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HIP AND KNEE JOINTS FLEXIBILITY IN YOUNG AND ELDERLY PEOPLE: EFFECT OF PHYSICAL ACTIVITY IN THE ELDERLY

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Abstract. Exercise plays an important role in preventing and reducing elderly incapacity. The aim of the present study is to evaluate the articular mobility of the hip and knee joints in a group of healthy youngers and elders as well as the effects of physical activity upon the latter. 67 young patients and 43 elders of both sexes were tested through the Metrecom system. The elderly group was divided in two subgroups: sedentary and active subjects. The latter underwent a training period consisting in three months of low-cardiorespiratory impact program at the end of which subjects were tested again. In comparing youngers and elders the former showed significantly higher articular mobility both at the hip and at the knee joints. Active elders showed significantly higher ROM than sedentary ones with the exception of hip flexo-extension. Subjects who underwent training evidenced a significant increase of ROM in knee flexo-extension as well as hip flexo-extension and abduction-adduction. In a similar way, there was an increase in ROM regarding intra-extra rotation hip motion even if not reaching significance. It can be concluded that age-related decay of mobility in the joints herein studied can be efficiently contrasted with an active style of life and that a training period can further improve the mobility of the lower limb.

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Key words: Hip – Knee – Flexibility – Elderly - Physical activity

Introduction

Much interest has been given to the study of articular mobility especially regarding prevention of functional incapacity in elderly patients determined by articular degeneration such as those present in progressive chronic

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osteopathologies [13,29]. Most studied joints are represented by the hip and the knee taking also in consideration their close functional relationship in that they are part of the kinetic chain of the lower limb and they have a high incapacity potential during ambulation [34].

Chronic inflammatory diseases present a selective reduction of articular mobility in some types of motion. For example, osteoarthritis mostly shows both reduced extra-rotation of the hip and flexo-extension of the knee [29]. Nevertheless, it is well known that with ageing a progressive decay in body efficiency is observed in adult subjects. Similarly, a gradual decay is also described for the neuromuscular apparatus with subsequent decrease of functional capacity even under healthy conditions [11,16,17,35]. Therefore, it is possible to hipothesize that a harmonic and progressive decay in articular mobility is related to aging. Factors that can increase the velocity of this progression are multiple; for example, a direct correlation has been described between body mass index (BMI) and reduction of hip and knee articular mobility [21,19]. Recently, McHugh (1998) has demonstrated that muscular-skeletal flexibility of the knee and hip in young subjects is mainly related to mechanical rather than neurological properties [23].

Both prevention and treatment of functional incapacity in elders represents one of the main objectives of modern society. Moreover, mean life expectancy has increased and consequently, the number of elderly patients has also increased [1]. There are many studies in the literature that support the benefits of physical activity in preventing and reducing incapacity of elderly patients [8,12,28].

The aims of this study are: a) to evaluate hip and knee mobility by means of a non invasive method in young and elderly patients in good health conditions. b) to evaluate the effect of life style upon articular mobility in elderly patients comparing sedentary ones with those practicing physical activity on a daily and chronic basis. c) to evaluate in the same sample of elderly patients the effect of a training program (acute activity) upon articular excursion.

Material and Methods

Subjects: The study has been performed considering two homogeneous samples: 67 young patients of both sexes, practicing daily physical activity, corresponding to students of the first year at the Institute of Motor Sciences (IUSM) in Rome, and 43 elderly patients, aged over 60, frequenters of a center for elderly persons belonging to the Municipality of Rome, whose anthropometric characteristics are summarized in Table 1.

Table 1
Anthropometric characteristics and number of participants of the sample

	Mean age (years)	SD	Mean height (cm)	SD	Mean weight (kg)	SD	n males	n females
Young	19.3	3.2	175	5.4	70.2	4.6	33	34
Elderly	64.3	5.4	163	3.2	68.1	5.4	12	31

Patients were enlisted after an accurate anamnesis and an objective examination in order to exclude bearers of any past or present disabling pathology involving the hip or knee, severe depressive statuses and/or cognitive deficits. Subsequently, a questionnaire [40] was given to elderly patients in order to collect information regarding the type of physical activity developed by them along their lives and thus define two further subgroups: sedentary and active elderly (Table 2).

Table 2
Distribution of the elderly in active and sedentary subjects according to daily physical activity during the last years, as revealed after performing the questionnaire

	n	Males	Females
Active	23	7	16
Sedentary	20	5	15

Finally, within the active subjects of the elderly group, 21 volunteers were enlisted accepting to participate to a training cycle of general aerobic gymnastics lasting 3 months, 3 times a week for 60 minutes each. At the end of the training period they were tested again in order to calculate the articular mobility values following the same protocol used for the rest of the patients.

*Instruments***:** Measurement of the articular excursions of the hip and the knee were performed with the aid of the Metrecom system (Faro Medical Technologies Inc., Montreal, Canada). This consisted of a calculator, a supporting column, a spinal screening tool, and a three-dimensional pointer composed of a mobile arm incorporated with 6 gonio-potentiometers and a handle provided with a ferrule.

The method considered the calibration of the system with respect to the screening tool before any registration. After calculating the three Cartesian planes of reference, these were marked with the aid of a dermographic pencil on two surface anatomic reference points: the projection of the articular fulcrum (central point) and a fixed long-distance reference (peripheral) point either at the start position than at extreme grades of motion. The articular excursion is then registered by means of two successive acquisitions of the coordinates regarding the central and peripheral points of the articular segment, first in a normal orthostatic position and then at maximal articular excursion. The calculator reconstructed the trajectory of both articular axes, beginning and end of the motion, passing through the central and peripheral points, projecting them then on the reference plane and calculated the intersection angle.

The accuracy of the results was controlled throughout several points measured along each of the axes: the deviation of the input value was always within 1.5 mm whereas the maximum non orthogonal error was less than 0.5 if considering a range of arm motion of 1500 mm [2,26].

Experimental design: All the patients underwent an evaluation of articular excursion of the hip and the knee in the dominant limb by means of the Metrecom system.

The articular mobility of the hip was studied in the three planes of the space evaluating motion of flexo-extension (sagittal plane), abduction-adduction (frontal plane) as well as extra- and intra-rotation (transversal plane). The anatomical points of reference were as follows:

a) flexo-extension along the sagittal plane. The reference points were represented by the apex of the great trochanter (or its outer projection in case of significant adipose tissue) as articular fulcrum and the outer articular line of the knee, anterior portion, as the distal point. Flexion movements of the hip and the knee was performed beginning in a supine base position with the arms along the hips and prone hands; the movement of extension, in turn, was performed with the ipsilateral leg flexed and the subject lying prone;

b) abduction and adduction along the frontal plane: the articular fulcrum was represented by the anterior projection of the femoral head and the tibial tuberosity as the distal point. The movement was performed lying supine with the ipsilateral leg extended, abducting the limb along the bed plane and adducing the same from the base position after rising it 30°;

c) rotation along the transversal plane: the fulcrum is represented by the proximal lateral angle of the patella; the peripheral point, in turn, was the center of

the heel sole. The subject executed the movement lying prone with prone arms extended along the hips, joined thighs, and the ipsilateral knee flexed 90°.

The evaluation of the articular mobility of the knee was performed through movements of flexo-extension. The anatomical points of reference were as follows:

flexo-extension along the sagittal plane: the fulcrum was the outer interarticular line of the knee, anterior portion, the apex of the outer malleolus as the distal point. The evaluation of the excursion was performed with the subject lying prone with the feet protruding out of the bed.

The above protocols were repeated thrice during the same session of registration for each of the patients, and the mean value was considered for each subject belonging to both groups (younger and elderly subjects).

Statistical analysis: Data obtained from all the patients were submitted to a statistical analysis. The mean values and the standard deviations of the range of motion (ROM) for the hip and the knee joints were calculated for all the movements in study. A comparison between the groups (younger versus elderly, men versus women, active people versus sedentary and pre-training versus post-training) was calculated by means of the Student's test.

Results

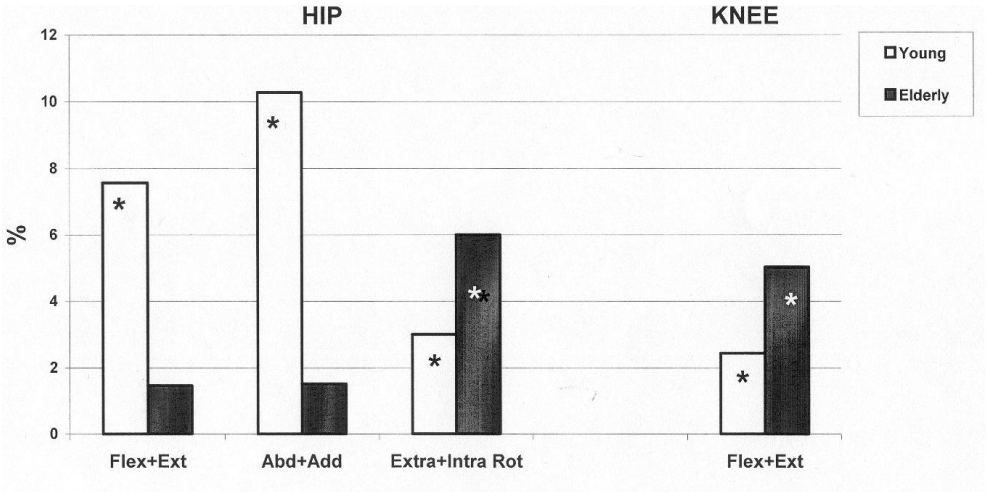

Fig. 1

Percentage increase of the articular flexibility in women versus men in younger and elderly subjects; *=P<0.05

White columns represent the relationship between ROM in young males and females; the black ones represent the same relationship in elderly, both of them

expressed as percentages for the different joints, in the movements of flexion and extension (Flex+Ext), abduction and adduction (Abd+Add), and rotation (Extra-Intra Rot).

Sex-related articular mobility: Differences in sex-related articular mobility are shown in Figs. 1 and 2. Women showed higher articular excursions for all the joints in study both in young and elderly subjects. A significant difference was revealed between men and women when considering hip flexo-extension and abduction-adduction in young subjects as well as hip intra-extra rotation and knee flexo-extension in young and elderly subjects (Fig. 1).

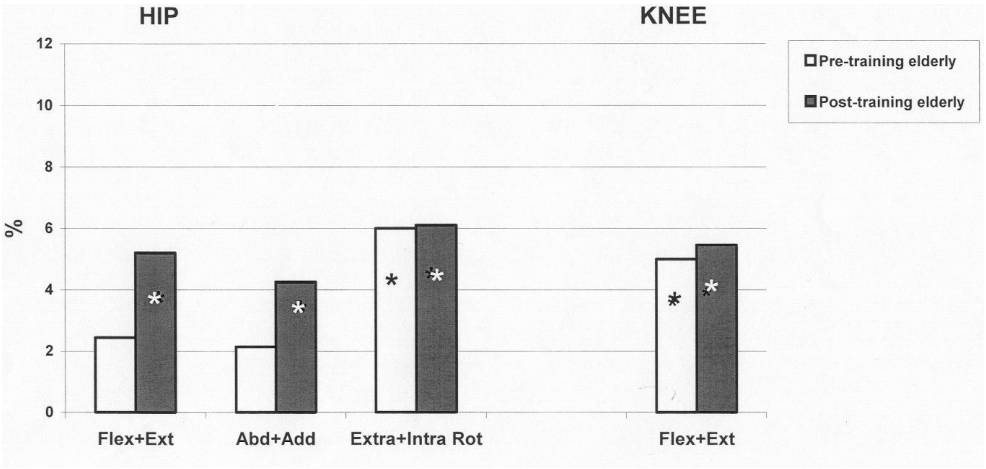

Fig. 2
Percentage crease of the articular flexibility in women versus men in pre-trained and post-trained elderly subjects; *=P<0.05
White columns represent the relationship between ROM in pre-trained males and females; the black ones represent the same relationship in post-trained elderly, both of them expressed as percentages for the different joints, in the movements of flexion and extension (Flex+Ext), abduction and adduction (Abd+Add), and rotation (Extra-Intra Rot).

Although articular mobility for hip flexo-extension and abduction-adduction in elderly was higher in the women, it did not reach statistical significance. Pre-training elderly subjects, a subgroup of elderly, did not show any statistical significance for ROM between men and women as also observed in the entire group of elderly for hip flexo-extension and abduction-adduction (Fig. 2).

Nevertheless, the same group after training (post-training) presented a significant sex-related difference for all the motions in study (Fig. 2).

In addition, sex-related differences are analog in the group of elderly and in the two subgroups of sedentary and active elderly (data not shown).

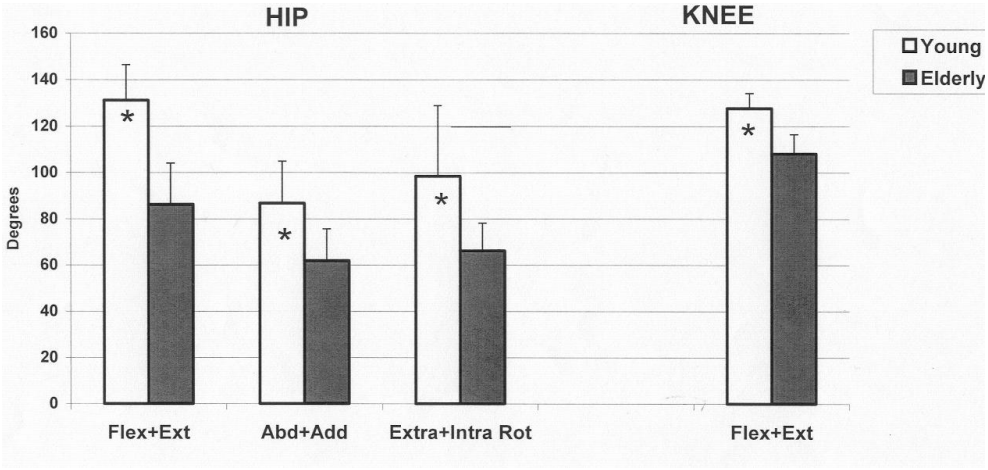

Fig. 3
Hip and knee flexibility for the group of young and elderly; *=P<0.05
White columns represent the mean values (+1 ds) corresponding to young subjects, those black to elderly, in the two joints, for the movements of flexion and extension (Flex+Ext), abduction and adduction (Abd+Add), and rotation (Extra-Intra Rot).

Age-related articular mobility: Young subjects showed a higher articular mobility for all the motions herein considered; such a difference was always statistically significant (Fig. 3).

The amount of reduction of ROM in the elderly subject varies according to the joint: knee flexo-extension showed a 15% decrease of ROM with respect to young subjects. Reductions of ROM values in the elderly were 34%, 29%, 33% for hip flexo-extension, adduction-abduction and intra-extra rotation, respectively (mean value: 32%).

Activity-related articular mobility: After submitting the questionnaire the elderly group was divided in two subgroups, those who have had in the past a sedentary life style and those who have had an active life style. In such a way it was possible to study the effect of different life styles of chronic physic activity upon ROM values for the hip and the knee.

The subgroup of active elderly always showed higher ROM values with respect to sedentary subjects for all the joints considered. A significant different ROM was found in both groups exclusively for hip abduction/adduction and intra-extra rotation (Fig. 4).

Training-related articular mobility: Pre-training active elderly subjects accepted to undergo a training period in order to evaluate the effects of work weight upon the joints studied. Such work was administered by means of specific training sessions and acute general exercise. Trained active elderly showed an improvement of ROM in all the motions. Such difference was significant only regarding hip flexo-extension. Minimal differences were observed, in turn, between pre and post-training for hip intra-extra rotation (Fig. 5).

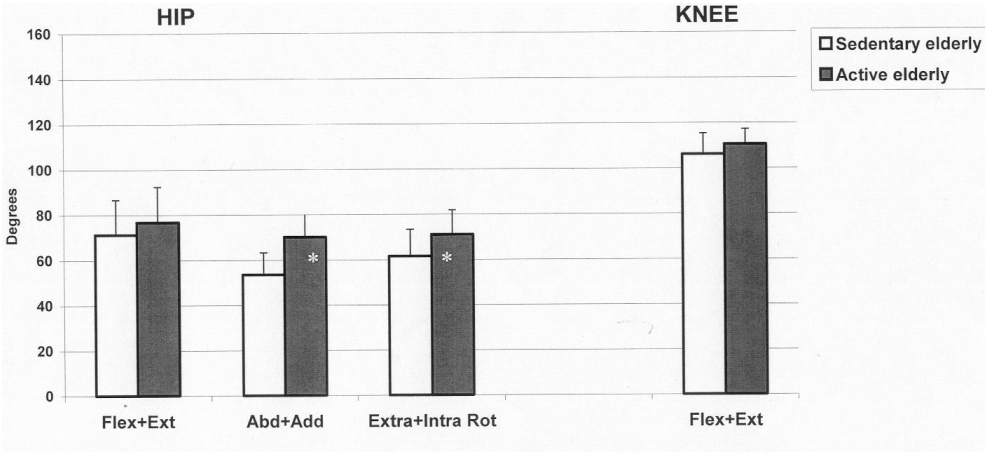

Fig. 4
Flexibility of hip and knee joints in sedentary elderly versus active elderly; *=P<0.05
White columns represent the mean values (+1 ds) corresponding to sedentary elderly, those black to active elderly, in the two joints, for the movements of flexion and extension (Flex+Ext), abduction and adduction (Abd+Add), and rotation (Extra-Intra Rot).

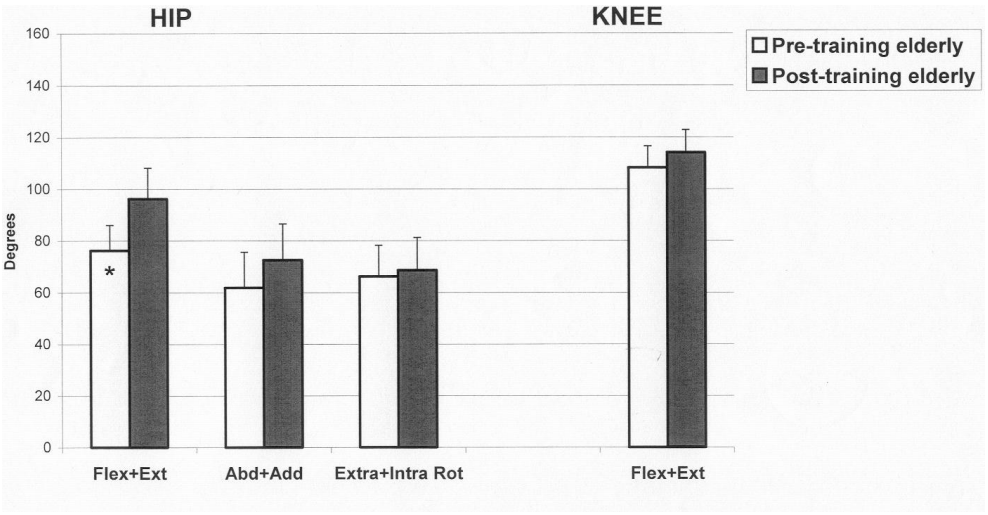

Fig. 5
Hip and knee flexibility of elderly subjects before and after training; *=P<0.05
White columns represent the mean values (+1 ds) corresponding to pre-training elderly, those black to post-training elderly, in the two joints, for the movements of flexion and extension (Flex+Ext), abduction and adduction (Abd+Add), and rotation (Extra-Intra Rot).

Discussion and Conclusion

It is well known that articular mobility is related to a series of factors [11-19] and physical decay is present in older subjects [38]. Moreover, females show a higher articular excursion with respect to males in different body regions [24-39].

The present findings regarding both young and elderly subjects agree with the literature. In fact, in one of our previous studies performed on the mobility of the spine, sex-related decay of articular mobility gave similar results [22]. Hip flexion-extension and abduction-adduction motions were not statistically different when comparing both sexes in the whole group of elderly; however, a significativity were present again after the training period.

A high Body Mass Index (BMI), osteoarthritis and diabetes are among the most important pathological factors related with a reduction in articular mobility [13,29,21,19]. In particular, motions that appear to be mostly affected (disabling) by osteoarthritis are knee flexion and hip flexion and outer rotation [29]. Our sample, composed by healthy elderly subjects, showed a harmonic decay of hip mobility and, to a lesser extent, knee mobility. This agrees with Roach and Miles

[28] who indicated hip extension as the motion showing a higher loss of ROM and a lower decay of mobility for the other motions. Considering our sample of subjects who were not suffering of obesity or other relevant chronic pathology, this decay is likely to be correlated to a common age-related reduction in articular mobility.

Articular aging is associated to a series of phenomena among which reduction of the muscular mass, alterations of the cartilage matrix [36-39], chondrocytes function [31,14] and subchondral bone [10], with a subsequent irregularity of articular rimes, reduction of the articular space [18] and modifications of connective tissue features [4]. Moreover, articular cartilage appears stiffer and more brittle with advancing age [37] showing a lower level of deformation with respect to healty young subjects [15]. As a consequence of the cartilage and joint tissue degeneration articular aging may determine a decrease in the articular mobility of the joints.

Alterations of cartilage morphology and mechanical properties occur in ostearthritis. However, it is unclear whether similar changes also takes place physiologically during aging, in the absence of disease, although the morphological, biochemical and mechanical alterations recall those present in the initial osteoarthritis [14,18,25,3].

After performing a questionnaire elderly were divided in two groups: sedentary and active subjects. As already reported [22], articular mobility was always higher in active elderly. This finding is likely to confirm that non specific but constant physical activity may contribute to prevent the general decay in articular mobility. However, hip and knee flexion-extension did not differ statistically between active and sedentary elderly subjects. This may be explained by the fact that flexion-extension of the lower limb is usually carried out during the activity of daily life and, therefore, performed even by sedentary subjects. Nevertheless, hip flexion-extension improved with an acute load enough to obtain a statistically significant rise after one cycle of physical activity.

In a similar way, all the motions showed a general improvement of the values after the training period, although it was not significant (compare pre- and post-training). This suggests that an acute load may still further improve articular mobility mainly acting upon the muscular component that responses faster to the training programs.

The benefic effect of a low-impact cardio-respiratory training upon fitness of patients is a well known fact [5-7]. Among the different physical abilities that may be considered, articular mobility represents the base for the normal management of personal autonomy within normal activities of daily life [33,20].

In conclusion, according to our previous studies performed also on other joints [22], the present findings indicate that either chronic and acute work in the elderly may act efficaciously in contrasting inevitable decay of physical capabilities. In particular, it is possible to improve articular mobility, and thus limiting articular inability, a quality considered among those the most important for the maintenance of personal autonomy.

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