mclaine, 2002). In gymnastics, every maneuver (whether male or female) ends with a landing (Čuk & Marinšek, 2013).

The gymnast needs an extraordinary level of balance control especially during the competition (Moraru, Neculaeş, hodorcă, 2014). Accordingly, a significant amount of balance training should be practiced throughout the year in order to meet the balance requirement (Vuillerme et al., 2001). In addition, it is among the information in the literature that gymnastic exercises support strength development in children and thus have an effect on balance performance (Akın & Kesilmiş, 2020). The landing phase after the routines performed on both male and female gymnastics equipment should end with a perfect standing position. Otherwise, every deviation from the correct position is considered as a mistake and the necessary score deductions are made by the judge. (Xiao et al., 2017) Tanasă et al., 2020 found that gymnastics training improved balance capacity as a result of their study on the effects of gymnastics training on static balance in children aged 4 to 8 years. According to Daly, Bass & Finch, 2001 strength, which is among the basic motoric properties, has a significant effect on gymnastic performance. The improvement in different types of force especially in artistic gymnasts causes significant effects on the application of the movements performed on the floor, balance beam and vaulting table (Kankal, 2008). Evridiki, Aggeliki & Vassiliki, 2004 presented that the movement education program positively affected the jumping and dynamic balance performances of preschool children aged 4-6. In this study, a statistically significant difference was found between the S&R pre-test and the post-test of the participants. According to Aedo-Muñoz et al., 2019 flexibility is accepted by gymnasts and trainers as the most important physical parameter after strength in performing artistic gymnastic exercises with high technique and quality (Sterkowicz-Przybycień et al., 2019). In a study, it was observed that stretching and strength training specific to the lower extremity positively affected the lower extremity control of athletes (Sağiroğlu Kurt, Pekünlü & Özsu, 2017). However, no significant difference was found between the S&R pre-test and post-test test in the study that Nazari & Lim, 2019

investigated the effect of a 12-week core training program on the physical properties of rhythmic gymnastics.

CONCLUSION

The effect of 12-week artistic gymnastics training on children's strength balance performance was investigated in this study. The results show that artistic gymnastics training carried out at a frequency of 3 days a week for 12 weeks can be said to improve children's forearm flexor muscle strength and static balance performance. This situation may contribute to the performance to be demonstrated in future competitions. As a result, it is thought that the significant findings obtained will contribute to the literature. Almost all measures displayed significant main effect, small and medium (effect size) improvements for time (post-test > pre-test).

Declaration of Conflicting Interests

The author declare no conflict of interest.

REFERENCES

Aedo-Muñoz, E., Araya-Ibacache, M., Miarka, B., Moya-Jofre, C., Cancino-López, J., Mozer, RL., & Brito, C.J. (2019) Effect of sex differences in sports groups on hamstring flexibility based on the sitreach test: new parameters for Chilean athletes. *Journal of Physical Education and Sport*, 19(4), 2374-2378.

Akın, M., & Kesilmiş, I. (2020). The effect of blood flow restriction and plyometric training methods on dynamic balance of taekwondo athletes. *Pedagogy of Physical Culture and Sports*, 24(4), 157-162.

Akşit, T., & Cırrık, G. (2017). Comparison of static and dynamic balance parameters and some performance characteristics in rock climbers of different levels. *Turkish Journal of Sport and Exercise*, 19(1), 11-17.

Bayraktar, L. (2005). *Comparison of physical and motorial development features of female athletes at the age group12-12 in swimming,gmnastics and athletism branches*. M.Ü. Health Science Inst. Master Thesis, İstanbul.

Berisha, M., & Çilli, M. (2016). The Effect of Basic Gymnastic Elements on 15 and 16 Years Old School Students Performance Obtained during the Basic Gymnastic Training. *CBU Journal of Physical Education and Sport Sciences*, 11(1), 37-45.

B-Razak, R., Mea, K.K., Hussain, R.N.J.R., Kassim, N..AM., & Othman N. (2018). The effect of hand grip strength and trunk rotation strength on throwing ball velocity. *Malaysian Journal of Movement, Health & Exercise*, 7(1).

Castillo-Rodriguez, A., Onetti-Onetti, W., Sousa-Mendes, R., & Chinchilla-Minguet, JL. (2020). Relationship between Leg Strength and Balance and Lean Body Mass. *Benefits for Active Aging. Sustainability*, 12(6), 2380.

Cohen, J. (1988). *Statistical power analysis fort he behavioral sciences (2nd ed.)*. Hillsdale, NJ: Erlbaum.

Cohen, SB., Whiting, WC., & Mclaine A.J. (2002). Implementation of Balance Training in a Gymnast's Conditioning Program. *In: Medicine*, Vol. 10p. 1533-4295.

Čuk, I., & Marinšek, M. (2013). Landing quality in artistic gymnastics is related to landing symmetry. *Biology of sport*, 30(1), 29.

Daly, R., Bass, S. & Finch, C. (2001). Balancing the risk of injury to gymnasts: how effective are the counter measures? *Sports Medic*ine, 35(1), 8-20.

Erdogan, M., Sağıroğlu, I., Şenduran, F., Ada, M. & Ateş O. (2016). An Investigation of the Relationship Between Hand Grip Strength and Shooting Performance of Elite Shooters. *Istanbul University Journal of Sport Science* 6(3),22-30.

Evridiki, Z., Aggeliki, T., & Vassiliki D. (2004). The Effects of a Developmentally Appropriate Music and Movement Program On Motor Performance. *Early Childhood Research Quarterly*, 19(4), 631–642.

Gardasevic, J., & Vasiljevic, I. (2017). The effects of the training in the preparation period on the coordination transformation with football players U16. *Kinesiologia Slovenica*, 23(3), 12-17.

Genc, H., Cigerci, A.E., & Sever O. (2019). Effect of 8-week core training exercises on physical and physiological parameters of female handball players. *Physical education of students*, 23(6), 297-305.

Granacher, U., Muehlbauer, T., Maestrini, L., Zahner, L., & Gollhofer A. (2011). Can balance training promote balance and strength in prepubertal children? *J Strength Cond Res* 25(6) 1759–1766.

Ipekoglu, G., Karabiyik, H., Er, F., Erdogan, C.S., Cakir, E., Koz, M., Baltaci, G., Colakoglu, F.F. (2018). Does Bosu Training Affect on Dynamic and Static Balance in Adolescent Taekwondo Athletes? *Kinesiologia Slovenica*, 24(1), 5-13. *Journal of Sports Physical Therapy* 7(2), 124-138.

Kankal, M.B. (2008*). Comparison of physical, physiological and performance characteristics of 9-12 year old aerobic and rhythmic gymnasts*. Ankara Universıty Health Sciences Institute; Master Thesis, Ankara.

Karataş, M. (2017). *Effect of 12-Week Basic Gymnastic training on physical fitness in 6 to 7 year-old boys*. Fırat University, Institute of Health Sciences, Physical Education and Sports Department, *Master Thesis, Elazığ*.

Koçyiğit, B., Akın, S., & Şentürk, A. (2020). The effects of combined trainings on tennis serve speed in tennis players. *Turkish Clinical Journal of Sports Sciences Sci*.12(2):137-46.

Krejač, K., Žvan, M., Peharec, S Milan., Čoh, Milan. (2020) Correlation of handgrip strenght with vertical and horizontal plyometric jumps, *Kinesiologia Slovenica*, 26, (3), 78-95.

Kutac, P., Jurkova, S., & Farana R. (2019). Morphological characteristics of young female artistic gymnasts from the czech republic. *Science of Gymnastics Journal*, 11(1).

Le, T., & Shim, A. (2019). Does a correlation exist between handgrip strength and coincidence timing? *Journal of Science and Medicine in Sport*, 22 S107.

Molinari, C.I., Costa, V.R., Monteiro, K.O.F.F., & Nunomura, M. (2018). Critical Analysis Of The Performance Of Women's Artıstıc Gymnastics in Brazil in The 2004-2016 Olympic Cycles. *Science of Gymnastics Journal*, 10(3) 453-515.).

Moraru, C., Neculaeş, M., Hodorcă, R.M. (2014). Comparative study on the balance ability in sporty and unsporty children. *Procedia-Social and Behavioral Sciences*, 116, 3659-3663.

Nazari, S., & Lim, B.H. (2019). Effects of a 12-week core training program on physical characteristics of rhythmic gymnastics: A study in Kuala Lumpur, Malaysia. *Malaysian Journal of Movement, Health & Exercise*, 8(1), 157-174.

Ruiz, J. R., Ortega, F. B., Gutierrez, A., Meusel, D., Sjöström, M., & Castillo, M. J. (2006). Health-related fitness assessment in childhood and adolescence: a European approach based on the AVENA, EYHS and HELENA studies. *Journal of Public Health*, 14(5), 269-277.

Sabin, SI., & Alexandru, S.D. (2015). Testing agility and balance in volleyball game. https://www.topendsports.com/testing/tests/balance-stork.htm

Sağiroğlu, I., Kurt, C., Pekünlü, E., & Özsu, İ., (2017). Residual effects of static stretching and selfmyofascial-release exercises on flexibility and lower body explosive strength in welltrained combat athletes. *Isokinetics And Exercise Science*, 25 135–141.

Savucu, Y., Karataş, M., Eskiyecek, CG., Yücel, A.S., & Karadağ, M. (2018). Effect of 12-week basic gymnastic training on physical fitness in 6 to 7 year old boys. *Turkish Journal of Educational Studies*, 5(3), 53-65.

Sleeper, D., Kenyon, L., & Casey, E. (2012). Measuring fitness in female gymnasts: Measuring fitness in female gymnasts: the gymnastics functional measurement tool. *International journal of sports physical therapy*, 7(2), 124.

Sterkowıcz-Przybycıeń, K., Sterkowicz, S., Biskup, L., Żarów, R., Kryst, Ł., & Ozimek, M. (2019). Somatotype, body composition, and physical fitness in artistic gymnasts depending on age and preferred event. *Plos one*, 14(2), e0211533.

Suchilin, N.G., & Arkaev, L.I. (2004). *Gymnastics-how to create championships. 1st Ed*. Meyer & Meyer Sport Uk. Ltd. 55-81.

Şahin, G., Koç, H., Baydemir, B., Abanoz, H., Coşkun, A., & Günar, B. B. (2019). Analysis of some performance parameters of fencer according to gender and age. *Kinesiologia Slovenica*, 25(1), 27-34.

Tanasă, RA., Dumitru, I.M., & Budacă, M.V. (2020). The effects of gymnastics training on static balance among children aged 4 to 8. Bulletin of the Transilvania University of Brasov. *Series IX, Sciences of Human Kinetics*, 13(1), 111-118.

Vuillerme, N., Danion, F., Marin, L., Boyadjian, A., Prieur, J.M., Weise, I., & Nougier, V. (2001). The effect of expertise in gymnastics on postural control. *Neuroscience letters*, 303(2), 83-86.

Xiao, X., Xiao, W., Li, X., Wan, B., & Shan, G. (2017). The influence of landing mat composition on ankle injury risk during a gymnastic landing: a biomechanical quantification. *Acta of bioengineering and biomechanics*, 19(1).

Yasemin, A.R.I., Tunçel, A., & Harbili, E. (2020). The relationship among agility, speed, anaerobic power, and upper extremity strengthin young handball players. *Physical Education and Sport Sciences Journal*, 22(2), 71-81.

Yeadon, M.R., & Hiley, M.J. (2000). The mechanics of the backward giant circle on the high bar. *Human Movement Science*, 19(2), 153-173.

Ziyagil, M.A., Tamer, K., Zorba, E., Uzuncan, S., & Uzunca, N.H. (1996). Evaluation of physical fitness and antropometric characteristics of 10 12 years old primary school boys according to their age and participatio n in sports b y using eurofit test batteries. *Gazi Journal of Physical Education and Sport Sciences*, 1(1), 20-28.