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COMPARISON OF HOME- AND GYMNASIUM-BASED RESISTANCE TRAINING ON FLEXIBILITY IN THE ELDERLY

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ABSTRACT

Aging results in a natural loss of flexibility, which is especially essential in the maintenance of functional abilities of the aged to perform activities of daily living. Resistance training may provide a stimulus for flexibility, in addition to its extensive health benefits, since its action is through a full range of motion. The purpose of this study was to compare the effects of a home- and gymnasium-based resistance training programme on flexibility in the elderly. Forty-nine inactive elderly males and females aged 55 to 85 years were assigned to either an eight-week, three times weekly home- (HB) (n=25) or a gymnasium-based (GB) (n=24) resistance training programme at a rating of perceived exertion of 11 to 12 (very mild discomfort). Both groups were equally effective at significantly (p<0.05) increasing right shoulder flexion, right shoulder extension, left and right internal rotation, left and right external rotation, and left and right hip flexion. This study demonstrates that a home- or gymnasium-based programme can improve flexibility and allow the elderly to maintain functional ability and lead independent lives.

Key words: Elderly; Joint mobility; Strength training; Weight training.

INTRODUCTION

In recent years, improvements in health management and medical care have led to an increased life expectancy. The result of this is a growing aging population in both Europe and the United States of America (USA), with more than eleven million people over the age of 65 years living in the United Kingdom (UK) and a predicted increase of over two million between 1996 and 2021 (Ramsbottom *et al*., 2004). In the USA, adults over the age of 65 years make up 12% of the total population, and they are the largest growing segment of the population. It is estimated that the percentage of adults of 65 years and older will increase to 20% and the number of individuals aged 85 and older will more than double to 8.5 million by 2030 (Lees *et al*., 2005). Although the 7% proportion of individuals over 60 years of age in South Africa (SA) (Statistics South Africa Census 2001, 2003) is considerably lower than in the UK and the USA, this proportion is projected to increase so that more than one person in 10 in SA will be 60 years or older by 2025 (Joubert & Bradshaw, 2006).

Along with this increased life expectancy, there are increasing health concerns about the elderly population. In this regard, consequences of aging are mostly related to the degenerative changes and reduced efficiency and capabilities of the elderly (Martini, 1998), which can result in a loss of functional capacity and independence (Frontera & Bigard, 2002). With this loss, the essential activities of daily living such as bathing, eating and dressing, in addition to instrumental activities such as cooking and cleaning, can also become more difficult with increasing age (Lees *et al*., 2005). Flexibility in the joints can become limited (Alter, 1996; Kell *et al*., 2001) and this decrease in flexibility with advancing age appears to be more significant after the age of 50 (Gabbard, 1992). The age-associated decrease in flexibility may be due to declining tensile strength of the ligament-bone complexes (Neumann *et al*., 1994); collagen becoming more soluble and cross-linked (O'Shea, 2000); cartilage, ligaments and tendons becoming stiffer and more ridged (McArdle *et al*., 2000); the cells becoming less able to repair the matrix (Buckwalter *et al*., 1993); joints becoming less stable and the synovial membranes degrading and losing viscosity of the synovial fluid (Gabbard, 1992).

Physical activity can improve flexibility by increasing collagen turnover in ligaments by lengthening skeletal muscle fibres, increasing muscle mass (Goldspink, 1992; O'Shea, 2000), increasing chondrocytes (Buckwalter *et al*., 1993), building up collagen fibre cross-linkage formation, synovial membranes and increasing the viscosity of synovial fluid (Brooks *et al.*, 1996). Thus, a habitually active lifestyle is associated with less functional impairment even in already frail individuals of extreme old age (Fiatarone, 1996). Resistance training along with stretching exercises may contribute to an increase in flexibility and can provide a stimulus for flexibility, since its action is through a full range of motion that is close to the natural movement of a joint (Fleck & Kraemer, 1997; Kell *et al.*, 2001). Training through a full range of motion together with stretching helps to reduce and reverse age-related fibrosis and helps to maintain flexibility with increasing age (Bayles, 1997; O'Shea, 2000). Resistance training has been shown to improve flexibility in the ankles, quadriceps, hamstrings, hips and lower back regions. When this is combined with gains in strength, the flexibility provides for greater body control and stability in everyday functional activities (O'Shea, 2000). O'Shea (2000) describes the hips, lower back, buttocks, quadriceps and abdominals as the sources of power for the elderly and as such needs to be emphasised in a training regime.

PURPOSE OF THE STUDY

Maintaining and restoring the health and independence of the growing senior population in a cost-effective manner is very important, since geriatric rehabilitation will increasingly be considered in the planning of health care services in the coming years (Wells *et al.,* 2003). In this regard, a home-based rehabilitation programme can be inexpensive, which is especially necessary in developing countries due to limited transport. Home-based programmes are appropriate for use in aged-care centres that do not have specialised equipment or personnel. Therefore, the purpose of this study was to compare the effects of a home- versus gymnasium-based resistance training programme on flexibility in the elderly.

METHOD

Subjects

Following responses to information leaflets distributed at community recreation centres, places of worship, tertiary institutions and local medical centres, 49 inactive elderly males (n=14) and females (n=35) aged 55 to 85 years volunteered to participate in this study. Prior to participation in the study, all volunteers provided written informed consent, underwent medical screening and were allowed to discontinue the study at any time. Subjects that suffered from absolute and relative exercise contra-indications were excluded from participation in the study (ACSM, 2006) and were required to not have participated in any structured exercise for at least six months prior to the study (Shaw *et al*., 2009). The Institutional Review Board at the Tshwane University of Technology approved this study.

Flexibility assessment

Maximal flexibility of the shoulders, calves, hamstrings and quadriceps was measured via a protractor goniometer and non-distendable measuring tape. Maximal flexibility was defined as the point where the joint attained end-range, until tightness was felt or the subject expressed slight discomfort. Maximal flexibility was passively measured first on the right side and then on the left side of the body. The best of three measurements was recorded to the nearest degree. No warm-up was performed prior to the initial flexibility measurements and subjects were not allowed to perform any exercise 48 hours prior to the measurements.

Specific flexibility measurements included: shoulder flexion/extension, shoulder external /internal rotation, shoulder abduction/adduction; and ankle flexion/extension, hip flexion and knee flexion as per the recommendations of Leighton (1987). For shoulder flexion/extension flexibility, each subject was placed in a supine position with the knees flexed and the evaluated shoulder over the edge of the supporting surface to allow scapulothoracic, sternoclavicular and acromioclavicular motion to occur with glenohumoral motion. The elbow was fully extended and held parallel to the supporting surface as measured by an inclinometer. The administrator then moved the subject’s arm upward for shoulder flexion or downward for shoulder extension as far as possible until the point where the joint attained end-range, namely when tightness was felt or the subject expressed slight discomfort. The movements were repeated with the opposite arm.

While in the supine position, shoulder internal/external rotation flexibility was assessed with the elbow bent at 90° and held parallel to the supporting surface as measured by an inclinometer. The administrator then moved the subject’s wrist either forward for shoulder internal rotation or backward for shoulder external rotation as far as possible. The distance the wrist travelled was noted for each side. Shoulder abduction/adduction flexibility was similarly assessed in the supine position at the side edge of the supporting surface and with the elbow extended and the arm held at 90° shoulder flexion and slight medial shoulder rotation. The subject was required to perform horizontal adduction as close to the chest as possible, which served as the starting point. The subject was then required to performed horizontal abduction as far as possible. At this point the degree of movement was recorded for each side. While still in the supine position, with both legs straight and the lower leg remaining on the floor, each subject's leg was raised by the administrator as far as possible. The distance the leg travelled was noted as the score for hip flexion flexibility for each side.

Knee flexion flexibility was measured in the prone position. The administrator bent the subject's knee as far as possible towards the buttocks. The distance the lower leg travelled was noted as the score for each side. Ankle flexion flexibility was also measured in the prone position with the subject's straight legs off the supporting surface. The subject began the test with the foot perpendicular to the floor. The administrator bent the ankle as far as possible towards the supporting surface. The distance the foot travelled was noted as the score for each side. In turn, the amount the toes could be pointed as far as possible was recorded as ankle extension flexibility.

Training protocols

Subjects were matched by gender and randomly assigned using a schedule generated from a table of random numbers to either a home-based (HB) (n=25) (mean age 68.51±9.6) or gymnasium-based (GB) group (n=24) (mean age 71.51±11.6) with an equal distribution of females and males in each group in an attempt to equalise for the male and female differences across groups at baseline. All subjects had to perform their respective programmes three times per week at a rating of perceived exertion (RPE) of 11 to 12 (very mild discomfort) (Fleck & Kraemer, 1997). Prior to commencement of the training period, all subjects participated in a familiarisation session in which they were taught how to perform all the prescribed exercises. They were also provided with illustrations and relevant descriptions of the prescribed exercises. Both groups did not receive any motivational support during the intervention period. In addition to this, the exercises performed, the weight used and the number of sets and repetitions completed for each exercise were recorded at each training session.

The GB programme commenced with five minutes of easy cycling, followed by five stretching exercises each performed for two to three sets of 20 seconds. The GB group had to complete eight resistance training exercises, which included supine hip lifts or bridges, seated machine *latissimus dorsi* pull-downs, seated machine bench press, supine crunches with arms across chest, seated machine leg extensions, prone machine leg curls, standing dumbbell shoulder shrugs or raises and standing machine calf raises, for two to three sets of 10 to 15 repetitions. Each session concluded with a five-minute cool-down cycle. The subjects in the HB group warmed-up for five minutes by performing one set of standing half squats, standing half lunges, walking on the spot, standing frontal raises and standing shoulder shrugs or raises for 10 to 15 repetitions, followed by five stretching exercises each performed for two to three sets of 20 seconds. The HB subjects had to complete two to three sets of 10 to 15 repetitions of supine hip lifts or bridges, supine double knee to chest lifts, standing upright rows, supine crunches with arms across chest, sitting and rising from a chair and standing calf raises.

Statistical analyses

Standard statistical methods were used for the calculation of the means and standard deviations (±SD). The t-test was applied to determine differences between pre- and post-tests at a significance level of 95% or $p \leq 0.05$. An analysis of variance (ANOVA) for repeated measures was performed on the data to determine which of the programmes was the most effective. Data was analysed using the Statistical Package for Social Sciences (SPSS) Version 14, (Chicago, IL) at a significance level of 95% or $p \leq 0.05$.

RESULTS

No dropout of subjects was recorded in the present study and as such no intention-to-treat analysis was performed. Further, no significant differences in compliance to the exercise programmes were found between the groups with all subjects having 100% adherence to the individual exercise programmes. The flexibility variables of both the HB and GB were found to be homogenous at the pre-training except for right shoulder flexion ($p=0.013$), right shoulder extension ($p=0.023$), left ($p=0.005$) and right shoulder external rotation ($p=0.000$), left ($p=0.000$) and right shoulder internal rotation ($p=0.002$), left ($p=0.004$) and right hamstring ($p=0.011$) flexibility (Table 1). The results revealed that both training groups significantly ($p<0.05$) improved right shoulder flexion and extension, left and right shoulder external rotation, left and right shoulder internal rotation, and left and right hamstring flexibility (Table 1). Furthermore, both programmes proved equally effective at improving the flexibility of the elderly.

DISCUSSION

The principle findings of this study demonstrate that a HB and GB resistance training programme is equally effective at improving shoulder and hamstrings flexibility of the elderly, but not the flexibility of the quadriceps and calves. This is despite the fact that the HB group had additional strength training in the form of standing half-squats and standing half-lunges included in their warm-up. Notwithstanding the findings of Girouard and Hurley (1995) that 10 weeks of three times weekly heavy resistance training does not result in improvements in flexibility in untrained males aged 50 to 74 years, this study's findings are similar to those of Adams *et al*. (2001), Fatouros *et al*. (2001), Fatouros *et al*. (2005) and Kalapotharakos *et al*. (2005). Adams *et al*. (2001) found a significant increase in flexibility assessed by sit-and-reach following an eight weeks of twice weekly resistance training programme in 44 to 68 year-old African American females. Similarly, Fatouros *et al*. (2005) found a significant increase in flexibility following a 24-week, three times weekly low-, moderate- and high-intensity resistance training programme consisting of 10 exercises in healthy, inactive males aged 65 to 78 years. Fatouros *et al*. (2001) found significant increases in shoulder flexion, extension and adduction, hip flexion, knee flexion, elbow flexion and sit-and-reach following 16 weeks of resistance training in inactive elderly males aged 65 to 78 years. Furthermore, 12 weeks of three times weekly heavy and moderate resistance training both improved flexibility in terms of sit-and-reach in inactive older adults aged 60 to 74 years (Kalapotharakos *et al.*, 2005).

Resistance training together with stretching exercises have been shown to improve flexibility due to resistance training emphasising a full range of motion that is close to the natural movement of a joint (Fleck & Kraemer, 1997). When resistance training is preceded or combined with flexibility training, it can lead to greater body control and stability in everyday functional activities (O'Shea, 2000). This study's significant improvements in flexibility indicate the success of the intervention programmes in increasing flexibility, regardless of whether the improvement was due to the flexibility exercises, the resistance exercises or the combination of the two training components.

TABLE 1: **FLEXIBILITY CHANGES FOLLOWING HOME- AND GYMNASIUM-BASED RESISTANCE TRAINING**

Variable (unit of measurement in degrees)	Training	Pre-training Mean	Pre-training SE	Post-training Mean	Post-training SE	GB vs HB p-value#
L-Shoulder	GB	172.39	2.08	175.26	1.40	0.383
Abduction	HB	173.40	2.66	176.36	1.92	
R-Shoulder	GB	172.39	2.08	175.26	1.40	0.262
Abduction	HB	172.52	2.68	176.36	1.92	
L-Shoulder	GB	180.00	0.00	180.00	0.00	0.236
Adduction	HB	179.20	0.62	180.00	0.00	
R-Shoulder	GB	180.00	0.00	180.00	0.00	0.236
Adduction	HB	179.20	0.62	180.00	0.00	
L-Shoulder	GB	161.48	1.53	164.18	1.04	0.071
Flexion	HB	158.94	2.53	165.02	2.00	
R-Shoulder	GB	159.10	1.21	164.00†	1.47	0.050**
Flexion	HB	156.92	2.12	162.59†	1.79	
L-Shoulder	GB	50.75	2.21	54.08	2.79	0.168
Extension	HB	53.34	2.42	57.59	1.68	
R-Shoulder	GB	53.50	2.26	62.92†	3.46	0.000**
Extension	HB	52.70	2.29	66.91†	1.77	
L-Shoulder	GB	15.35	1.38	23.21†	2.42	0.000*
Ext. Rotation	HB	14.94	1.18	22.41†	1.59	
R-Shoulder	GB	18.98	2.06	31.00†	2.24	0.000*
Ext. Rotation	HB	19.70	1.76	29.61†	1.46	
L-Shoulder	GB	17.19	1.27	27.05†	2.08	0.000**
Int. Rotation	HB	17.10	1.68	34.64†	2.65	
R-Shoulder	GB	22.52	2.62	35.37†	3.01	0.000**
Int. Rotation	HB	22.54	2.27	38.36†	2.21	
L-Quadriceps	GB	22.62	1.76	20.90	1.54	0.991
	HB	17.08	0.76	17.09	1.04	
R-Quadriceps	GB	22.55	1.48	21.64	1.52	0.870
	HB	18.12	1.41	18.46	1.48	
L-Hamstring	GB	48.10	2.98	61.21†	2.94	0.031*
	HB	57.70	3.06	68.18†	3.61	
R-Hamstring	GB	51.13	3.05	63.21†	3.37	0.022*
	HB	61.08	2.79	70.27†	2.64	
L-Calves	GB	8.18	0.75	9.65	0.77	0.706
	HB	10.36	0.72	10.00	0.59	
R-Calves	GB	8.84	0.72	9.33	0.66	0.857
	HB	10.85	0.54	10.72	0.41	

L: Left; R: Right HB: Home-Based; GB: Gymnasium-Based SE: Standard Error
† Significant difference within group from pre- to post-training # Comparison of change scores
* significant difference for GB [improved more than HB]
** significant difference for HB [improved more than GB]

Due to this improvement in flexibility in response to resistance training, this study surmises that resistance training can be safely included, and provide the elderly with optimal flexibility and the other additional benefits that come from resistance training, such as muscular hypertrophy, which could stimulate bone growth and associated connective tissue (Baechle & Earle, 2000). Resistance training can also be beneficial since it can promote bone mineralisation and help to prevent osteoporosis in later life. This programme might even provide for a greater stimulus in bone mineralisation, since the free weight and body weight exercises are constrained by the lifter rather than by a machine, requiring muscles to work in stabilisation as well as support (Baechle & Earle, 2000).

While the present study did not assess treatment fidelity and could not determine whether the subjects over-reported their fidelity on self-report forms, it is important for future studies to identify the best and most feasible means of monitoring fidelity after an intervention to determine the extent to which interventions are being delivered as intended and to determine what level of fidelity is necessary to promote desired outcomes in practice settings (Stirman & Kimberly, 2009). The findings of the present study provide information that will assist in designing resistance training programmes that may be more cost efficient in producing health and fitness benefits in the elderly. This is so since the results indicate that the elderly can effectively and productively enhance their flexibility by training at home, when access to a gymnasium facility is unavailable or undesired. Home-based training may be a solution for the elderly that have transport dilemmas, are in aged-care centres that do not have specialised equipment or personnel, and is safer than using specialised gymnasium equipment, thus making it more possible for the elderly to maintain functional ability and lead independent lives.

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