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THE EFFECTS OF EXERCISE-ASSOCIATED FLEXIBILITY IN ELDERLY PERSONS: SYSTEMATICALLY EXAMINED RESEARCH

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Systematic review
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Abstract

Introduction: Flexibility is defined as a maximum mobility amplitude. Flexibility drops with the age. It is very well known that a physical activity stands out as a decisive factor in terms of quality lifestyle, which, at the same time, prevents and reduces various physical and psychological age-associated changes. Stretching exercises or flexibility excercises are particularly important part of each training programme as they increase the mobility span at joints, relax muscles and ease everyday activities, making a body more flexible and helping in the prevention from injuries.

Methods: The works through two databases PubMed, Cihnal, Embase, Open-J-Gate i Google Scholar have been sought. The works of experimental character on exminees over 60 years of age have been analyzed. The works dealing with the issue of flexibility directly or indirectly through a research by its very content, have been sought.

Results: By initial database search we have come across with a preliminary figure of 3810 works, which have consequently produced 16 works by a meta-analysis, being analysed in details, from which a comprehensive conclusion has been eventually inferred.

Conclusion: Exercise including joints relaxation by its content, such as water exercise, then the one excluding uncoordinated rash motions by its content, such as pilates, has been scientifically proved to be beneficial to the elderly population. As a result, minimum injury exercise contributes to the improvement in all psycho-physical abilities, including flexibility.

Key words: **flexibility, effects, exercise, adults, the elderly, yoga, pilates, Tai Chi**

Introduction

The scientists have indicated that there is a possibility in the health improvement and prevention of diseases through physical activity and training, even in adults with reduced abilities and a complex clinical picture, the improvement is possible with a meticulous control and a moderate strain, thereby, reducing the risk from injury to a minimum, while the progress is guaranteed.

In the elderly population, it is very clear that flexibility reduces with the age. The Control Group of individual authors has recorded negative measurements (after only six weeks, which has proved flexibility rapidly reducing with the age) (Lanier, 2016).

Physical activity and training bring about the enlargement of a muscle mass and a muscle strength and a better functional ability in regard of coordination, balance, and flexibility, which, intrinsically reduce the risk from injury caused by the falling. (Barker, 2016).

The stretching exercises or flexibility are particularly crucial part of any training programme for expanding the scope of movements in the joints, relaxing the muscles and easing everyday activities by making the body as much as supple possible, thereby helping in the prevention from injuries like tendon spraining or overstraining. (Grez, 2009).

Regular and correct stretching substantially reduces and prevents the risk from injuries such as muscle ruptures, arising for muscle inflexibility (Baker, 2001).

Activities improving flexibility include the exercises which extend the muscles, here are some of them: swimming, tai chi, specialized aqua aerobics for the elderly people, yoga, pilates (Melro, 2016).

The objective of the work is to establish which exercise programs contribute most to the increase of flexibility in the elderly persons.

Methods

Research strategy

The following are electronic database utilized for gathering data on exercise-related effects on flexibility in the elderly people: PubMed/Medline, Cihnal, Embase, Open-J-Gate and Google Scholar. The works published between 2000 and 2017 have been sought. The following keywords have been utilized during a search: flexibility, effects, exercise, adult, elderly, seniors, yoga, pilates, tai chi.

Type of Study

The review included journal articles written in English and published during the last 17 years.

Type of Intervention

Analyzed scientific articles were to be of an experimental character, including a physical activity, flexibility, and a tested population being older than 60 years of age.

Type of Outcome Measure

Analyzed scientific articles were to be of an experimental character, including a physical activity, flexibility, and a tested population being older than 60 years of age.

Exclusion criteria

The exclusion criteria were as follows: studies without (1) test flexibility; (2) studies without estimation of the flexibility; (3) studies written in languages other than English.

Data analysis

Table 1 provides an overview of close analyses of 16 studies that met the set criteria. Following the conventions for systematic reviews, the table presents the following parameters**:** groups, participant's sample information (author, title of the work, location, number of examinees, age group of examinees, duraton of treatment, treatment, test flexibility and results).

Results

3810 works have been found by the review of electronic database. Due to search criteria requiring the researches be experimental and longitudinal ones, one has come to the figure of 1520 works to be taken for a further analysis. For the abstract reading 978 works which haven't met the over 60 years age criteria, have been dropped . Out of the remaining 542 works 526 have been omitted for the scope of the works being published. Sixteen works from 2000 to 2017 have been taken for a further analysis.

Graph 1 Systematic review flowchart

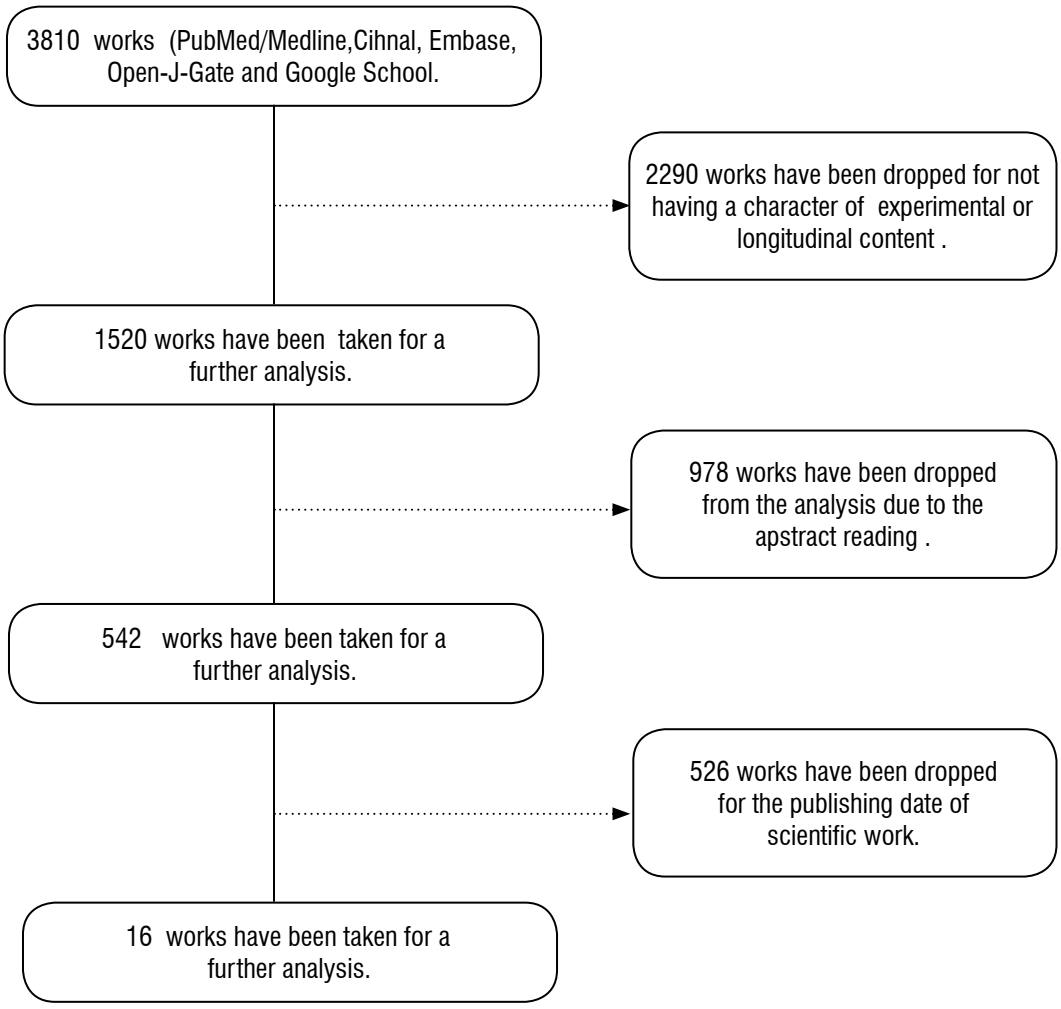

Table 1- Summary of characteristics of all studies meeting the inclusion criteria								
Author	**Title of the work**	**Location**	**Number of examinees**	**Age of an examinee**	**Duration of treatment**	**Treatment**	**Tests**	**Results**
Vitielo, M.D. et.al.	Successful 6-month endurance training does not alter insulin-like growth factor-I in healthy older men and women	Washington, USA	52 examinees (31 male and 21 female	≥60 years	6 months , three times a week, duration of treatment around 30 minutes	Stretching and strength exercises	VO2max, body weight, back scratch.	By increase – related flexibility we do not obtain the improvement in endurance
Grez, G.B.	Pilates exercise positively affects balance, reaction time, muscle strength, number of falls and psychological parameters in 65+ years old women	Turkey	100 examinees (100 female)	≥60 years	12 weeks , three times a week, for an hour duration .	pilates with a ball and elastic tapes	Sit and Reach Test	The improvements in all the segments have been achieved as well as in flexibility.
Elena, S. A.	The role of water Tai Chi on neurological components in aerobic aquatic practice in the elderly	Romania	18 examinees (8 male , 10 female)	60 – 75 years	1 month, every day a different programme of exercise	Tai Chi, aqua aerobic, stretching, fitness, yoga in water	Back Scratch and Sit and Reach Test	The combination of these programmes has The combination of these programmes obtained the results in the strength improvement, flexibility, balance and aerobic endurance
Jensen, A. M.	Improving General Flexibility with a Mind-Body Approach: A Randomized, Controlled Trial Using Neuro Emotional Technique	Texas	45 examinees (23 male, 22 female)	≥60 years	40 minutes, two times for 20 minutes	Neuro-emotional technique, excersise with chiropractors	Black Box Test of the left and right hand	The results obtained through the 40 minute treatment have shown the improvement in the muscle flexibility .
Lanier, B. et al.	The Effect of Pilates on Range of Motion in Aging Adults Living in Assisted Living Facilities	Tennessee	10 examinees	≥60 years .	6 weeks , twice a week for a 30 minutes	Pilates	The Movement span in the joints has been measure by a goniometer	The improvements in all of the joints have been achieved, the most notably in the elbow joint
Lee, H. et al.	The effects of nursing interventions utilizing serious games that promote healthy activities on the health behaviors of seniors	South Korea	30 examinees	≥65 years.	12 weeks , two times a week , for an hour	Virtual game for improvement of coordination za poboljšanje and flexibility	Sit and Reach Test	The Programme without statistically significant improvements in a flexibility

Author	Title of the work	Location	A number of examinees	Age of an examinee	Duration of treatment	Treatment	Tests	Results
McDermott, A. Y. et al.	Exercise and the elderly: guidelines and practical prescription applications for the clinician	Boston	1 examinee	82 years.	5 weeks , 5 times a week for an hour	Yoga, tai chi, strength and stretching exercises	Preclination, obviation, rotation , measured by a goniometer.	The elderly woman has achieved a flexion in the joints and comprehensive health by complying to the Programme through a moderate scope and a long period time .
McDermott, A. Y. et al.	Exercise and the elderly: guidelines and practical prescription applications for the clinician	Boston	1 examinee	70 years	6 weeks , everyday routine change	Strength exercises in a gym, walking .	Strain Test on a t readmill track	The change in feeding Change in feeding habits , reduction of body weight through a physical activity, have brought about the improvement in flexibility of the lower extremities.
McDermott, A. Y. et al.	Exercise and the elderly: guidelines and practical prescription applications for the clinician	Boston	1 examinee	61 years .	6 months , 20 minute walking and 10000 feet walking later on	The strength exercise, the pilates in the gym, walking in the park	Blood pressure sugar in the blood , a deep **S**it and Reach on the bench ..	Practicing long walking, reducing a bad cholesterol in blood produced the improvement in the joint flexion.
McDermott, A. Y. et al.	Exercise and the elderly: guidelines and practical prescription applications for the clinician	Boston	3 examinee	≥60 years	6 months , walking for the start of the treatment , as well as the strength exercises in the later stage.	Swimming , tai chi, specialized aqua aerobic for the elderly, yoga and tai chi .	Blood taking, a study of examinees about how they feel, the measuring of he of the joint span movement by a goniometer.	The treatment of a medical nature measured The medical treatment The medical treatment with physical exercises and change in feeding habits produces the improvement in both the comprehensive benefit to the health and flexibility.
Melro, F. et al.	Metabolic health and perceived quality of life in older adults after a 16-week exercise programme	Portugal	65 examinee	≥60 years.	16 weeks , four times a week, every time lasting for an hour.	Hydro – gymnastics, the strength exercise in the gym .	Blood example, a survey of examines about how they feel through training days.	The improvement in the blood picture and a bigger strength and flexibility has been recorded.
Todde, F et al.	A 12-Week Vigorous Exercise Protocol in a Healthy Group of Persons over 65: Study of Physical Function by means of the Senior Fitness Test	Italy	40 examinee	≥65 years.	12 weeks every single day lasting for 65 minutes .	Vigorous exercise	Back scratch test and chair sit and reach test.	The results obtained have shown the improvement in all segments, including both a flexibility of upper and lower extremities.

Author	Title of the work	Location	A number of examinees	Age of an examinee	Duration of treatment	Treatment	Tests	Results
Saavedra, J. et. al.	Aquatic activities, health-related physical fitness and quality of life	Spain	28 examinees	≥60 years .	5 weeks everyday treatment of 30 and 60 minutes	Physical – fitness training in water	Anterior trunk flexibility, post hoc test, pre-test.	All the results read from the table where flexibility has been mentioned have shown that a p level of (≤0.05) has been below the value , whereby there has been a significant difference from the start and the end of testing.
Sanders, M. et. al.	Aquatic Exercise for Better Living on Land: Impact of Shallow-Water Exercise on Older Japanese Women for Performance of Activities of Daily Living (ADL)	Japan	26 examinees	≥60 years.	12 weeks, three times a weeks for 60 minutes	Exercise in the shallow water	Sit and reach test and back scratch test.	Sit and Reach Test has brought Sit and Reach Test brought about on how there has been an improvement in flexibility in the lower part of the body by 16%, while the upper part of the body was measured by a Back Scratch to up to 54 mprovement.
Stathokosta, L et. al.	Exercise Modality Choices One Year After Intervention in Previously Inactive Older Men and Women	Canada	176 examinees (62 male , 114 female)	≥60 years .	Physical activities monitored , without a concrete direction of the scope.	Aerobic, tai chi, walking and stretching , only walking, yoga, dance ,pilates, bicycle riding , golf, swimming, tennis	Study	The Survey has proved that a physical activity of any type has had favorable effects s on the entire health as well as the increase in the flexibility.
Wang, M. Y. et. al.	Physical-Performance Outcomes and Biomechanical Correlates from the 32-Week Yoga Empowers Seniors Study	Los Angeles	24 examinees	≥60 years .	32 weeks , two times a week for 60 minutes	Hatha yoga	Back Scratch Test and Sit and Reach Test	The results have shown that there haven't been significant changes in the Back Scratch Test through ANOVA database analysis (p= 0.20 i 0.06).

Discussion

The majority of results received have produced the positive conclusions that flexibility through a physical exercising has been increased, which was carried out by twenty works analysed, whereby they have encompassed flexibility-related problematics directly or indirectly. The treatment have been applied in the period of 5 weeks to a year. The elderly age of examinees has ranged from 60 years and older, and the final results have been equally in men and women examinees.

The exercises included in the treatment in elderly persons have mainly been of a moderate intensity, in a majority of cases, it has been the pilates, though, the exercises such as tai chi, aquatic and gym exercises have also not been dropped in the research.

For the sake of various types of trainings, we have classified the discussion by the works on a dry land and the ones in water which have been reflecting some specific methods, we also mention them as a third whole of the discussion by the review of research.

In his work, Franceso Todde has employed the treatment titled "Vigorous exercise", consisting of three phases: a warming phase lasting for 10 minutes, the active one lasting for 45 minutes which has included mixed exercises and a recovery phase lasting for 10 minutes. After 12 weeks,

the research carried out over both genders has given significant results in tests such as a Seat and Back Scratch Test (2016).

Some studies have been carried out at home, examinees have received brochures by which they have guided themselves with, nonetheless, such a sort of studies has lacked a substantial motivation, whereby a lot of examinees have given up during the treatment, around some 23%, 20 of participants have completed the programme. Injury-related evaluation has reduced to 42% in a week and even 64% in the group which has applied the pilates and stretching techniques, which the pilates acts efficiently on the improvement of flexibility in the elderly persons. (Barker, 2016).

One of the studies has been carried out by a distance, 176 examinees (a middle value of 70 ± 5 years ; 63 males, 114 females) and a year-long period of time. The study has been carried out in the area of North America, more precisely Canada. Due to a large area to cover for a study, a half of examinees has personally been visited, while the remaining has been examined by a phone. The examinees have been physically active, doing the entire scopes of activities, some of them being: aerobic, tai chi, walking and stretching, yoga, dance, pilates, bicycle riding, swimming, tennis and many other.

The results have been registered in every 8 weeks, and at the end of the year the parameters showing the improvement in a health (they have felt healthier) have been received, they have improved their physical functions, they have lost weight, they have been motivated by the instructors for a better life, they have been socialized in a certain society through a physical activity. The study carried out over them has given a clear picture that what has been achieved in people most is to have been feeling good, and right behind that has been the improvement of physical ability, under which flexibility falls as well, which has been the subject of the seminary work. Stathokostas, 2016).

Barret, C. carries out a study of 44 elderly examinees, of the age over 60 years. The study has included Experimental and a Control Group**,** which have been assigned a two-hour exercise treatment, two times a week in the period of ten weeks. The professional therapeutist has followed the evaluation of progress, at the very beginning of the treatment, after two weeks, two weeks before the end and at the end final when measurement has been carried out. What has been particularly interesting in this work is that a Control Group has undergone a treatment as well, but only in stretching exercise, while an Experimental Group has undergone both exercises of strength in addition to stretching exercises. For results reading and assessment in change, a multivariant analysis of covariance has been used. The results have shown that both in Experimental and Control Group the improvement has been achieved, whereby a flexibility in Control Group has been improved, while in Experimental Group, in addition to a flexibility, both strength and balance have been increased. (2002).

Some studies have applied the Hatha yoga and its impact on the increase of flexibility. 24 examinees older than 60 years have been included in the work. The Control Group hasn't participated, but the examinees have undergone the Hatha yoga programme. The treatment has been applied in 60 minutes, two times a week in 32 weeks, whereby lighter exercises have been applied in the initial 16 weeks, and the remaining 16 weeks the programme has been a bit more strenuous. In addition to a study of a functional ability, strength, balance, change in flexibility has been monitored as well, whereby we have only been focused on the results of a flexibility.

For examining flexibility, two tests have been utilized,1) Back Scratching and 2**)** Sit and Reach**.** In the first test, the examinees have been asked to put one hand over the shoulder, and with the other one from behind try to reach the one over the shoulder, a distance between two middle fingers has been marked as a movement span**.** Out of the three attempts, the best one is recorded.

In another test, the examinee have been asked to sit down at the edge of a chair, then one leg be folded in the knee at a 90^{o} while the other one should be stretched with an elevated foot. The examinee has been asked to try, in an deep preclination, to reach a thumb on his foot. The distance between the middle finger on a hand and a palm on a thumb presents a movement span for the lower part of the body. Out of the three attempts, the best result has been recorded. The results have shown that there haven't been substantial changes in the Back Scratch Test and Sit and Reach Test through ANOVA data analysis . ($p = 0.20$ i 0.06) (Wang, 2016).

The exercise programme called SASS (Stay Active Stay Strong) have been applied a week in a period of six weeks. The examinees have been 60 years old and a strain level has been classified for beginners (without experience), a middle level (with certain knowledge about fitness) and an advanced level (persons with a substantially more experience) The intensity has reflected in a set of weights classified by a level**.** 225 examinees have completed the treatment, some of the results describing the improvement in flexibility have been Back Scratch Test and the results have produced the improvement of 1.77 cm ($p<0.001$). In the discussion, the author has come to the conclusion that the SASS Programme has lead to the improvement of a functional ability which has included strength, flexibility of lower extremities, endurance, agility and a dynamic balance (Bates, 2009).

The results obtained in the work of Lanier. B. have shown that an Experimental Group has increased a movement span in all ten movements, and the best results have been obtained in the elbow joint flexion. In A Control Group**,** even negative measurements have been recorded, which could lead to the conclusion that a flexibility in an advanced age has been declining rapidly. (2016).

Some of the exercises in the pilates have been pursued with a pilates balls and elastic tapes, whereby the 12 week treatment has produced a statistical difference in the increase of flexibility in old women over 65 years of age. (Grez, 2009).

Some of the scientists have been dealing with the shallow water exercises. As it has been widely known that an immersed body in water becomes lighter for a volume which it ejects from its body out of the water (Archimedes' law), therewith the presence in such an environment relaxes the joints and enables an easier performing of certain movements and exercises.
Stan Amelia has been trying through aqua aerobic to prove its efficiency in the improvement of a flexibility. The flexibility programme has included the following exercise: tai chi in water, and circle water spray right, -circle water spray left; ; -hands like clouds; -ying yang; -full moon. Aquatic (water) yoga and exercises -mountain warrior; -toe lock; -chest expansion. The Pilates in water and exercises -spinal twist; -mermaid/merman; -single leg stretch. Seat and Reach Test has confirmed that there have been certain improvements of a flexibility both in male and female examinees (2013).
The study has been carried out over 26 women with the of age (mean 70.5), out of this figure 13 have been in the Control Group and the remaining in the Experimental Group. The elderly women in the Experimental Group have undergone the 12-week long treatment, three days a week and 60 minutes water exercises. Some of the shallow water exercises have been as follows: walking through water, sitting in water and standing up, lateral walking, as well as the exercises on dry land: walking, shooting, lateral walking as well as card playing. The results have shown that flexibility has been measured by a Sit and Reach Test and, being such one, it has produced the improvement in flexibility of the lower part of the body by 16%, while the upper part of the body has been measured by a Back Scratch and it has created the improvement of even 54% (Sanders, 2016).
The health issue in an advanced age can be versatile, some of the scientists have tried, through aqua aerobic, to rehabilitate certain injuries, such as meningitis, cardio-respiratory diseases, osteoarthritis, fibromyalgia, osteoporosis, obesity to impact on the quality of life. Due to a wide scope of diseases, as well as various age categories in persons, scientists have included three groups in their research, one entirely healthy, of an age of (20.6 ± 1.1), of other middle age (53.1 ± 12.5) and the third one of an age of (64.1 ± 7.6). In addition to many results obtained, we shall have been focusing only on those ones flexibility-related. The data have been processed by the ANOVA method as there were three Groups in order to establish a correlation between them, whereby they have been processed by a post hoc test and pretest in order to establish a difference from the beginning of the measurement and a final measurement. All the results read from the table where a flexibility have been mentioned showed that a p level (≤ 0.05) has been below the value, whereby there has been a statistically substantial difference from both the beginning and the end of the measurement, which has meant that a physical activity has a positive impact on the improvement of flexibility in all segments of the body, as well as in all age ranges (Saavedra, 2006).
The treatment striving to the improvement of flexibility is sometimes deviating from an already ingrained path, so we have come across the works which have been applying different methods in their content, as well as their results obtained.
In the work whereby they have studied on how neuro-emotional technique has had the effects on the improvement of flexibility, the professional chiropractors and specific neuro-emotional exercises have obtained the improvement of flexibility, which has been measured by a Black Box Test (Jensen, 2012).
The scientist Lee, H.Y. have designed the games originating in South Korea, those are, in fact, virtual video-games in which a character from the game is moving, based on movements assigned by players, it is to say, in this case by examinees of age range of over 65, a number of examinees: 30. During a 12 month-long examination, the exercise through the game has been carried out twice a week . The examination included only one Group Pre-test/ Post -Test Group.
The flexibility has been measured by a "Sit and Reach Test'' described in the previous works. The Pre-test and post-test flexibility-related results have obtained a p level of 0.506, which means that these virtual games have not reached any particular difference worth mentioning in this survey. (2015).
The results have shown that an age-related flexibility has been decreasing, though, as well as increasing certain physical activity. Measurement tools which the scientists have applied have been mainly tests measuring amplitude-related movements in the specific joint, some of those tests have been „Back Scratch" (Todde, 2016), then „Sit and Reach" Test (Sanders, 2016), „ Black Box Test" (Jensen, 2012). Moreover, the movement span being measured by some scientists has been carried out individually, some of those movements have been a flexion of the left and right elbow, a flexion and extension of the neck, the left and right shoulder approximation and the right and left shoulder flexion. (Lanier, 2016)

Conclusion

Flexibility defined as a mobility-related degree in the joints is one of the precedents which enables the elderly persons an easier moving in the space. It has been proved that a flexibility is decreasing with an advanced age, which has, in general, unfavorable effects not only on the movement in general, but on the other body movements.
The studies have shown that, by certain physical activities, we do improve a mobility degree in the joints, whereby stretching exercises as well as some static exercises for muscles strengthening, such as in the pilates and yoga, have proved most beneficial.
Since the studies have been carried out in the elderly population, all treatments have been monitored under the watchful eyes of professionals, the volume and intensity have often been adapted to their abilities, with an objective of preventing injuries. The results with a biggest sta-

tistic importance have been in the pilates, tai chi and yoga. The studies,which, in its essence, were dealing aqua aerobics, stretching exercises, strength exercises, have also achieved its goal of increase-related flexibility, but not to an extent as in the previously mentioned ones. There have been as well the works trying to influence flexibility through virtual games, but the results have been unfavorable.
Therefore, the pilates, tai chi and yoga stand out as the most efficient programmes for flexibility increase.

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