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STRUCTURED EXERCISE PROGRAM IS FEASIBLE AND IMPROVES FUNCTIONAL CAPACITY AMONG OLDER ADULTS IN PUERTO RICO

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Abstract

Hernandez, O. J. & Ramirez, F. A. (2014). Structured exercise program is feasible and improves functional capacity among older adults in Puerto Rico. **PENSAR EN MOVIMIENTO: Revista de Ciencias del Ejercicio y la Salud, 12 (2),** 1-15. Physical inactivity is a major risk factor affecting overall health and functional capacity among older adults. In this study we evaluated functional capacity in 22 older adults in Puerto Rico (mean age ± standard deviation = 73.3 ± 8.2 years) before, during and after eight weeks participation in a structured exercise program. Functional capacity was evaluated using a field test battery (body composition, flexibility, coordination, agility and balance, muscle endurance and cardiorespiratory endurance) validated for this population. Also, cardiorespiratory fitness (VO_2max) and blood lipid levels were evaluated in a sub-sample (n = 7). A repeated measures ANOVA was used to detect changes in functional capacity before, during and after the exercise program. A paired t-test was used to evaluate changes in VO_2max and lipids before and after the program. Flexibility improved significantly during the exercise program (51.6 ± 12.2 vs. 57.7 ± 8.1 cm, p=0.04) and this change was sustained at the end of the program (54.4 ± 10.2 cm). At eight weeks into the program, time in the agility and balance test improved by two seconds and muscle endurance improved by five repetitions ($p<0.05$ for all). No changes were observed in body composition, coordination, VO_2max and lipid levels ($p>0.05$). These results suggest that participation in a structured exercise program for eight weeks can positively impact factors that improve movement capacity in older adults.

Key words: Physical Fitness; Ageing; Feasibility; Programmed Exercise

Resumen

Hernandez, O. J. & Ramirez, F. A. (2014). Programa de ejercicio estructurado es viable y mejora la capacidad funcional en adultos mayores en Puerto Rico. **PENSAR EN MOVIMIENTO: Revista de Ciencias del Ejercicio y la Salud, 12 (2),** 1-15. La inactividad física es un factor de riesgo principal que afecta la salud y capacidad funcional en adultos mayores. En este estudio se evaluó la capacidad funcional en 22 adultos mayores en Puerto Rico (edad promedio ± desviación estándar = 73,3 ± 8,2 años) antes, durante y después de ocho semanas de participar en un programa de ejercicios estructurados. La capacidad funcional se evaluó mediante una batería de pruebas de campo (composición corporal, flexibilidad, coordinación, agilidad y balance, tolerancia muscular y tolerancia cardiorrespiratoria) validadas para esta población. Además, en una sub-muestra (n = 7) se midió la aptitud cardiorrespiratoria (VO2max) y los niveles de lípidos en sangre. Se utilizó una ANOVA con medidas repetidas para detectar cambios en la capacidad funcional antes, durante y después del programa. Con una t-pareada se evaluaron cambios en VO2max y lípidos antes y después del programa. La flexibilidad mejoró significativamente durante el programa (51,6 ± 12,2 vs. 57,7 ± 8,1 cm, p=0,04) y el cambio se sostuvo al final del programa (54,4 ± 10,2 cm). El tiempo en la prueba de agilidad y balance mejoró por dos segundos y la tolerancia muscular aumentó por cinco repeticiones al cabo de ocho semanas (p<0,05 en todos). No hubo cambios en la composición corporal, coordinación, VO2max y nivel de lípidos (p>0,05). Estos resultados sugieren que la participación en un programa de ejercicios estructurados por ocho semanas puede impactar positivamente aspectos que promueven la capacidad de movimiento en el adulto mayor.

Palabras clave: Aptitud física, Envejecimiento, Viabilidad, Ejercicio programado

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One of the major challenges in public health nowadays is maintaining optimal health status, independence and mobility in the growing population of older adults (CDC, 2003). This is explained by the biological changes associated with the ageing process that increase the risk of chronic diseases and disability. However, some of these biological changes like the reduced cardiorespiratory fitness (VO_2max), increased cholesterol, glucose intolerance, loss of calcium and reduced lean body mass, are likely produced by the combined effect of ageing and the physical inactivity and sedentary behaviors characterizing the older adult population (Chodzko-Zajko et al., 2009).

Physical exercise programs for older adults are very limited and mostly inaccessible in Puerto Rico (PR) and other countries around the World (Lopez, 2001; Rikli & Jones, 2013; Romero-Arenas, Martinez-Pascual, & Alcaraz, 2013). Available programs are mostly focused on very low intensity recreational activities (Lopez, 2001; Romero-Arenas et al., 2013). Some studies have reported a 50-73 % participation in exercise interventions for older adults (Leszczak, Olson, Stafford, & Brezzo, 2013; Rikli & Jones, 2013). The feasibility of a structured exercise program for older adults in PR and its effect on functional capacity has not been documented. Therefore, in this study we tested the following hypotheses: 1) at least 75 % of participating older adults will complete the structured exercise program; 2) the exercise program will improve functional capacity, cardiorespiratory fitness and blood lipid levels.

Methodology

A cuasi experimental design was used consisting of one group measured before, during and after a structured exercise intervention (during = at week four, and after = at week eight of the intervention).

Selection of Study Sample.

A convenience sample was selected among participants in the “Hope for the Elder” community-based program in San Germán, PR. After being authorized by the program board of directors and the Institutional Review Board (IRB) of the Interamerican University of Puerto Rico, a meeting was conducted with the program directors and potential participants to explain the study purpose and protocol including the scientifically structured exercise program (CSEP) and the evaluations before, during and after the program. Inclusion (older adults at least 60 years of age, medical evaluation and authorization to participate in the exercise program) and exclusion (diagnosed neuromuscular or neurocognitive disease, uncontrolled rheumatic disease, anemia, recent embolism, uncontrolled metabolic disorders, acute and recurrent diseases, active infections and constant fever, illicit drug use or use of medications altering heart rate response) criteria were also explained.

Medical evaluations and authorization to participate in the study were obtained by a family physician and a cardiologist in the community-based program. Medical evaluations included presence of chronic diseases, physical activity level, general and cardiovascular health status, tobacco and alcohol use. A resting electrocardiogram was also obtained and evaluated by the cardiologist. From a total of 30 older adults evaluated, 27 received medical release to participate in the study and later completed the informed consent form when all their questions were answered by study personnel. Of these 27 participants, 22 (males = 3, females = 19) completed all evaluations one week before, during (at week four) and one week after the program (after week eight), and were included in the analyses.

The evaluations before starting the CSEP included anthropometric measurements (weight, height, and thigh and biceps circumferences) and skinfold measures (chest, abdomen and thigh for men; triceps, thigh and suprailiac for women). These measurements were used to estimate percent body fat (Crombie et al., 2004). Resting blood pressure and heart rate (HR) were also measured. Resting HR was used to obtain the target exercise HR using a percentage of the HR reserve (Crombie et a., 2004).

Of the 22 participants, a sub-sample of 9 participants was randomly selected for additional measurements, seven of which (women= 6, men=1) completed all measurements that included cardiorespiratory (VO_2max) and blood lipid levels (HDL and LDL) before and after the exercise intervention. Before starting the CSEP, familiarization sessions were conducted where a HR monitor was included. The CSEP consisted of three weekly sessions from 8:30 to 10:30 a.m.: dancing on Mondays, muscle strengthening exercises on Wednesdays, and walking on Fridays.

Functional Capacity.

Functional capacity was evaluated with a battery of tests (Osness et al., 1996) validated among older adults in PR (Luhring, 1996). These tests are designed to identify parameters associated with functionality among older adults such as body composition, flexibility, agility and balance, coordination, muscle endurance and cardiorespiratory endurance. Evaluations were conducted in the morning and divided in two days: cardiorespiratory endurance the first day and the rest of the tests the second day. All tests were administered on three occasions: before starting, during (at week four), and after (after week eight) the CSEP.

Body Composition. Pondered index, a measure based on body weight and height (height/3 x weight) was used. Body weight was measured with light clothing and no shoes or socks. Height was measured with a metric tape vertically attached to a wall. After removing shoes and socks, each participant stood looking forward with their back against the wall. A ruler was placed horizontally over their head to register their height. Body mass index was also determined (BMI: kg/m^2).

Flexibility. With legs extended on the floor, feet apart by 30.5 cm and a 91.4 cm ruler placed on the floor at toe level between the legs, each participant placed one hand over the other and flexed their trunk sliding forward over the ruler sustaining the final position for at least two seconds. The highest distance reached in three attempts was registered.

Coordination. *On a table top, at* 12.7 cm of one end, a 76.2 cm long line was marked and over that line six 7.6 cm perpendicular lines were marked separated one from the other by a 12.7 cm distance. Three unopened soda cans of 341 ml were placed over perpendicular lines one, three and five. The test consisted of recording the time it took for each participant to turn all three cans and place them on the next perpendicular line (line tow, four and six), and then return them to the original position. Two practice attempts were allowed before the two trials from which the shortest time was recorded.

Agility and Dynamic Balance. From a sitting position on a chair with hand rests and both toes on the floor, the test consisted of timing from the moment each participant stood up, walked around the right side of a cone placed 182.9 cm from the chair, returned to the seat, sat down, stood up again to walk around the left side of another cone, and returned again to the seat and sat down. Each participant was instructed to complete the test as fast as possible and to use the hand rests to keep balance and prevent falls. The shortest time from two trials was recorded.

Muscle Endurance. From a sitting position on a chair without hand rests, both toes on the floor and looking forward, each participant held a light weight (3.6 kg for men and 1.8 kg for women) with their dominant hand, arm hanging on the side with their hand supine while the non-dominant hand rested over the thigh. The test consisted of completing as many elbow flexions and extensions as possible in 30 seconds. A zero was recorded when participants could not flex their elbow.

Cardiorespiratory Endurance. The time it took for each participant to walk 800 meters as fast as possible in a 400 meter track was recorded.

Cardiorespiratory Fitness (VO2max) and Lipids. Before starting the eight week CSEP, a sub-sample of seven participants completed two additional tests: cardiorespiratory fitness (VO_2max) and blood lipid levels (total cholesterol, HDL, and LDL). The cardiorespiratory fitness test was administered by an exercise physiologist in the Center for Sports Health and Exercise Sciences at the Olympic Center in Salinas, PR. The test was conducted on a treadmill using the modified Bruce protocol (Heyward, 2006).

A medical technologist took all blood samples for the lipid profile test by electrophoresis (Spectrophotometer-Hitachi 704). All samples were analyzed in the Porta Coeli Clinical Laboratory in San Germán, PR.

CSEP

The scientifically structured exercise program was conducted from 8:30 a. m. to 10:30 a. m., three days per week during eight weeks. Dancing exercises were included on Mondays, muscle strengthening exercises on Wednesdays, and walking on Fridays. Dancing exercises included low impact aerobic dancing, popular music dancing, and ballroom dancing. Muscle strengthening exercises included the use of elastic bands, hand weights of 0.5 to 0.9 kg, medicinal and balance balls, and a variety of exercises on the floor and while standing or sitting. Walking sessions were conducted on parks or athletic tracks nearby the community-based program.

The intensity and duration of each activity was modified according to each participant's response. Exercise intensity started at 50 % of HR max and was increased by 5 % every two weeks. Exercise duration started with 15 to 20 minutes and was increased by 5 % every four weeks, with 20 to 30 minutes sessions by the end of the intervention. All CSEP included an initial warm-up period (five to 10 minutes) and a final recovery session (10 to 15 minutes). Warm-up and recovery sessions included five-to-ten meter walks, flexion and extension of knees, hips, elbows, shoulders, and other body movements using a chair and a wall for support. Relaxation exercises with classical music were also included at the end of the recovery period.

Statistical Analyses

Statistical analyses included measures of central tendency (mean) and variability (standard deviation). The percentage of CSEP sessions completed was used to determine attendance and feasibility of the program. Inferential analysis included a repeated measures ANOVA to identify differences between measures before, during (at week four), and after the program (after week eight). A dependent t-test was used to detect differences in the VO_2max and lipid level measured in a sub-sample before and after completing the CSEP. An alpha of 0.05 was used to establish statistical significance and all statistical analyses were conducted with Minitab 16 for Windows (Minitab Statistical Software, Minitab Inc. 2010, Pennsylvania, U.S.).

Results

General Characteristics.

Participants' age ranged between 60 and 93 years, with a mean ± standard deviation of 73.3 ± 8.2 years. Body weight was 66.5 ± 15.4 kg, height was 150.6 ± 9.2 cm, and BMI was 29.2 ± 6.0 kg/m^2. The estimated percent body fat at the start of the study was 25.5 ± 7.6 %. Resting HR was 80.1 ± 13.5 beats per minute, and resting blood pressure was 130/79 ± 12/4 mmHg. The average attendance to the CSEP sessions was 76 %.

Functional Capacity.

Table 1 shows the mean ± standard deviation (SD) of all variables of interest before, during (at week four), and after the CSEP (after week eight): pondered index, flexibility, coordination, agility and balance, muscle endurance, and cardiorespiratory endurance. A symbol is used to identify values during and after the exercise program that are significantly different from the values before the program (alpha < 0.05).

Seventy-five percent of participants reached values of 11.9 units or less in the pondered index before starting the exercise program and these were not changed during or after the program ($p = 0.190$). Mean BMI was maintained in the overweight category (25.1 to 29.9 kg/m^2) in all evaluations (data not included in the table). Flexibility improved significantly during (increased by 6.1 cm at week four), and after the program (increased by 3.8 cm between weeks four and eight) ($p = 0.003$). Time in the agility and balance test and the number of repetitions in the muscle endurance test improved significantly by week eight ($p = 0.013$ and $p < 0.001$, respectively) compared with the results before starting the program. Coordination and cardiorespiratory endurance did not change as a result of the CSEP ($p = 0.286$ and $p = 0.217$, respectively).

VO_2max and Blood Lipids.

VO_2max in the sub-sample increased by 1.68 ml $\cdot kg^{-1} \cdot min^{-1}$ from pre to post-testing (21.6 ± 5.1 to 22.9 ± 8.0 ml $\cdot kg^{-1} \cdot min^{-1}$), but the difference was not statistically significant ($p = 0.23$). Total cholesterol, HDL and LDL did not change significantly as a result of the CSEP (191.0 ± 18.4 to 184.5 ± 27.1 mg/dL [p = 0.97], 56.3 ± 15.7 to 50.5 ± 16.2 mg/dL [p = 0.99], and 101.1 ± 25.2 to 95.9 ± 34.4 mg/dL [p = 0.43], respectively).

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Discussion

The most important findings of the present study are: 1) the feasibility of the CSEP was shown with over 75 % attendance; and 2) the significant improvement in many functional capacity criteria after eight weeks of participation in the CSEP for older adults in PR.

Improvement in flexibility as a result of the CSEP is one aspect that has been observed in previous studies including physical activity and exercise for older adults. Performing flexibility exercises at the beginning and end of each CSEP session could have influenced this result. For example, it has been observed that older adults significantly improve their flexibility after participating in aerobic exercise that included an initial stretching session (Clark, 1994) and also a muscle resistance session out of the water (Roma et al., 2013). Also significant improvement in flexibility has been shown among older adults after participating in a 12 month Tai Chi program (Lan, Lai, Chen, & Wong, 1998), after participating in a 12 week aerobic exercise program post hospitalization (Brovold, Skelton, & Bergland, 2013), or after participating in functional exercises organized into circuits (Whitehurst, Johnson, Parker, Brown, & Ford, 2005). Flexibility significantly improved at week four of the CSEP and the improvement was sustained at week eight of the program, thus suggesting that the program was effective in causing changes in flexibility. This is especially relevant given the fact that poor lower back and hamstring flexibility is associated with chronic back pain, risk of falls and fractures, and reduced capacity to engage in daily activities among older adults (Cedric & James, 1999; Gallon et al., 2011; Lan, et al., 1998). It has also been suggested that good flexibility helps improve speed, dynamic balance, and muscle endurance (Stanziano, Roos, Perry, Lai, & Signorile, 2009; Thompson, 1991), all of them important to achieve good mobility.

The observed improvement in agility and balance supports other studies that have used different exercise programs in older adults (Chodzko-Zajko et al., 2009; Chou, Hwang, & Wu, 2012; Kronhed, Möller, Olsson, & Möller, 2001). Studies that have evaluated exercise programs for older adults which include walking, dancing, muscle endurance, strength and flexibility, and also exercise programs in the water, have also reported improvements in posture stability and balance (Chodzko-Zajko, et al., 2009; Kim & O'Sullivan, 2013). Improving and maintaining good balance is important to prevent falls and fractures in the older population (Chodzko-Zajko et al., 2009; Gillespie et al., 2003).

The significant improvement in muscle endurance observed in the present study also supports other studies in which specific exercises for muscle strength were offered to older adults (Brandon, Boyette, Gaash, & Lloyd, 2000; Mayer et al., 2011; O'Neill, Thayer, Taylor, Dzialozyuski, & Noble, 2000; Westhoff, Stemmerik, & Boushuizen, 2000). The CSEP in the present study included one day for muscle strength and endurance activities suggesting that general exercise programs can also stimulate muscle strength improvements among older adults; and therefore, help improve or maintain factors associated with movement capacity such as walking speed, standing from a chair, carrying objects, and walking up and down a stair (Brandon, et al., 2000; Mian et al., 2007; Pinto et al., 2014).

Body composition was a criterion that did not change as a result of the CSEP in our older adult participants. This aspect was different from other studies that have reported a reduction in body weight and body fat among older adults after participation in exercise programs (Lee, Kim, & Oh, 2013; Meredith, Frontera, O'Reilly, & Evans, 1992; Romero-Arenas et al., 2013; Tan, Li, & Wang, 2012; Toth, Beckett, & Poehlman, 1999). Two factors could explain the lack of change in body composition observed in the present study: 1) the lack of dietary control or dietary modification, or education about nutrition in the CSEP, and 2) the volume and intensity of the physical activities included in the CSEP could have been insufficient to provoke an energy deficit. However, it is also important to prevent unnecessary weight loss among older adults that are associated with health complications, particularly among those that are not obese (Soenen & Chapman, 2013). Participants in the present study did not increase their body weight or BMI after eight weeks, a finding that could also be interpreted as positive.

The lack of change in coordination as a result of the CSEP differs from a previous study (Bennett & Castiello, 1994) in which an important reduction in the time to transport and manipulate objects was observed among older adults. In that study, Bennett y Castiello (1994) argued that the reduction was possibly due to a lower emphasis on the accuracy and more emphasis on the final result that was to complete the task as fast as possible. In the present study, the test emphasis was on both the accuracy and the speed. Although the CSEP did not include specific activities for motor coordination, the fact that this criterion did not decrease could be the result of other manual activities included in the community-based program (Ranganathan, Siemionow, Sahgal, & Yue, 2001). It has been suggested that coordination can progressively improve by slowly but precisely engaging in simple movement patterns (Fujiyama, Hinder, Garry, & Summers, 2013; Kottke, Halpern, Easton, Ozel, & Burrill, 1978) and that participation in exercise programs helps prevent the loss of motor skills and coordination among older adults (Heyward, 2006; Leszczak et al., 2013; Skelton, Greig, Davies, & Young, 1994; Wong, Lin, Chou, Tang, & Wong, 2001).

Cardiorespiratory endurance as part of a battery of functional capacity tests could be influenced by a good VO_2max as well as by a good mechanical efficiency when completing a distance as fast as possible. The former has a molecular and genetic component, while the latter has a neuromuscular and perceptual component more directly related with motor capacity (Joyner & Coyle, 2008). Improvements in cardiorespiratory endurance have been observed during field tests (Mian, et al., 2007) and improvements in VO_2max during laboratory tests conducted with older adults after participating in exercise programs (Chodzko-Zajko et al., 2009; Hagner, Hagner-Derengowska, Wiacek, & Zubrzycki, 2009). Although there was a tendency to reduce the time during the 800 m test, the difference was not statistically significant and, therefore, we concluded that cardiorespiratory endurance as a criterion of functional capacity did not improve with participation in our CSEP. It is possible that the intensity of the activities provided during the CSEP were not enough to provoke changes in this component. Similarly, there was a tendency for the VO_2max to improve but the difference was not significant. This could also be explained by the small number of participants in the sub-sample.

High density lipoprotein (HDL) and low density lipoproteins (LDL) did not change significantly as a result of the CSEP. This observation supports previous studies (Ready et al., 1996; Wagner, La Croix, Buchner, & Larson, 1992), but differs from others (Fahlman, Boardley, Lambert, & Flynn, 2002; Gallon et al., 2011; Isler, Kosar, & Korkusuz, 2001; Kostka, Lacour, Berthouze, & Bonnefoy, 1999) in which HDL improved as a result of an exercise intervention among older adults. It is possible that exercise programs for this population require a higher duration and higher intensity level in order to reach significant changes in these parameters.

There are several limitations in the present study worth discussing. First, the battery of tests to evaluate physical fitness and functional capacity associated with older adult's capacity for an independent life (Rikli & Jones, 2013) was not considered and should be included in a future study. However, the battery of tests selected for the present study is the only one that has been validated in older adults in PR (Luhring, 1996) and the observed results were within those reported by Luhring (1996). The lack of information regarding nutrition and energy expenditure, and the control over the volume and intensity of the CSEP were two limitations that could probably influence our results and should be considered for future studies. It is interesting to highlight that these controls are not the norm in real life situations suggesting that exercise programs like the CSEP provided in this study is still valuable for improving or maintaining functional capacity parameters among older adults in PR. Finally, the sub-sample was probably too small (n = 7) to be able to detect significant changes in VO_2max, and also the number of male participants (n = 3) limited the capacity to establish differences by sex.

Another interesting evaluation of the present study was the feasibility and satisfaction of the participants with the exercise program. Regular and on-time attendance, the effort to complete all activities, and the rapport between participants and researchers all suggest that the CSEP is feasible and acceptable to a group of older adults in PR. In conclusion, our results suggest that the CSEP is not only feasible but also beneficial in improving functional capacity, an essential aspect of mobility and general health among older adults. Programs such as the one provided in the present study could help reduce sedentary behaviors and increase the engagement of older adults in daily physical activities that improve independence and quality of life.

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Table 1.

Mean and standard deviation (S.D.) of study variables before, during and after the exercise program.

	n	*Before*		*During (4 weeks)*		*After (8 weeks)*		p (F)
		Meana	S.D.	Mean	S.D.	Mean	S.D.	
Pondered Index (units)	22	11.3	1.0	11.3	0.8	11.5	0.7	0.190 (1.73)
Flexibility (centimeters)	22	51.6	12.2	57.7*	8.1	54.4*	10.2	0.003 (6.57)
Agility and Balance (seconds)	22	29.9	10.8	29.8	10.5	27.9*†	8.6	0.013 (4.81)
Coordination (seconds)	22	12.4	4.7	11.1	4.8	11.8	8.3	0.286 (1.29)
Muscle Endurance (repetitions)	22	18.5	5.9	23.4	5.2	23.9*†	4.5	<0.001 (20.67)
Cardiorespiratory Endurance (min)	22	11.6	3.8	11.2	3.7	11.2	3.3	0.217 (1.35)

* $p < 0.05$ compared with pre (before) test, † $p < 0.05$ compared with during test"