Education of the Lower Body Flexibility in Students by Combining Various Types of Stretching during Physical Education Lessons

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Abstract: Goal: The identification of the effectiveness of the application of dynamic stretching (DS) and static stretching (SS) during warm-up and cool-down, in regards to lower body flexibility. Participants: 206 boys and 91 girls, first- and second-year students of the Dunărea de Jos University, Galați, involved in over 90% of the physical education lessons over the course of both semesters of the academic year 2018-2019, for 28 weeks, 1 module/2 hours weekly. Results: The statistical calculation performed with ANOVA, with repeated measurements indicates the existence of significant progress (values of $F < .05$), for both genders, in most of the applied tests, but the size of the effect (Partial eta squared/ η^2_p) shows a weak influence of the independent variable on the flexibility values in half of the analyzed cases. The average values of the girls' performances are significantly superior to the boys' results, in 6 out of 8 tests. Conclusions: The stretching types used during the physical education lessons are effective, producing results in regards to flexibility and to the initial, reduced training level, however, in order to get stronger effects, one physical education lesson per week is not a viable solution to achieve long term favorable adaptations.

Keywords: *flexibility; stretching; physical education; students; warm up; cool down.*

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1. Introduction

An optimal level of flexibility, alongside muscle strength and body stability, are factors that condition one's wellbeing and health, depending on age, sex, training level and stage, fatigue, lifestyle, occupation, genes, etc. (Micheo et al., 2012). Regardless of sport, flexibility conditions the quality of the performance, but also the superior manifestation of the coordinative and conditional skills - speed, strength and endurance (Alexe, 2010; Badau & Badau, 2011; Badau & Badau, 2018; Dobrescu & Constantinescu, 2006; Enoiu, 2006).

The importance of stretching is highlighted by Takeuchi and Nakamura (2020) who, by questioning 138 coaches from 21 different sports, has shown that 126 of them used one type of stretching, 77 used both types (DS+SS), 39 only SS, and 10 only DS. The average values for the 2 types of stretching are relatively close: 21.38 sec for SS and 22.1 sec for DS.

The benefits of static stretching (SS) and dynamic stretching (DS) as basic elements of physical fitness are diverse: improvement of the range of motion (ROM) as a result of increasing the tissue tolerance to stretching, muscle relaxation, mental relaxation, ensuring the body-mind-spirit unity, body symmetry and correct posture, improvement of spine pain, of muscle cramps and pain, injury prevention, improvement of the quality of sleep and motor performances, self-discipline and knowing one's own body, generating joy and pleasure, increasing the quality of life (Alter, 2004; Knudson, 2006; Peeler & Anderson, 2007; Rubini et al., 2007; Snyder et al., 2006; Zakaria et al., 2015).

Increasing muscle temperature is essential before starting stretching programs, so the SS and DS must be preceded by aerobic warm-up, which can ensure by itself high ROM values before the main work in the professional athlete students, without using SS. One must avoid static stretching with maximum tension and range, using instead submaximal tensions, with less repetitions for less 30 sec. (Chaouachi et al., 2010). The selection of the types of stretching must be correlated to the particularities of the motor tasks that need to be accomplished/ the specifics of training and competition work. Paradisis et al. (2014) studied the acute effects of DS and SS on a group of 47 students, in regards to the quadriceps, hamstrings, plantar flexor and hip extensor muscles. SS has performance weakening effects for sprint and power, but it was noticed that DS also reduces power, without however affecting the sprint results. The comparison between the DS and SS effectiveness as part of the warm-up - after a 5 minute aerobic

effort - was made by (Perrier et al., 2011), by measuring the reaction time, the hamstrings flexibility and the vertical jumps / countermovement jump (CMJ), on a group of 21 young men, of an average age of 24.4. The best CMJ values are after performing DS, the reaction time has not significantly changed, and the flexibility values have increased for both types, but without a significant difference between DS and SS, the authors, however, recommending DS before power, agility and sprint work, this type of stretching being capable of increasing blood flow easier, and thus, increasing muscle temperature.

The favorable or limiting effects of these types of stretching are often described contradictorily in the professional literature (Behm & Chaouachi, 2011; D'Anna & Gomez Paloma, 2015; Opplert & Babault, 2018). Multiple experts say that SS holds not many beneficial effects, especially for times longer than 60 seconds, affecting physical performances in sprint, jumping, maximal strength, with average values of -5-30%, while shorter stretches influence in an insignificant way the performances, the values being different according to the moment of recording. Values smaller than 15 sec are more effective than the ones of 30 or 60 sec, experts advising not to use it 10 minutes to 2 hours before main competition work. Its use is well suited for the cool-down phase, favoring the body's return within normal ranges and the elimination of toxic catabolites. DS is a good alternative to SS, suited especially for the warm-up phase for the main physical activities, offering an average performance gain of +11.3%.

The influence of static stretching vs dynamic/ ballistic stretching through 20-minute programs on flexibility and maximal strength was highlighted by Bacurau et al. (2009), in a study conducted on young women averaging 23.1 years old. There were decreases in strength after SS, but not after DS, thus the authors do not recommend SS during warm-up in sports that demand high levels of strength. In regards to acute flexibility, both types of stretching generate significant increases in the hip joint ROM, with SS giving better values. A similar experiment regarding the hamstrings eccentric force and functional performance conducted on 45 active men for 10 weeks - 3x30 sec SS vs 3x30 DS repetitions - showed a decrease in strength after the SS, which should be used cautiously (Barbosa et al., 2020).

Contraindications for the use of SS are stated also by Kistler et al. (2010), writing that its use right after a dynamic warm-up by young athletes affects the sprinters' performances for the interval 20-40 m, being impossible to recover this delay for the final result in the 100 m event.

The study conducted by Yamaguchi and Ishii (2005) on the effects of the 30 sec duration of SS vs DS in regards to power/leg extension in

active students with an average age of 22.8, has shown that SS decreases muscle strength and only DS is effective and recommended for sports activities that require jumping. A comparison between stretching programs and their effects on volleyball players' sprinting performances on short distances - 4.5 - 9 m - was done by Alipasali et al. (2019), by implementing dynamic and static programs 3 times/week, for 6 weeks. Both types of stretches are effective, statistically significant performances being recorded, the witness group (NS) being the only one without any progress. The effectiveness of both types of stretching is supported by Matsuo et al. (2019), who proposes 5 minutes work intervals for the lower body, both DS and SS generating a decrease in the passive rigidity of the tissues, an increase in the ROM, but also a decrease in the isometric force, without any significant differences.

There are also experts who state the effectiveness of SS. The SS types are more effective than DS and PNF in regards to ROM values, the minimal duration being of at least 5 minutes/session, 5 sessions/week; one session/week does not have the desired results (Thomas et al., 2018). The fractioned type of SS - 3x30 sec cu 30 sec break - is believed to be more effective than the continuous - 90 sec - in regards to vertical take-off performances in elite gymnasts (Bogdanis et al., 2019).

2. Material and Methods

Purpose: the research tries to identify the effectiveness of both types of stretching during the physical education lessons in higher education, expressed in the flexibility values of the lower body.

Research hypotheses: It is presumed that:

H0: There are no significant differences between the average values of the flexibility tests recorded during the 3 assessments of the analyzed groups ($m_1=m_2=m_3$).

H1: There are significant differences between performances during tests, separately on genders, as a favorable effect of stretching ($m_1 \neq m_2 \neq m_3$).

H2: The female group records higher, statistically significant average values than the male group, for the entire battery of tests.

Organization of the research

Participants

The studied group comprised 297 first- and second-year undergraduate students (206 males and 91 females) of the Dunărea de Jos

University, Galați, with an average age of 23.62 ± 4.3 years, studying Medicine and A.C.I.E.E. (Automatic Control, Computer Science, Electrical and Electronic Engineering). The subjects have participated in at least 90% of the physical education classes, 2 hours per week, over the course of the academic year 2018-2019. All the tested subjects were declared medically apt for physical effort, most of them not being involved in regular physical activities.

Procedure

The students went through the stretching program over the course of the 28 weeks of the academic year, being informed in regards to the goals of the study and being familiarized with the proposed exercises. The tests were conducted at the FPES Human Performance Research Center, in Galați, at 3 distinct moments: at the beginning of the first semester, at the end of it / before winter holidays - week 12, and at the end of the second semester, at the same time intervals, and under similar temperature conditions. For reasons of space, this study presents only the results regarding the lower body flexibility.

Flexibility training

The preparation of the physical education lessons consisted in selecting the DS and SS stretching exercises for both the upper and lower body, establishing a dosage and placement within the activities. Their usefulness was correlated with the themes of the lesson and the planned type of dominant work: power, endurance/repetitive, combined, etc. The duration of the stretches, the number of series and repetitions were adapted to the students' physical capabilities and in agreement with the recommendations of experts. Versions of DS were preferred for the warm-up: forward and side lunges, repeated flexions of the calf on the thigh, lifting a knee to the chest, flexions of the core on the pelvis and putting the palms on the floor, lifts on tiptoes and heels, balancing and pendulation of the lower limbs. The DS activity (5 minutes) was preceded by jogging/aerobic effort for 3 minutes, and the frequency of movements and their range was individualized. For the cool-down part, the SS was preferred, with a total duration of 5 minutes, with stretches of variable length, between 10-30 sec. For both types an exaggerated range was avoided, because it might have caused discomfort and possible injuries. The proposed exercises aimed to stretch all lower limb joints (hip, knee, ankle), as well as the main muscles involved in performing the movements during the main part of the lesson (the tibialis anterior /posterior muscles, the femoral muscles, the gluteus

muscles, the iliopsoas, the quadriceps, the hamstrings, the superior gemellus, the soleus, etc.).

Tests description

T1. Flexibility of the coxofemoral articulation from the sitting position legs apart: the palms slide on the ground along a graded ruler until they get fixed at the level of the groin, up to the maximum individual amplitude. The value read at the level of the finger tips is being registered.

T2. Flexibility of the coxofemoral articulation from the supine position: traction of an inferior member bent towards the chest, palms on the knees. The perfect contact between the thigh and the knees is quantified by 10 points, the partial contact by 5 points and the lack of contact by 0 points.

T3. Frontal plane hip flexibility: the inferior members are straight apart in a lateral position, up to the personal limit; the distance from the pubis to the ground is being measured.

T4. Sagittal plane hip flexibility: the inferior members are straight apart in an antero-posterior position; the distance from the pubis to the ground is being measured.

T5. Flexibility of the inferior members: from a sitting position, back against the wall the inferior members are gradually taken apart, stretched knees; the maximum resulted angle is measured by the means of a goniometer.

T6. Flexibility of the hamstring muscles: from the supine position, a stretched inferior member is lifted in a vertical position and the respective position is maintained. 10 points are given for maintaining 90° , 5 points for maintaining it under the same angle but no less than 45° and 0 points for the incapacity of holding the foot in the required position.

T7. Flexibility of the inferior members and the spine while semi-sitting on a bench/step: the body is bent forward, arms stretched towards the ground and stretched knees; The movement is blocked at the individual maximum amplitude limit. The distance from the fingertips to the top of the toes is measured.

T8. Knee flexibility: a slow flexion of the leg on the thigh is executed, for a random inferior member from a prone position, without any external help. 10 points are awarded for an obvious contact between the heel and the gluteus muscles, 5 points for near contact and 0 points for lack of contact.

3. Results

The data analysis used the ANOVA procedure with repeated measurements, separately for the two sexes, for establishing the differences between the 3 tests for the paired samples, but also a comparison of the average results between the female group and the male group (Hair et al., 2009; Murariu, 2018; Murariu & Munteanu, 2018; Opariuc-Dan, 2011; Statistics & Theory, 2020). The use of this procedure needs to meet multiple criteria, including the sphericity one (Maucly's). If the test values relate to a threshold of $P > .05$ and the epsilon (ϵ) value are equal to 1, then the sphericity conditions are met, if not ($P < .05$) the Huynh-Feldt corrections are applied for $\epsilon > 0.75$, and the Greenhouse-Geisser ones for $\epsilon < 0.75$, which attracts the modifications of the freedom degrees. Table 1 presents these results, to which is added the size of the effect/Partial eta squared (η_p^2), which indicates the influence and practical effectiveness of the independent variable/stretching program on the dependent variable/ flexibility. The confidence interval was set at 95% ($P < .05$).

The sphericity conditions are met only for the first test by both sexes, the aforementioned corrections being applied in the other situations. Even if the F values correspond in most cases to statistically significant thresholds ($< .05$), one can observe that there are 4 situations where this is not the case: flexibility of the coxofemoral joint in supine position in girls, flexibility of the hamstrings in supine position, also in girls, and flexibility of the knee in prone position in both sexes. All of these cases are related to very low values of η_p^2 , which confirms the limited/statistically insignificant performances. Moreover, the η_p^2 values indicate strong effects ($\eta_p^2 > .14$) only for half of the presented situations, existing also cases in which statistically significant F values are accompanied by a weak ($.01 < \eta_p^2 < .05$) or medium ($.06 < \eta_p^2 < .14$) effect. For example, in T4/Sagittal plane hip flexibility in boys, $F(1.14 ; 234.57) = 12.05$, $P < .05$, but $\eta_p^2 = .056$, which indicates a weak to medium effect of the proposed program. The strongest effects were encountered in T7/Flexibility of the inferior members and the spine while semi-sitting on a bench/step, the girls recorded a $F(1.56; 140.55) = 12.05$, $P < .05$, with $\eta_p^2 = .493$, and the boys a $\eta_p^2 = .600$.

Table 1 *ANOVA results with repeated measurements*

Test no.	group	Maucly's Test of Sphericity		Correction factor	df	Error df	F	Sig.	Partial eta squared (η^2_p)
		Sig.	ϵ						
T1	boys	.413	1.000	Sphericity Assumed	2	410	132.330	.000	.392
	girls	.474	1.000	Sphericity Assumed	2	180	65.878	.000	.423
T2	boys	.000	.820	Huynh-Feldt	1.640	336.265	9.365	.000	.044
	girls	.000	.824	Huynh-Feldt	1.647	148.249	3.068	.059	.033
T3	boys	.000	.715	Greenhouse-Geisser	1.431	293.307	123.906	.000	.377
	girls	.000	.708	Greenhouse-Geisser	1.417	127.525	34.938	.000	.280
T4	boys	.000	.572	Greenhouse-Geisser	1.144	234.578	12.058	.000	.056
	girls	.002	.882	Huynh-Feldt	1.798	161.778	44.972	.000	.333
T5	boys	.000	.930	Huynh-Feldt	1.859	381.111	31.447	.000	.133
	girls	.000	.634	Greenhouse-Geisser	1.238	114.142	14.862	.000	.142
T6	boys	.000	.815	Huynh-Feldt	1.619	331.923	6.150	.005	.029
	girls	.000	.818	Huynh-Feldt	1.611	144.964	1.508	.226	.016
T7	boys	.000	.887	Huynh-Feldt	1.774	363.640	306.974	.000	.600
	girls	.000	.781	Huynh-Feldt	1.562	140.553	87.449	.000	.493
T8	boys	.000	.810	Huynh-Feldt	1.620	332.153	3.030	.061	.015
	girls	.000	.747	Greenhouse-Geisser	1.514	136.267	2.368	.111	.026

Table 2 indicates the significance of the pair differences for the 3 moments of testing (t_i - initial, t_{int} - intermediary, t_f - final), on sexes. The results are represented in charts, for a part of the tests, in order for the reader to better visualize the progress of the performances over the course of the academic year.

Table 2. Results of the significances of mean differences on pairs of tests

Test group no.	p	$t_i - t_{int} / \text{sem1}$			$t_{int} - t_f / \text{sem2}$			$t_i - t_f$		
		Mean difference	Std. error	Sig. ^a	Mean difference	Std. error	Sig. ^a	Mean difference	Std. error	Sig. ^a
T1	boys	-.432*	.045	.000	-.277*	.042	.000	-.709*	.044	.000
	girls	-.214*	.051	.000	-.330*	.046	.000	-.544*	.046	.000
T2	boys	-.146*	.059	.042	-.146*	.059	.042	-.291*	.082	.001
	girls	-.110	.077	.475	-.110	.077	.475	-.220	.108	.135
T3	boys	.262*	.045	.000	.301*	.025	.000	.563*	.034	.000
	girls	.297*	.074	.000	.192*	.040	.000	.489*	.058	.000
T4	boys	.291*	.040	.000	.245	.130	.182	.536*	.132	.000
	girls	.330*	.049	.000	.049	.035	.497	.379*	.045	.000
T5	boys	-.209	.098	.102	-.461*	.077	.000	-.670*	.083	.000
	girls	-.396	.175	.078	-.330*	.087	.001	-.725*	.123	.000
T6	boys	-.097	.048	.136	-.097	.048	.136	-.194*	.067	.013
	girls	-.055	.055	.960	-.055	.055	.960	-.110	.077	.475
T7	boys	-.864*	.077	.000	-.951*	.059	.000	-1.816*	.082	.000
	girls	-1.154*	.110	.000	-.088	.073	.689	-1.242*	.124	.000
T8	boys	-.049	.034	.473	-.049	.034	.473	-.097	.048	.136
	girls	-.055	.055	.960	-.110	.077	.475	-.165	.094	.250

a. Adjustment for multiple comparisons: Bonferroni.

*. The mean difference is significant at the .05 level

One can notice that the mean differences between ($t_i - t_f$) are in concordance with the F thresholds in the first table, there were however, a series of insignificant differences of the means for the shorter time values: ($t_i - t_{int}$) and ($t_{int} - t_f$), respectively. As an example, even if the mean difference between ($t_i - t_f$) in boys for T6/Flexibility of the hamstrings in supine position is related to a threshold of $P = .013$, a significant value $< .05$; the differences between ($t_i - t_{int}$), and between ($t_{int} - t_f$), respectively, correspond to a threshold of $P = .136$, an insignificant value of $> .05$, thus the semestrial progress is insignificant, the final significant value being a result of the cumulated effect of the proposed activities for the entire training period. .

There are also cases in which the progress in the first semester is insignificant, while in the second semester there are significant differences, as in the case of T5/flexibility of the lower limbs from a sitting position, for both sexes. Another situation is the reverse, in which there is significant

progress only in the first semester, and no significant improvement in the second one, this showing a flattening of the results following an adaptation to the stimuli. For example, in T4/Sagittal plane hip flexibility, in both sexes the difference ($t_i - t_{int}$) corresponds to a significant threshold of $P < .05$, but the difference ($t_{int} - t_f$) in girls is associated to a threshold of $P = .497$, while in boys, to a $P = .182$, both $> .05$ and insignificant.

Figure 1. Test 5- Progress of the results for the flexibility of the lower limbs from a sitting position

Table 3 synthesizes the progress of the means for the three tests, as well as a comparison between the means difference on sexes. One can observe the impossibility to progress in both sexes for T8/Flexibility of the knee, this being the most difficult test of all, only 17 boys (8.25%) and 7 girls (7.69%) managing to get points here, the girls' progress being null after the first semester, all differences being insignificant. One explanation why the test is so difficult is given by the atypical working position, but also by the interdiction to pull one's foot toward the gluteus muscles using one's hand, which is allowed in test 2, and which would have allowed an improvement of the results, many cases lacking only 1-2 cm to produce the contact between the heel and the buttocks. The recorded values indicate difficulties of active stretching of the quadriceps and, maybe, a limitation of the hamstrings' force of contraction.

Table 3. Progress of the performances and the mean difference between sexes

Test no.	group	t _i	t _{int}	t _f	Mean	Mean difference	Std. Error	Sig. ^a
T1	boys	42.456	42.888	43.165	42.837	.507	.736	.491
	girls	42.077	42.291	42.621	42.330			
T2	boys	6.626	6.772	6.917	6.772	-2.789*	.331	.000
	girls	9.451	9.560	9.670	9.560			
T3	boys	46.427	46.165	45.864	46.152	9.458*	1.075	.000
	girls	36.956	36.659	36.467	36.694			
T4	boys	41.879	41.588	41.342	41.603	12.015*	1.230	.000
	girls	29.824	29.495	29.445	29.588			
T5	boys	102.981	103.189	103.650	103.273	-10.540*	1.657	.000
	girls	113.440	113.835	114.165	113.813			
T6	boys	6.626	6.723	6.820	6.723	-2.123*	.294	.000
	girls	8.791	8.846	8.901	8.846			
T7	boys	-2.985	-2.121	-1.170	-2.092	-8.451*	1.344	.000
	girls	5.560	6.714	6.802	6.359			
T8	boys	.363	.413	.461	.412	.083	.186	.655
	girls	.275	.275	.440	.330			

a. Adjustment for multiple comparisons: Bonferroni.

*. The mean difference is significant at the .05 level.

Figure 2. Test 8- Progress of the results for the flexibility of the knee

The female subjects recorded statistically significant and superior results than the male subjects during all tests, with the exception of T1/Flexibility of the coxofemoral articulation from the sitting position legs apart (Figure 3) and T8/Flexibility of the knee, but the superiority of the

boys in these two tests is not statistically confirmed, the mean differences being insignificant, $P=.491$ and $.655$, respectively, values $>.05$.

Figure 3. Test 1 - Flexibility of the coxofemoral articulation from the sitting position legs apart

Even if for T7/Flexibility of the lower limbs and spine while semi-sitting on a bench/step the progress in both sexes is significant, the boys' final average result is disappointing, because it is negative (-2.09cm). Although 115 cases (55.82%) have recorded positive values, they cannot compensate the negative values, the lowest being -35 cm. This is not encountered in the girls' case, where the average final result is positive (6.35 cm), the positive values were recorded in 80 cases (87.91%), and the lowest value was -17 cm.

Figure 4. Test 7- Progress of the results for the flexibility of the lower limbs and spine while semi-sitting on a bench/step

4. Limitations and discussions

The influence of stretching on the lower body flexibility is reflected in numerous studies, conducted on various age categories and physical

activities. A study using the same tests, but conducted on the students of FPES Galati has shown the influence of curricular practical activities on the lower body flexibility, without significant accumulations in most cases, generated by the higher level of physical training and reaching certain individual limits, the female subjects recording better results (Mocanu, 2020). A lack of laboratory tests (based on sensors, video cameras, EMG, etc.) used in other studies is a limitation of this research; this study cannot offer detailed information regarding the agonist-antagonist-stabilizer relation for the muscles involved in the studied movements or the degree of involvement of each muscle group in the case of synergistic actions. Following the practical measurements, the authors have reached the conclusion that certain tests can be optimized in regards to the quantification of data, eliminating the scores and replacing them with finer measurements of articular angles, especially where the individual anthropometric values / arm or leg length decrease the objectivity of the results: test 1 gives an advantage to people with long arms, while tests 3 and 4 are the opposite, people with longer legs record lower values for the same articular angle. Another aspect that was observed is that the tests are based on usual working positions (various forms of standing and sitting), and the movements are similar to frequently used stretching exercises, which makes the results have significantly improved values, due to the subjects being familiar with and adapted to that motor structure. Contrarily (tests 6 and 8 contain less used working positions and movements, e.g. prone and supine positions), the same progress was not recorded.

The performance of DS by female adolescents aged between 16-17 within an 8-week program of 2 sessions/week, followed by 4 weeks of break, then continued with another 4 weeks of DS at the same frequency, has generated significant improvements in their thigh/hamstrings flexibility and extensibility. The break period had canceled all progress, but the recommencement of stretching in the second phase of the program has allowed the recovery of losses from the end of the first stage, the participants not reporting any problems related to injuries or muscle discomfort (Becerra-Fernández et al., 2016).

Takeuchi and Nakamura (2020) have studied the effectiveness of various durations of maintaining SS at a high intensity up until reaching the maximum point of discomfort, in order to increase the hamstrings flexibility and strength, on a group of 14 young men of an average age of 20.8. They propose static stretches of 10, 15 and 20 seconds, observing an improvement in the ROM and a reduction of the muscle-tendon rigidity, regardless of the duration, recommending the 10 sec time for increasing

flexibility and decreasing the chances of injury, and over 15 sec for increasing the contraction force right after stretching.

The effects of stretching on the dynamic range of motion of the hip during the kick of the dominant leg in 18 male football players with an average age of 19.22 has show through video analysis that higher values were recorded after using DS in the warm-up part, increasing the effectiveness of the performance and reducing the risk of injury, compared to SS or NS (Amiri-Khorasani et al., 2011).

Increased knee extension values were recorded after performing DS, in comparison with the effects induced by SS, in a study conducted by Meroni et al. (2010). Both types of stretching were applied on a group of 65 healthy subjects, for 6 weeks; the subjects who used DS recorded better results after 3 weeks, at the end of the 6 weeks, and kept the high values 4 weeks after ending the program, whereas the subjects who used SS recorded lower values and higher losses of flexibility.

A study conducted by Chan et al. (2001) on 40 Hong Kong students, with an average age of 20.3, with no spine, hip or calf injuries, has shown that the favorable effects of stretching programs, in regards to the hamstrings flexibility and ROM, are set both after 8 weeks and faster - after 4 weeks, with 3 sessions/week, 5 repetitions x 30 sec of SS, the stretches being preceded by 5 minutes of aerobic activity / jogging.

The stretching types and their combinations used during warm-up were verified by Kafkas et al. (2019). They tested a group of 15 men that were regularly involved in physical activities: jogging + NS, jogging + SS, jogging + DS, jogging + SS+DS, jogging + DS + SS, with a duration of 5 minutes. The flexibility values do not differ significantly, but the best results were recorded for the SS.

The study conducted by Donti et al. (2018) on 77 preadolescent female gymnasts for 15 weeks, 3 sessions/week, in which they compare between continuous SS (90 sec.) and fractioned / intermittent SS (3x30 sec. with a 30 sec break) proves that the repetition version generates a higher progress of the ROM, both on a short term/immediate basis and on a long term basis.

Improved values for the hamstrings were recorded by Ayala et al. (2013), after applying an active stretching program for 12 weeks, with 3 sessions/week, 3 minutes of active stretching of 6 sets x 30 sec, 20 sec break between sets, aimed to young people with an average age of 22.1, with a normal but limited flexibility.

5. Conclusions

The significant progress recorded in both sexes for most tests are not supported by high values of the size of the (η^2_p) effect in 50% of the analyzed versions, thus the proposed stretching exercises cannot be highly effective by programming only one single module of 2 hours per week. The precarious level of physical training (most of the subjects do not engage regularly in physical activities) could explain the recorded improvements, thus existing a chance for significant increases in all of the physical fitness components, not just flexibility. It is necessary to extend this kind of studies on other categories of the population, in order to highlight the influence of the lifestyle, profession, age, types of stretching and various sports on flexibility.

Acknowledgement

The team that carried out the present study declares on their own responsibility that the subjects participating in the research were informed of the voluntary nature of participation in the research, understood the information received and requested for research. They understood that withdrawal from the research can be done at any time, without any adverse consequences on the participant. Research has observed the ethical standards of research, we mention that the students have given their consent for the participation to this research.

This article is the equal contribution of all authors.

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