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**Original Article**

# Dynamics of indicators of active and passive flexibility during the annual cycle of stretching classes

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**Abstract:**
**Purpose**: this study analyses the dynamics of indicators of active and passive flexibility in the joints of the upper extremities in girls aged 15-16 years after an annual cycle of extracurricular stretching classes. **Design/methodology/approach:** during the school year, 35 high school girls were involved in extracurricular stretching classes three times a week. Classes lasted for 90 minutes and had a traditional structure: preparatory, main and final parts. We investigated the effect of stretching exercises on active and passive flexibility in the joints of the upper extremities using the goniometry method. **Findings:** goniometric measurements after a one-year cycle of stretching classes proved the effectiveness of the implemented extracurricular program. Having a systematic training throughout the year, girls aged 15-16 years improved flexibility in the joints of the upper extremities, statistically significantly increased the movement amplitude in the joints of the upper extremities. It can be argued that specially organized motor activity in the form of stretching classes changes the mobility indicators of the joints of the upper extremities. Such changes are an indicator of preventive measures against domestic injuries. **Research and practical limitations/implications:** the results of our study confirm the effectiveness of implementing extracurricular stretching classes in secondary schools. It should be also stated the limitation includes a relatively small sample size for statistical measurement, but it does not significantly affect the results of the study. **Originality/value**: lots of scientists study the role of stretching classes mainly in a sports environment, however, we investigated the health-improving effect of using stretching classes to increase motor activity and improve the quality of life of high school girls, but not athletes.
**Keywords: high school girls; stretching classes; active and passive flexibility, motor activity**

## Introduction

Many students and teachers underestimate the importance of flexibility in the framework of school physical education, although in some movements it plays a fundamental role. The development of flexibility can be effective in helping young people to achieve desired goals in various types of sports, affecting the level of sportsmanship, and preventing sports as well as domestic injuries (Motahari-Tabari 2017).

According to the results of the study (Judge et al.2020) 95.4% of surveyed trainers include stretching exercises in the post-competition and pre-competition periods. Developing muscle elasticity through stretching is one of the most important aspects of training (Rogan et al.2016). Underestimating this factor can lead to injuries and other diseases of the musculoskeletal system (Di Mauro 2016). Exercises for developing muscle elasticity are recommended to be used to maintain or optimize the movement amplitude in people who are professionally engaged in sports (Ferrara et al. 2019). However, the majority of scientists study the role of stretching classes mainly in a sports environment(Fakhro 2020), it is necessary to investigate the health-improving effect of stretching to increase motor activity and improve the quality of life of high school children, but not athletes.

The study of the World Health Organization shows a tendency of physical activity decrease among youth all over the world, while it is noted that girls have significantly lower physical activity than their male peers. The global guidelines state that young people under the age of 17 should be physically active for at least 60 minutes a day (moderate intensity) and engage in high-intensity exercise at least three times a week. In addition, the traditional physical education program does not provide high school girls with sufficient information on the impact of exercise on their reproductive health. Thus, the involvement of girls in extracurricular forms of physical education classes will allow to apply an individual approach more widely, taking into account the specific features of the formation of the female body.

The significance of the research topic is due to the following contradictions:


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- between a significant number of studies on the physical health of children and disappointing statistics of the youth health conditions;
- between the need to improve physical education of young people and students ' attendance at physical education classes;
- between the desires of high school girls to improve their physical fitness level and methodological justification of the stretching program for developing flexibility;
- between fragmented scientific research on the development of flexibility and the lack of methods for developing flexibility by means of stretching.

Thus, the purpose of this study is to analyse the dynamics of indicators of active and passive flexibility in the joints of the upper extremities in girls aged 15-16 years after an annual cycle of extracurricular stretching classes.

## Material & methods

***Participants***

The study involved 35 high school girls aged 15-16 years, who were participated in extracurricular stretching classes at the secondary school. All participants and their parents were informed about the purpose and objectives of the study, and informed consent was obtained. The individuals involved in the study were normotensive, without any cardiovascular diseases, metabolic disorders, neurological disorders, injuries or disorders of the musculoskeletal system. The research related to human use has been complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the Human Research Ethics Committee of Lesya Ukrainka Volyn National University.

***Procedure/Test protocol/Skill test trial/Measure/Instruments***

During the school year, 35 high school girls were involved in extracurricular stretching classes three times a week. Classes lasted for 90 minutes and had a traditional structure: preparatory, main and final parts. We investigated the effect of stretching exercises on active and passive flexibility in the joints of the upper extremities using the goniometry method at the beginning of the study (before systematic stretching) and at the end of the study (after a formative experiment – a summer cycle of stretching). The proposed extracurricular form of classes corresponds to the age characteristics of girls' development and the specifics of material and technical support of secondary schools.

***Data collection and analysis / Statistical analysis***

Using the MedStat program, for a variation series whose distribution does not differ from the normal one at the significance level $p \geq 0.1$, arithmetic mean values (X), standard deviations (δ) and errors (m) were calculated. The statistical significance of the difference between the indicators was analyzed by the Student's criterion ($p<0.01$).

## Results

There are active and passive forms of flexibility. Active flexibility is the ability of a person to achieve a large (maximum) movement amplitude performing exercises independently without an external force, by independent tension (contraction) of muscle groups that perform movements in a particular motor segment.

Passive flexibility is the ability to perform movements with the greatest movement amplitude under the influence of external forces: the efforts of a partner, the weight of one's own body, special devices that have a direct physical impact on a particular motor segment.

Comparison of these indicators makes it possible to identify a "lack of flexibility", in other words, the presence of a reserve for developing flexibility by stretching.

Goniometric measurements of active flexibility indicators in the shoulder joints showed symmetry of the motor range during flexion, abduction, and adduction. Asymmetry in the extension of shoulder joints of the right and left arms was found ($p<0.01$) [Table 1].

**Table 1. Results of goniometric measurements to determine the movement amplitude in the shoulder joint at the beginning of the study (active flexibility)**

| Movement amplitude | A right side | | | | | A left side | | | | | p |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | X | δ | m | min | max | X | δ | m | min | max | |
| Flexion | 177,3 | 3,07 | 0,52 | 170 | 180 | 177,3 | 3,09 | 0,52 | 170 | 180 | =0,936 |
| Extension | 42,8 | 5,59 | 0,95 | 30 | 56 | 41,7 | 4,89 | 0,82 | 32 | 54 | <0,01 |
| Abduction | 177,1 | 3,28 | 0,56 | 170 | 180 | 176,7 | 2,92 | 0,49 | 170 | 180 | =0,627 |
| Adduction | 36,3 | 4,3 | 0,73 | 28 | 45 | 35,1 | 3,02 | 0,51 | 30 | 40 | =0,186 |

According to the results obtained when determining the movement amplitude in the elbow joints, all participants in the study showed the maximum physiologically possible movement amplitude. Analysis of goniometric measurements on the right and left showed symmetry of movements [Table 2].

**Table 2.Results of goniometric measurements to determine the movement amplitude in the elbow joint at the beginning of the study (active flexibility)**

| Movement amplitude | A right side | | | | | A left side | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | X | δ | m | min | max | X | δ | m | min | max |
| Flexion | 146,8 | 3,56 | 0,6 | 140 | 154 | 146,4 | 3,43 | 0,58 | 140 | 150 |
| Pronation | 90 | 0 | 0 | 90 | 90 | 90 | 0 | 0 | 90 | 90 |
| Supination | 90 | 0 | 0 | 90 | 90 | 90 | 0 | 0 | 90 | 90 |

According to the evaluation of wrist jointmovements, all girls who participated in the study performed movements symmetrically when flexing and extending the joints. Statistically significant ($p<0.01$) asymmetry was observed in abduction and adduction of wrist joints
[Table 3].

**Table 3.Results of goniometric measurements to determine the movement amplitude in the wrist joint at the beginning of the study (active flexibility)**

| Movement amplitude | A right side | | | | | A left side | | | | | p |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | X | δ | m | min | max | X | δ | m | min | max | |
| Flexion | 81,6 | 6,44 | 1,08 | 70 | 94 | 80,8 | 5,47 | 0,93 | 70 | 90 | =0,168 |
| Extension | 65,6 | 5,76 | 0,97 | 50 | 78 | 65,6 | 5,99 | 1,01 | 54 | 80 | =0,953 |
| Radial abduction | 24,6 | 3,19 | 0,53 | 18 | 30 | 23,7 | 2,76 | 0,46 | 18 | 28 | <0,01 |
| Elbow adduction | 31,5 | 2,73 | 0,46 | 25 | 38 | 30,8 | 2,41 | 0,41 | 26 | 37 | <0,01 |

Passive flexibility was determined using the same methods as active flexibility. The obtained data show the symmetry of movements in the shoulder joint in all the studied planes of motion [Table 4].

**Table 4. Results of goniometric measurements to determine the movement amplitude in the shoulder joint at the beginning of the study (passive flexibility)**

| Movement amplitude | A right side | | | | | A left side | | | | | p |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | X | δ | m | min | max | X | δ | m | min | max | |
| Flexion | 180,0 | 0 | 0 | 180 | 180 | 180,0 | 0 | 0 | 180 | 180 | =1,0 |
| Extension | 45,6 | 4,97 | 0,84 | 35 | 57 | 44,7 | 4,32 | 0,73 | 36 | 55 | =0,047 |
| Abduction | 180,0 | 0 | 0 | 180 | 180 | 180,0 | 0 | 0 | 180 | 180 | =1,0 |
| Adduction | 39,5 | 4,18 | 0,7 | 32 | 48 | 38,8 | 2,73 | 0,46 | 32 | 44 | =0,452 |

Determining an active movement amplitude of elbow joints, we noted the maximum physiologically possible indicators in all examined study participants. In this regard, we did not measure passive mobility in elbow joints. As for active mobility in the wrist joints, a statistically significant ($p<0.01$) asymmetry of movements was recorded during goniometry of the abduction. Studying the amplitude of passive movements in other planes of motion, we confirmed symmetry in movements in flexion, extension and adduction [Table 5].

**Table 5. Results of goniometric measurements to determine the movement amplitude in the wrist joint at the beginning of the study (passive flexibility)**

| Movement amplitude | A right side | | | | | A left side | | | | | p |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | X | δ | m | min | max | X | δ | m | min | max | |
| Flexion | 85,5 | 5,95 | 1,01 | 74 | 96 | 84,0 | 5,57 | 0,94 | 73 | 93 | =0,023 |
| Extension | 68,6 | 5,26 | 0,88 | 55 | 80 | 68,3 | 5,61 | 0,94 | 60 | 82 | =0,489 |
| Radial abduction | 26,3 | 2,48 | 0,42 | 22 | 31 | 25,3 | 2,41 | 0,41 | 20 | 29 | <0,01 |
| Elbow adduction | 33,0 | 2,26 | 0,38 | 28 | 38 | 32,7 | 2,1 | 0,35 | 27 | 38 | =0,082 |

We studied the active movement amplitude of joints to determine the degree of flexibility development after a one-year course of stretching classes. Goniometric measurements of active range of motion of shoulder joints in the right and left arms indicated that the movements were symmetrical, the amplitude indicators increased in all studied planesof motion ( $p<0.001$) [Table 6].

**Table 6. Results of goniometric measurements to determine the movement amplitude in the shoulder joint at the end of the study (active flexibility)**

| Movement amplitude | A right side | | | | A left side | | | | *p* |
|---|---|---|---|---|---|---|---|---|---|
| | X | δ | m | *p (in comparison with the results at the beginning of the study)* | *X* | *δ* | *m* | *p (in comparison with the results at the beginning of the study)* | |
| Flexion | 180 | 0 | 0 | <0,001 | 180 | 0 | 0 | <0,001 | =1,0 |
| Extension | 52,9 | 3,68 | 0,62 | <0,001 | 52,7 | 4,89 | 0,82 | <0,001 | =0,47 |
| Abduction | 180 | 0 | 0 | <0,001 | 180 | 0 | 0 | <0,001 | =1,0 |
| Adduction | 42,5 | 2,13 | 0,36 | <0,001 | 42,5 | 2,03 | 0,34 | <0,001 | =1,0 |

The movement amplitude in elbow joints did not change statistically (p>0.4) at the end of the study. There was no pathological increase in the range of motion [Table 7].

**Table 7. Results of goniometric measurements to determine the movement amplitude in the elbow joint at the end of the study (active flexibility)**

| Movement amplitude | A right side | | | | A left side | | | | *p* |
|---|---|---|---|---|---|---|---|---|---|
| | X | δ | m | *p (in comparison with the results at the beginning of the study)* | X | δ | m | *p (in comparison with the results at the beginning of the study)* | |
| Flexion | 147,3 | 2,97 | 0,5 | =0,493 | 147,0 | 3,03 | 0,51 | =0,444 | =0,656 |

Repeated goniometric measurements of the amplitude of active movements in wrist joints showed that the movements in all planes of motion were symmetrical. Flexion, extension, and abduction rates had a statistically significant increase. Adduction rates in wrist joints of the right and left arms did not change statistically (>0.01) after a one-year stretching cycle [Table 8].

**Table 8. Results of goniometric measurements to determine the movement amplitude in the wrist joint at the end of the study (active flexibility)**

| Movement amplitude | A right side | | | | A left side | | | | *p* |
|---|---|---|---|---|---|---|---|---|---|
| | X | δ | m | *p (in comparison with the results at the beginning of the study)* | X | δ | m | *p (in comparison with the results at the beginning of the study)* | |
| Flexion | 92,8 | 4,39 | 0,74 | <0,001 | 92,8 | 4,53 | 0,76 | <0,001 | =1,0 |
| Extension | 75,4 | 4,21 | 0,74 | <0,001 | 75,2 | 4,71 | 0,79 | <0,001 | =0,47 |
| Radial abduction | 26,4 | 2,35 | 0,39 | <0,001 | 26,1 | 1,77 | 0,29 | <0,001 | =0,104 |
| Elbow adduction | 31,6 | 2,7 | 0,45 | =0,159 | 31,1 | 2,41 | 0,41 | =0,359 | =0,058 |

**Discussion**

During the primary goniometric measurement of the amplitude of the movement in joints of upper extremities in high school girls, it was found out that during active movements there is a certain asymmetry: in shoulder joints during extension; in wrist joints during abduction and adduction (p <0.01). As for the passive range of motion, asymmetry in the movements of the joints of the upper extremities was observed in wrist joint abduction. Determination of the active mobility deficit, on the one hand, characterizes personal reserve capabilities to increase active flexibility, and on the other hand, it can indicate the likelihood of injuries and disorders of the musculoskeletal system (Andrijchuk 2016).

According to the data, the initial asymmetry of movements in the right and left arms should not be increased during stretching. The obtained indicators are an important diagnostic criterion for the formation of a set of exercises, emphasize the importance of following the rules for performing stretching and are a signal for timely monitoring of flexibility indicators(Matsuo 2019).

Planning and implementing the program of extracurricular activities we followed the rules for drawing up a set of stretching exercises (Aftimichuk 2020):

- symmetry - during stretching classes, it is necessary to monitor the symmetry and uniformity of the load when performing exercises to avoid an imbalance of the right and left halves of the trunk;
- sequence of stretching exercises - exercises for the joints of the upper extremities, exercises for the trunk, exercises for the joints of the lower extremities;
- variability of sets of exercises;
- regulation;
- cyclicity;
- combination with strength exercises.

Repeated goniometric measurements after a one-year cycle of stretching classes proved the effectiveness of the implemented program. The movements in all studied joints were symmetrical. Pathological movements and hypermobility of the joints were not detected. The amplitude of active movements in shoulder joints in all planes of motion changed statistically significantly (p<0.001). The movement amplitude (flexion) in elbow joints did not change statistically (p>0.4). The amplitude of active movements in wrist joints during flexion, extension and abduction changed statistically significantly (p<0.001), and as for elbow adduction, the difference between the indicators is statistically insignificant (p>0.1).

The implemented extracurricular program showed the effectiveness of stretching among girls aged 15-16 years, in particular, active flexibility in the joints of the upper extremities increased statistically significantly.

In addition, the absence of pathological movements and traumatic injuries is proof of the health-improving effectiveness of the program. Thus, stretching as a means of diversifying specially organized physical activity among adolescents can be implemented in a school environment.

**Conclusions**

In summary, systematic stretching classes during one academic year increased the amplitude of active movements in shoulder joints and most movements in the wrist joints. In addition, compliance with the correct organization of exercises and the principles of dosage of physical capacity helps to eliminate the asymmetry of movements in the joints of the upper extremities.

The practical significance of the presented results will contribute to a broader implementation of stretching to diversify the physical activity of adolescents and reduce the level of physical inactivity.

The dynamics of indicators of active flexibility in the course of the annual cycle of stretching classes is analyzed and data on motor activity and range of motion in the joints of the upper extremities of Ukrainian girls aged 15-16 years are presented. These data can serve as a basis for further study of the features of the functioning of the musculoskeletal system of people of different age groups and gender. Moreover, obtained results will be valuable to compare the impact of stretching and other types of physical exercises on active flexibility and range of motion.

**Conflicts of interest**

Authors state no conflict of interest.

**References:**

Aftimichuk, O. (2020), The methodology of flexibility development in the teenagers who practice break dance by fitness program, *MOJ Sports Med*, Vol.4(2), pp. 36–39.

Andriichuk, O., Zadvorniy, Bohdan. (2020). Active flexibility in girls before and after the annual cycle of stretching classes. *PedagogyandPsychologyofSport*, Vol. 6(3), pp. 117-126.

Andrijchuk, O (2016), General lifestyle characteristics of students who practice sports, *Journal of Physical Education and Sport, Vol* 16.- Issue 1, pp. 699 – 702.

Andriychuk, O., Graida, N., & Masikova, T. (2019). Evaluation of Patients and Quality of Life in Practical Activities of Physical Therapy. *Physical Education, Sport and Health Culture in Modern Society*, Vol. 2(46), pp. 55-60.

Di Mauro, D., Buda, D., Magaudda, L., Trimarchi, G., Bonaiuto, A., & Trimarchi, F. (2016). Acute effects of static stretching on jumping performance: static stretching and jump. *Med Sport,* Vol. 69(3), pp. 309-20.

Fakhro, M., Chahine, H., Srour, H., & Hijazi, K. (2020), Effect of deep transverse friction massage *vs* stretching on football players' performance. *World J Orthop,* Vol.11(1), pp.47-56.

Faria, F., Reis,L., &Neiva,C. (2010) Effects of an isostretching training protocol to increase the musculoarticular flexibility and other physiological aspetcs on the quality of life. *Journal of Physical Education and Sport*,Vol. 28, pp. 128 – 135.

Ferrara, F., Forte, D., Senatore, B.,& D'elia, F. (2019) The relationship between stretching and jumping in artistic gymnastics, *Journal of Physical Education and Sport,* Vol.19 (Supplement issue 5), pp. 1856 - 1858.

Judge, L. W., Avedesian, J. M., Bellar, D. M., Hoover, D. L., Craig, B. W., Langley, J. … & Dickin, C. (2020), Pre- and Post-Activity Stretching Practices of Collegiate Soccer Coaches in the United State, *International journal of exercise science*, Vol.13(6), pp.260–272.

Kalkman, B.., Holmes, G., Bar-On, L., Maganaris, C., Barton, G., Bass, A. … & O'Brien, T. (2019). Resistance training combined with stretching increases tendon stiffness and is more effective than stretching alone in children with cerebral palsy: a randomized controlled trial. *Frontiers in pediatrics*, Vol *7*, pp. 333.

Koryahin, V., Iedynak, G., Blavt, O., Galamandjuk, L., Prozar, M., Zaikin, A., Veselovska, T., Golub, V., Kucher, T., Gurtova, T. (2020).Introduction of electronic devices in the test of flexibility. *Journal of Physical Education and Sport*, Vol. 20(4), pp. 1855-1860.

Kyranoudis, A., Sotirios, A., Ioannis I., Athanasios C., Vassilios G., Efstratios, K., Thomas, M. (2019) The acute effects of combined foam rolling and static stretching program on hip flexion and jumping ability in soccer players. *Journal of Physical Education and Sport*. Vol. 19 (2), pp. 1164–1172.

Matsuo, S., Iwata, M., Miyazaki, M., Fukaya, T., Yamanaka, E., Nagata, K. … &Suzuki, S. (2019). Changes in Flexibility and Force are not Different after Static Versus Dynamic Stretching. *Sports medicine international open*, Vol. *3*(3), pp.89–95.

Matsuo, S., Iwata, M., Miyazaki, M., Fukaya, T., Yamanaka, E., Nagata, K., Tsuchida, W., Asai, Y., & Suzuki, S. (2019). Changes in Flexibility and Force are not Different after Static Versus Dynamic Stretching. *Sports medicine international open*, Vol. *3*(3), pp. E89–E95.

Motahari-Tabari, N., Shirvani, M. A., & Alipour, A. (2017). Comparison of the Effect of Stretching Exercises and Mefenamic Acid on the Reduction of Pain and Menstruation Characteristics in Primary Dysmenorrhea: A Randomized Clinical Trial. *Oman medical journal*, Vol. *32*(1), pp. 47–53.

Motahari-Tabari, N., Shirvani, M. A., & Alipour, A. (2017). Comparison of the Effect of Stretching Exercises and Mefenamic Acid on the Reduction of Pain and Menstruation Characteristics in Primary Dysmenorrhea: A Randomized Clinical Trial. *Oman medical journal*, Vol. *32*(1), pp. 47–53.

Rogan, S., Brülhart, Y., Ledermann, T., Schmutz, N.,& Lujickx, E. (2016),Effectiveness analysis of muscle stretching during interferential current in soccer players – an explorative study, *Journal of Physical Education and Sport*, Vol.16, pp. 10-15.

Slavko, R., Brülhart, Y., Ledermann, T., Schmutz, N., Lujickx, E. (2016). Effectiveness analysis of muscle stretching during interferential current in soccer players – an explorative study. *Journal of Physical Education and Sport*. Vol.16, pp. 10–15.

Socha, M., Frączak, P., Jonak, W., & Sobiech, K. A. (2016). Effect of resistance training with elements of stretching on body composition and quality of life in postmenopausal women. *Przeglad menopauzalny = Menopause review*, Vol. *15*(1), pp. 26–31.

Todorova,V., Rybalko, P., Dubynska, O., Khomenko, O., Gvozdetska, S., Krasilov, A. Yevtushenko, Y. (2021). MmA exercises in physical education of 17-18 year old students. *Journal of Applied Exercise Physiology*. Vol. 10 (1), pp. 100-107.

Tupimai, T., Peungsuwan, P., Prasertnoo, J., & Yamauchi, J. (2016). Effect of combining passive muscle stretching and whole body vibration on spasticity and physical performance of children and adolescents with cerebral palsy. *Journal of physical therapy science*, Vol. *28*(1), pp. 7–13.

Ulyanytska, N., Indyka, S., Andriychuk, O., Yakobson, O., Grayda, N., & Lavrenyuk, V. (2020). Particularities of the Program for Psychophysiological Indicators' Recovery in Hcu Senior Pupils. *Physical Education, Sport and Health Culture in Modern Society*, Vol.2 (50), pp. 78-84.

Yıldırım, M. S., Ozyurek, S., Tosun, O., Uzer, S., & Gelecek, N. (2016). Comparison of effects of static, proprioceptive neuromuscular facilitation and Mulligan stretching on hip flexion range of motion: a randomized controlled trial. *Biology of sport*, Vol. *33*(1), pp. 89–94.

Zmijewski, P., Lipinska, P., Czajkowska, A., Mróz, A., Kapuściński, P., & Mazurek, K. (2020). Acute Effects of a Static Vs. a Dynamic Stretching Warm-up on Repeated-Sprint Performance in Female Handball Players. *Journal of human kinetics*, Vol. *72*, pp. 161–172.

Zmijewski, P., Lipinska, P., Czajkowska, A., Mróz, A., Kapuściński, P., & Mazurek, K. (2020). Acute Effects of a Static Vs. a Dynamic Stretching Warm-up on Repeated-Sprint Performance in Female Handball Players. *Journal of human kinetics*, Vol. *72*, pp. 161–172.