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ORIGINAL

LONGITUDINAL STUDY OF FUNCTIONAL FLEXIBILITY IN PHYSICALLY ACTIVE SENIOR CITIZENS

ESTUDIO LONGITUDINAL DE LA FLEXIBILIDAD FUNCIONAL EN MAYORES FÍSICAMENTE ACTIVOS

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ABSTRACT

Flexibility is an important component of physical fitness, particularly in elderly people whose flexibility tend to deteriorate with the passing of time. The purpose of this longitudinal study was to determine how flexibility of older adults' change over time. The control group consisted of 54 physically active adults (17 men and 37 women) all of which were 65 years and older. These adults participated in a 60 minute global fitness course, led by a trained instructor, twice a week. During the 12 month study, the subjects' flexibility was measured at four different times through chair sit and reach and back scratch tests.

The results show that the subjects who took part in this yearlong study, experienced positive results in flexibility in the areas tested. The results concluded that the subjects in the study that were previously engaged in regularly physical activity maintained and in some cases, improved flexibility through regular global fitness activity.

KEY WORDS: Flexibility, elderly, physical activity, chair-sit-and-reach test, back-scratch test, functional capacity, sedentary.

RESUMEN

Un importante componente de la condición física es la flexibilidad, particularmente para las personas mayores que suelen sufrir un deterioro de la misma con los años. Con el objetivo de conocer como la flexibilidad evoluciona a lo largo del tiempo en un grupo de personas mayores físicamente activas, este estudio longitudinal ha evaluado 54 sujetos mayores de 65 años (17 hombres y 37 mujeres), que participaban con regularidad en clases de mantenimiento físico global realizadas dos veces a la semana en sesiones de 60 minutos. Para la medición de la flexibilidad fueron aplicados los tests chair sit and reach y back scratch, en cuatro momentos distintos en un periodo total de 12 meses. Los resultados muestran la evolución positiva de la flexibilidad de las zonas testadas en el grupo de mayores practicantes de actividad física al final de un año. Se concluye que para los participantes previamente activos del estudio la flexibilidad fue mantenida con el tiempo e inclusive mejorada en el periodo total propuesto al conservarse un estilo de vida activo a través de la práctica regular de actividad física de mantenimiento global de la condición física.

PALABRAS CLAVE: *Flexibilidad, ancianos, actividad física, test chair sit and reach, test back scratch, capacidad funcional, sedentario.*

INTRODUCTION

It is a fact that senior citizens grow faster each year worldwide. Such event needs a growing need for looking after their well-being since physiologic, psychological and social changes that may alter overall physical performance appear at this point might as well be the consequence of limitations when carrying out daily activities (lack of autonomy and excess of dependence). That is precisely why a deep understanding on aging and its consequences is needed, for future social, economic and sanitary interventions will be successful.

In that respect, physical condition maintenance through regular physical activity is one of the most important points for successful aging. Besides, through supervised physical activity, it is more than possible to notice improvements in the health and overall state of mind in the elderly (Serrano-Sánchez, Lera-Navarro and Espino-Torón, 2013).

Flexibility is one of the key physical capacities for this group's health as it is of a paramount importance for each individual to keep on enjoying life's activities in an autonomous and independent manner (Vale, Novaes y Dantas, 2005), not to mention the functional performance implied (Geraldés, Albuquerque, Soares, Carvalho and Farinatti, 2008; Stanziano, Roos, Perry, Lai and Signorile, 2009).

Likewise, proper levels of flexibility are associated to the back performance (American College of Sports Medicine - ACSM, 2005; Da Silva Dias and Gómez-Conesa, 2008), to physical pains decrease (King et al., 2000; Ponce, Sempere and Cortés, 2014), to performance in daily tasks (Brach and VanSwearingen, 2002), to patterns of walking patterns (Cristopoliski, Sarraf, Dezan, Provensi and Rodacki, 2008; Schenatto, Milano, Berlezi and Bonamigo, 2009), to preventing from falling down (Guimarães and Farinatti, 2005), and, in turn, this is closely related to the overall quality of life (Gonçalves, Vale, Barata, Varejão and Dantas, 2011; Sławińska, Połuszny and Rożek, 2013).

Flexibility, according to some authors, is thought to be altered by the aging process (Bell y Hoshizaki, 1981; Einkauf, Gohdes, Jensen and Jewell, 1987; Shephard, 1998), decreasing, in some joints, the articular movement amplitude up to 40% (ACSM, 2009). This happens as a result of the negative influence of several factors upon flexibility, among other: aging (Marques et al., 2014; StathO.K.ostas, McDonald, Little and Paterson, 2013; Vagetti et al., 2015; Vaquero-Cristóbal, González-Moro, Ros and Alacid, 2012) and physical inactivity or sedentary manners (Santos et al., 2012; Sharkey and Gaskill, 2007).

This very last point can be considered as the major flexibility limiter when aging (Holland, Tanaka, Shigematsu and Nakagaichi, 2002), since sedentary way of life, so characteristic in the elderly, is fully understood as joints desuse and lack of stimulus for elongating muscles. Consequently, this generates a loss in

articular movements' amplitude, and in turn this can interfere in simple daily tasks execution such as combing one's hair, entering and getting out of a car, getting dressed, etc.

The current theory, suggests that an increase of the physical level followed by periods of activity, play a role against this tendency, helping to maintain active, flexible muscles and bigger articular mobility. Even in older people it is possible to achieve better flexibility through physical activity (Correa-Bautista, Sandoval-Cuellar, Alfonso-Mora and Rodríguez-Daza, 2012; Hulya, Sevi, Serap and Ayse, 2015; Toto et al., 2012; Vieira et al., 2015).

Despite the fact that several sources of information persevere on the theory that regular physical activity provides a good flexibility level, independently from age and the implications of it in the health of the elderly, it has been proven — among the different studies retrieved— that longitudinal studies on senior citizens' flexibility are not enough (Ayala and Sainz de Baranda, 2013). This is why the realisation of a longitudinal study aiming to verify the flexibility performance of the elderly practising regular sport activities, could provide more data to underline and intensify the expectation of maintaining flexibility performance among this very group.

For measuring up flexibility among the elderly, a battery of tests was created by Rikli y Jones (2001), evaluation physical condition, called: Senior Fitness Test (SFT), containing two flexibility tests: "back scratch" and "chair sit and reach". This are very appropriate tests for the elderly for their simplicity, security and execution of movements, as well as for their reliability and validity. Besides, this flexibility tests are capable to evaluate, particularly, body areas of great interest for functionality and health maintenance of the population, as it is the case of shoulders' mobility, lumbar area and hamstring muscles.

Because of the reasons mentioned hereinabove, as well as for scientifically contribute to this topic, a deeper study has been considered quite relevant. The main objective is to know the evolution of the overall flexibility over time in the shoulders area and lower members and lower part of the back, of a group of elderly previously physically active following an assisted global physical maintenance programme.

METHODOLOGY

Sample

The 54-people sample (37 females and 17 males) aged from 65 to 87 years old (M=70 years old; SD=4.4 years old) at the moment when the first test was done, they rarely went to the same sport and fitness centre in the Madrid area, having attended at least for six months before the first examination. The number of participants at the beginning of the research was 67 senior citizens but, as the

study periods are long, only 54 of them accomplished with the four examinations of flexibility proposed along the 12 months.

All the participants were functionally independent, with no physical or cognitive limitations whatsoever not allowing them to understand and carry out the tests. Moreover, they presented a medical report before the sport centre, making sure that physical well-being was kept for the efforts required in the activities.

The maintenance programme classes for the elderly attended by the sample was carried out twice a week, on a 60-minute-per-day basis, being offered by the sports centre from September to June with an intercourse during July and August.

The main objective of the classes was maintaining and developing the global physical capacities, not paying special attention at any part of the body whatsoever. For a better understanding of the characteristics of the activities carried out by the sample, not only before the study *per se*, but also during the programme, table number 1 shows, as an example, the kind of structure followed in the sessions.

Table 1. *General model of the assisted physical activity courses programme.*

GENERAL STRUCTURE OF THE SESSIONS			
Phase	Volume	Intensity	Contents
Warming	10 to 15 minutes	Low; reasonable progression	<ul style="list-style-type: none"> - Different kinds of displacements - Articular mobility - Active stretching of the biggest muscular groups
Main phase	35 to 40 minutes	Medium to high	<ul style="list-style-type: none"> - Cardiovascular activities and exercises with high aerobic components, resistance levels lower than 50% of FMS, in flexibility, equilibrium, co-ordination and reaction rapidity - Adapted games and sports - Circuits - Rhythmic activities, etc.
Back to calm	5 to 10 minutes	Progressive reduction of intensity (medium to low)	<ul style="list-style-type: none"> - Light displacement - Static stretching of the muscles involved in the session - Breathing and relaxing exercises

Study Parameters

This longitudinal study on flexibility evolution of the elderly, has a passive component rather than an interventionist one. As long as ethics are concerned,

the rules gathered by the Committee of Investigation Ethics by the Autonomous University of Madrid were implemented, being anonymity and confidentiality (for the sports centre and for the whole sample) preserved at all times. These were freely informed and signed all the papers concerning the proposed evaluations. Likewise all the rules related to ethic evaluations with humans, at both national and international levels, were respected.

As for flexibility evaluation, “back scratch” (TBS) and “chair sit and reach” (TCSAR) —measuring shoulders flexibility and lower members’, respectively— were used. According to Rikli and Jones (1999), “back scratch” test reliability is high ($r = 0.96$) as well as “chair sit and reach” one ($r = 0.95$), and both have got a reputed validity.

The measurements of the study were carried out in four different times throughout 12 months. The first gathering of data was reached at the end of January, the second one at the beginning of May, the third one at the end of October —when the participants had returned to the programme after the summer break— and the fourth gathering at the end of January the following year to the commencement of the study.

The tests were always put into practice by the same committee, previously familiarised with the corresponding evaluation process protocol. So as for the evaluations, environmental and temporal characteristics were considered. This is why all the tests were performed in the morning, before the global physical maintenance programme classes, at the same place and at an artificially controlled temperature; aiming to make participants feel as comfortable as possible at all times.

The processes followed for each test accomplishment, register and impregnability, were based upon the established and recommended protocols by Rikli y Jones (2001).

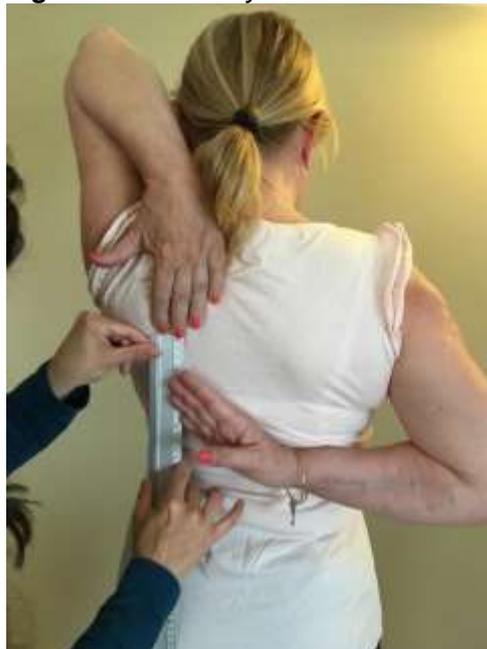
Before the evaluation, all the participants participated in a settled warming activity, a first period of three to five-minute long walk, followed by specific two to three-minute stretching activities. Once finished, information in relation to the rest of the activities was provided to the participants, as well as the execution of the movements by the assessor. Then a familiarization process break for each movement was given to them, they chose the preferred side, i.e.: with best results for each test, and they tried twice before carrying out the test. Each test was accomplished twice and, despite recording both results, only the best one was taken into real consideration.

The “back scratch” test was executed in each standing individual with one hand on top of the back and the other one on the bottom of the back —as shown in figure

number 1—, trying to get both hands together as much as possible. At the point of maximum stretching, when there is no pain, each individual will hang in that position for two seconds

for the assessor to record, using a ruler (in centimetres), the distance between both central fingers. Results were considered as positive if one finger overlapped the other, neutral if they only touched and negative if they did not touch each other.

Figure 1. Flexibility test “back scratch”.



In the “chair sit and reach” test, each individual was sited at the edge of a chair with its back against the wall, for stretching his or her preferred leg (normally extended) with his/her heel lean on the ground and his/her ankle at a 90° position. The individual moved towards (back straight, head put in line with body), with arms stretched and hands one over the other, trying to get as further as possible for touching his/her preferred stretched foot. The maximum scope was set to be maintained for two seconds for the assessor to meter the distance between the fingers and the foot. The data were registered in centimetres as it follows: positive if fingers and foot overlapped, negative if they did not touch and neutral if the only touched.

Figure 2. Flexibility test “chair sit and reach”.



For deeper comprehension in that respect, the data were compared to Kolmogorov-Smirnov normality tests as well as spherical Mauchly test. After they had been verified, variance analysis for repeated measures (ANOVA) was used for comparing it to the deviations (Díaz, 2009; Prieto and Herranz, 2010). For identifying the significant possible differences existing between the means, *post hoc* Tukey test (HSD) was implemented. The data were, as well, analysed through SPSS 20.0 programme at a 95 significance level ($\alpha=0.05$).

RESULTS

The following results shown in the graphics, tables and figures are presented as the value of the mean of the group as a whole, as there should not exist in this study any differentiation between genres. The data show the evolution of flexibility for the four periods tested and for the proposed parts of the body.

Table 2. Descriptive evolution of flexibility according to “back scratch” test (TBS).

Descriptive statistics; shoulder test						
		Age	TBS1	TBS2	TBS3	TBS4
Number	O.K.	54	54	54	54	54
Mean		69,9	-1,8	-0,2	-0,5	-0,1
Median		69,0	1,0	2,7	2,3	2,1
Mode		67	1 ^a	5,0	4,5	2,1 ^a
TD		4,4	8,5	7,8	7,7	7,6
Minimum		65	-28	-27,2	-22,5	-19,8
Maximum		87	13	12,5	14,4	12,5

a. Several modes do exist. The lowest value will be shown.
N.B.: TBS values expressed in centimetres.

The evolution of flexibility in the shoulder test (TBS) can be seen in figure number three, even with mean values negative, ANOVA shows significant differences between the first test (TBS1) and the rest (TBS1 < TBS2, $p = 0.001$; TBS1 < TBS3, $p = 0.003$; TBS1 < TBS4, $p = 0.001$). Notwithstanding, among moments TBS2, TBS3 y TBS4 there are not significant differences in flexibility performance.

Figure 3. Average values for shoulder test of flexibility (TBS).

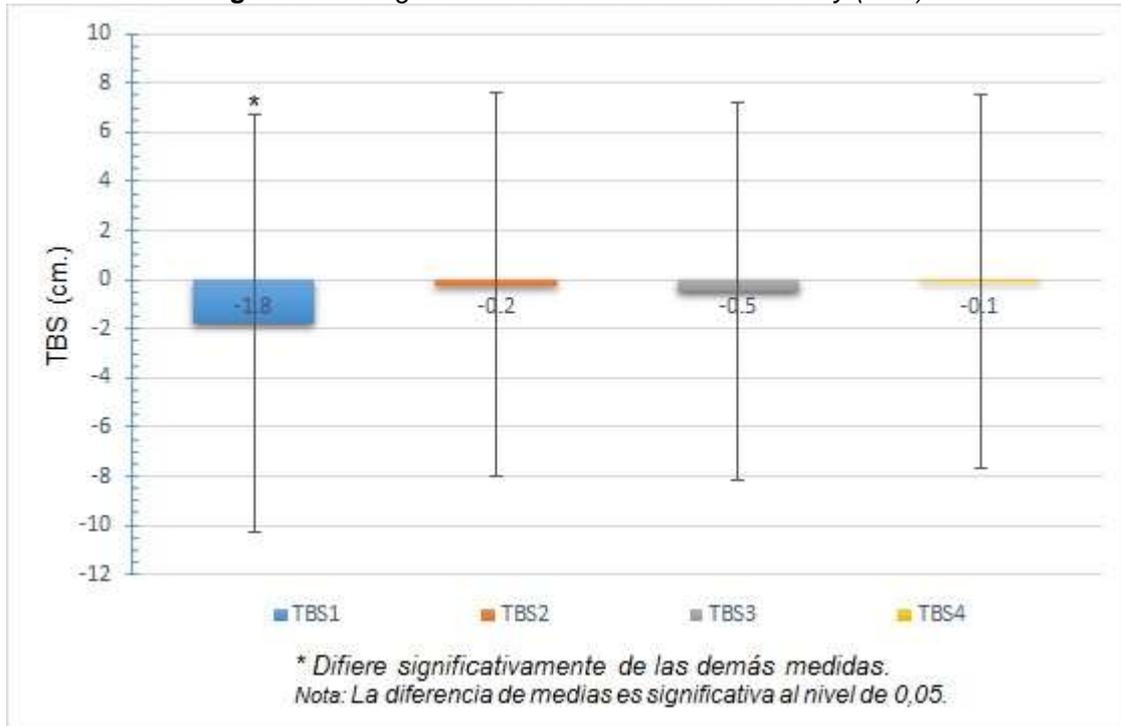


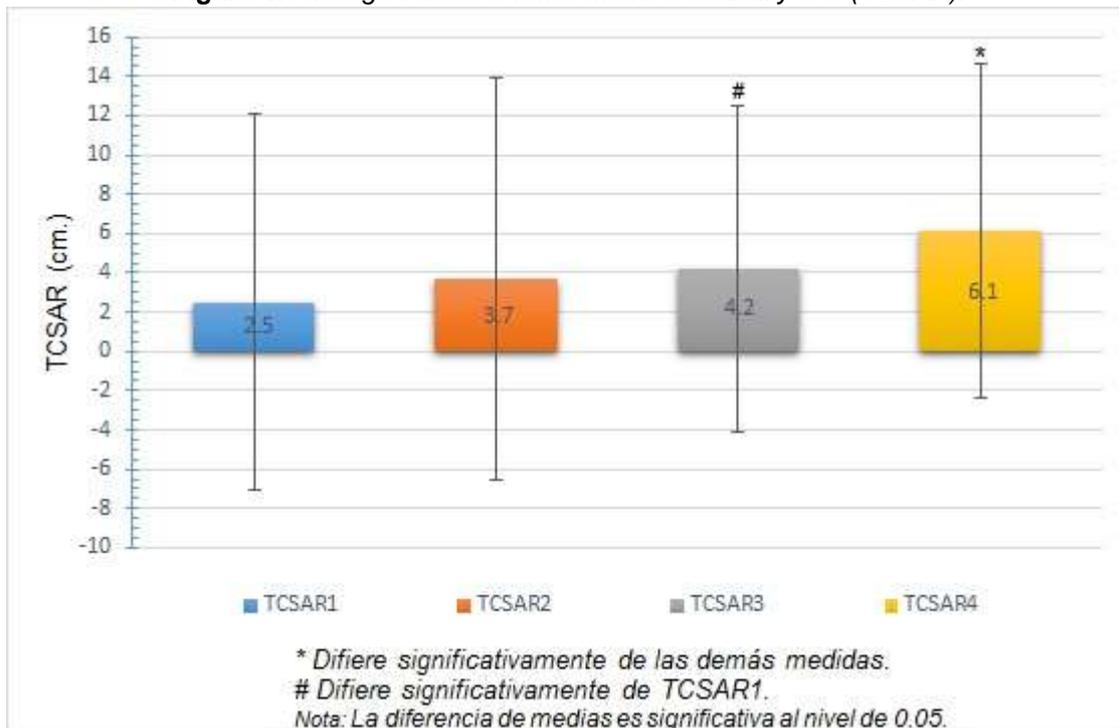
Table 3. Descriptive statistics of flexibility evolution in “chair sit and reach” test (TCSAR).

Descriptive statistics; lower member test						
		Age	TCSAR1	TCSAR2	TCSAR3	TCSAR4
Number	O.K.	54	54	54	54	54
Mean		69.9	2.5	3.7	4.2	6.1
Median		69.0	3.3	3	2.2	4.9
Mode		67	0	0	0	0
T.D.		4.4	9.6	10.2	8.3	8.5
Minimum		65	-24	-26	-16	-19.5
Maximum		87	22	22	22.8	21.5

N.B.: TCSAR values in centimetres.

TCSAR values differ significantly from the latter, as they accounted positive means and a regular evolution as it can be seen in figure four. *Post hoc* Tukey test (HSD) has identified differences between the last test value (TCSAR4) and the rest of the values achieved ($p = 0.001$), as well as between TCSAR1 and TCSAR3 ($p = 0.018$). However, variations between TCSAR1 and TCSAR2 and between TCSAR2 and TCSAR3 did not reached a significant difference at 95%.

Figure 4. Average values of lower member flexibility test (TCSAR).



DISCUSSION

According to the results obtained, the elbow flexibility, as well as the lower member one were improved at a significant level of 95% comparing the last test

with the very first one, well understood, in the elderly that participated on a regular basis in the physical condition maintenance programme, in relation to overall health improvement.

Positive evolution of flexibility in the elderly who were under the analysis differs very much with the statement of undisputed and irreparable problems in flexibility when aging. Despite the fact that aging is, without any doubt, an element of negative evolution of flexibility, physical activity is essential for an improvement of this skill. This is why it could be foreseen that the active elderly under this study will improve their flexibility levels, since they kept on having stimulus while stretching their muscles, being the latter capable of following a positive progression (Ayala and Sainz de Baranda, 2010; Vaquero-Cristóbal, López-Miñarro, Alacid-Cárceles and Esparza-Ros, 2015).

The results show that shoulder flexibility has increased after three months and then stabilised, while lower member flexibility could only increase significantly after nine months since the beginning of the programme. Such results can be proven by literature in our sample, following physical activity programmes with different protocols, improving flexibility in short periods of time (Coelho de Farias, Borba-Pinheiro, Oliveira and Gomes de Souza 2014; Correa-Bautista et al., 2012), or in longer periods of time (Cepero-González, Romero-Sánchez, Rojas-Ruiz and De la Cruz, 2012; Hulya et al., 2015).

The maintenance of shoulder flexibility could be well the result of a lack of effort in the training (enough lack of effort required to cause alterations). Notwithstanding, it seems to have been enough for keeping on maintain the flexibility levels recorded at the beginning of the study. As for the lower member flexibility, it should be taken into account that the sample was physically active and, as verified in the first evaluation, they registered a good performance in this area, consequently, increasing flexibility levels when the first values have been quite high, seems a bit more complicated. Nevertheless, it happens that normal levels in the efforts of the daily programme, could have been enough to stimulate the lower member progressively, offering a significant result only nine months following to the first evaluation of the “chair sit and reach” test.

Lack of improvement in both tests between the second and third evaluations can be due to the summer recess period. Some authors found that summertime and disuse were enough reason to lower elderly’s flexibility after having achieved good results throughout the programme (Antes, Minatto, Costa and Benedetti, 2013; Bocalini, Serra, Rica and Santos, 2010).

It is important to consider that the differences in flexibility among the mean, median and mode in the “chair sit and reach” test. The evolution of the mean shows a progressive improvement but, the mode itself seems to have remained steady and the median showed the lowest result for the third period, the highest for the fourth and this can be the proof of the negative effect of the summertime over the improvements set in the programme. In the evolution of the shoulder

flexibility, variations among mean, median and mode can also be appreciated. It can be seen that, even when means are negative at all times, the most repeated values were positive. This may be explained because of the significant differences among the individuals in their shoulders flexibility. In turn, those who performed worst in the “back scratch” test, recorded so many negative values, that influenced the general mean to be as well in a negative position.

The resources accessed in respect of longitudinal studies of this kind —having attended monitored programmes—, protect the results obtained in this very study for the shoulder flexibility (TBS) and for the lower member (TCSAR) after a period of 12 months (Lorca, Lepe, Díaz and Araya, 2011; Pereira, Baião, Carvalho and Correia, 2014; Rikli and Edwards, 1991). But it is possible to read such studies as those by Silva et al. (2015), which did not verify significant changes ($p < 0.05$) in its sample’s flexibility after a period of 10 months in a monitored programme of multitask exercises.

It is important to mention that longitudinal studies mentioned hereinabove verified the evolution of flexibility in the elderly who were previously following a sedentary way of life. Except the Pereira y cols. (2014) sample, who really was previously active, but following a hydrotherapy programme differing very much from that followed by our sample.

It can be seen as a success for our sample that they kept on following the programme, after having participated in it for six months before the first evaluation was carried out, and definitely achieved more positive results for themselves. These results confirm that regular physical activity (stretching) is a means to increase flexibility and maintain it at desirable levels over time. Then it is of a paramount importance to include such activities in such customized general programmes.

Close monitoring of the evolution in the levels of flexibility was important to control and build a structure for the physical activities carried out, since any other professional could access the data and consider that efforts are not enough and consequently vary the general scenario of the activities.

CONCLUSION

The evolution of flexibility was positive over time by improving the index after one year in the joints tested in the elderly group who continued working on their physical activeness for maintaining physical conditions at ordinary levels, twice a week, just like the ACSM (2009) recommends.

Some limits must be taken into consideration in this study, just like the inability to control daily tasks of samples with independent lives, considering as well the influence that this tasks may have in the results of the analysis of the physical shape. Besides, the sample was quite reduced and heterogeneous. For being a

group with specific characteristics it is important to notice that the results are implemented to the Elder participants of this very study and for the joints tested.

In future researches, a flexibility evolution study (in senior citizens to the limit of their physical dependence) as well as sample differentiation (according to physical condition or gender) would be very convenient, as well as a classification of the flexibility performance in the elderly according to the international standards of the field. Consequently, bigger information on senior citizens' flexibility would be provided and so public health policies improved.

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