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STRENGTH, BALANCE AND STABILITY: THE EFFECTS OF MODERATE INTENSITY RESISTANCE EXERCISE ON THE 40+ AGE GROUP

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ABSTRACT

Balance and stability have increased in importance, not least economically, over the last decade. With people living longer, year on year increases in falls, loss of independence, and escalating costs, it has never been more important to look at ways of improving balance. This study looked at the effects of moderate intensity resistance exercise on strength and balance in subjects between 41 and 62 years of age.

Subjects followed an 8-week intervention utilizing three resistance exercises; the standing chest press, deadlift, and leg press. Average strength gains for the chest press (10.66 kg), deadlift (31.47 kg), and leg press (25.94 kg), were all significant at the .001 confidence level.

Pre and post balance was assessed using the Balance Error Scoring System (BESS). The maximum possible error score was 60. For the pre intervention BESS tests, the mean score was 38.80 (± 6.96) and for the post intervention, 25.53 (± 7.25), resulting in a mean reduction of 13.27 in balance errors.

The results from a Paired T-Test indicated a significant decrease in BESS scores following the protocol (p=<0.0001) with an average improvement of 34.2%. The greatest individual BESS score improvement was 62.85% and the lowest was 4.16%. All participants improved their strength and balance scores as a result of the intervention.

INTRODUCTION

In the United Kingdom, 1 in 3 people living in the community over the age of 65 will fall each year. By the age of 80, 1 out of 2 people suffer falls. Fall rates for those living in nursing homes or institutions are even higher (Anderson, 2007). Falls and hip fractures cost the NHS in England and Wales over £2 billion annually and these figures and costs are set to increase annually with population growth in advanced age groups. Falls are the leading cause of accidental death in the elderly, particularly in the 3 months after a fall (Department of Health, UK, 2006).

In the United States of America a similar trend has emerged with nearly identical percentages at 65 and 80 years, with 53% of older adults having had fall-related hip fractures, experiencing another fall within 6 months. Interestingly, about 75% of falls are in or close to the home and on a consistent level (as opposed to on stairs, inclines or declines). In excess of $30 billion is spent annually on healthcare related falls in the USA, with an average per-fall injury cost of $19,440, excluding physician's services. The Elder Fall Prevention Act 2003 aimed to educate the public, expand services and research best practices, however, falls and costs of falls have steadily increased year on year.

Typically, injuries occur at the ankle, hip, femur, knee and wrist as a consequence of a slip or fall. There are a number of individual risk factors including poor bone density, predisposition to falls and poor self protection. Key risk factors are: older age, gender (particularly females), low body weight, previous falls, alcohol abuse, diabetes, cognitive impairment, poor vision, gait disorders, inappropriate footwear and environmental factors.

It is clear that falls can occur for a wide variety of reasons and numerous combinations of the above. It is also clear that improving balance, building strength and core stability, in all age groups, reduces the risk of falling, (Skelton, 2001; Melzer et al, 2004; Ozcan et al, 2005).

Poor balance increases the possibility of falls in older people (Anderson, 2008) and frequency of injury is related to relative stability.

Research in this area is important from economic, health, mortality and quality of life perspectives. Whilst the causes of falls in the elderly are multi-factorial, increasing strength and improving balance can be achieved well into the 90's. Reducing the potential to fall improves quality of life, sleep, independence, confidence and a sense of well being.

Strength and static balance control in the elderly is important (Jacobson et al, 2010) and even with short intervention periods, improvements in balance and stability are well documented. The majority of research on falls is in the 65+ age group as there are greater economic, physical, mental and social implications in this group. Risks increase with reduced mobility and frequent, prolonged periods in one position, as in a bed or chair, for instance. Conversely, general well being can be greatly enhanced by improving balance and stability with quite simple but regular exercise (Wallmann, 2001).

There are many programmes that look at improving balance, such as The Balance Error Scoring System, the Otago Exercise Programme and the Get Up and Go Programme. The Otago Programme looked at simple methods of increasing balance through strength exercises done on a frequent basis. This includes basic every day movements in normal populations. Hurley et al (1998) looked at quadriceps function, proprioceptive acuity and functional performance in healthy young, middle aged and elderly subjects and concluded that age related deterioration in sensorimotor function of muscle may contribute to the increased fear and frequency of falls in elderly subjects, thereby decreasing independence.

Quadriceps strength and postural stability both decline with age, resulting in impaired performance in daily living. There is, therefore, a logic which suggests that the earlier that action is taken in middle age to reduce any decline, the better. Since most research on balance and stability has focused on the 65+ age group, little has been undertaken in younger normative populations. It is accepted that balance and stability generally decline with age but at what age should we begin to consider balance as an issue in order to test and include preventative measures for those whose balance and stability may be declining at an earlier age?

This research looks at the 40+ age group with a view to testing balance pre and post intervention with moderate resistance exercise.

AIMS AND OBJECTIVES

The aim of this study was to examine the effects of moderate intensity resistance exercise on strength, balance and stability in adult subjects over the age of 40.

The objectives were firstly, to assess whether self-selected, moderate resistance exercise would result in significant strength gains in upper and lower body musculature.

Secondly, to determine whether this strength intervention would lead to significant improvements in balance scores using the Balance Error Scoring System (BESS).

METHODS

Participants

Five male (50.00 ± 6.86 years, 175.80 ± 4.15 cm, 76.20 ± 9.42 kg) and ten female (55.30 ± 5.49 years, 165.00 ± 4.97 cm, 69.70 ± 12.70 kg) subjects volunteered and gave written consent to take part in this study. Subjects' ages ranged between 41 and 62 years with a mean age of 53.53 (± 6.28). Experience with exercise varied from 0 to 10 years and only 2 were familiar with resistance training.

Details were provided about the purpose, activities and expectations and all participants were informed that they were free to leave the project at any time. A PAR-Q health questionnaire was also completed by each participant.

The study was approved by the Ethics Committee of Coventry University, West Midlands, United Kingdom.

Participants were excluded if they a) presented at any exercise session with a resting blood pressure in excess of 140/90 mmHg or whose resting heart rate (RHR) was greater than 90 beats per minute (BPM); b) used medication that influenced cardiovascular responses or any other substance that may have affected individual performance, including anti-inflammatory agents and herbal supplements; or c) had muscle, bone or joint impairments that could limit the execution of the exercises.

Managing exercise sessions for an ageing population requires careful monitoring of heart rate and blood pressure responses to workloads. According to Sidney and Shephard (1978), elderly subjects who train once per week should be limited to heart rates between 120 and 130 bpm. Panton et al (1995), expressed this limitation as a percentage of maximum heart rate (using 220 – age to establish maximum), and recommended target rates of 40%, 60%, and 80%.

Based on these criteria, subjects were monitored during their exercise sessions, and the workloads were adjusted to keep exercise heart rates at or below 130 bpm.

Resting BP and HR were also measured before and after each session to ensure safe practice and that they were within the acceptable limits of ≤140/90 mmHg and ≤ 90 BPM.

The characteristics of the participants are shown in Table 1.

Table 1. Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Participants	15				
Experience (Years)	15	0	10	4.80	4.06
Age	15	41	62	53.53	6.29
Height (cm)	15	158	179	168.60	6.97
Weight (kg)	15	48	90	71.87	11.79
Valid N (listwise)	15				

Experimental Protocol

Participants reported for their first session to undergo balance testing, and for familiarisation with the equipment and the types of exercises that they were expected to perform.

No dietary modifications were required and normal day-to-day activity was followed. All sessions and testing were carried out in the Coventry University Sports Centre (UK) and basic health and safety procedures and protocols were observed.

Subjects were advised that they may experience some soreness and or stiffness due to the nature of the exercises being performed, probably for the first time, and were advised that this would subside after a few days. All participants undertook the intervention and testing in isolation and were not influenced by each other or any external source in any phase of the protocol.

Balance Testing

Balance testing was administered during the first and last treatment sessions, using the Balance Error Scoring System (BESS), developed by researchers at the University of North Carolina, Chapel Hill, NC, USA.

Since repeat applications of the BESS has been associated with significant practice effects (Valovich et al, 2003), BESS testing was limited to only pre- and post-intervention sessions. During these sessions an average of 3 BESS tests was calculated in order to give a stable measure of balance (Broglio et al, 2009).

The BESS exam consists of three 20-second assessments, administered on a flat solid surface and a cushioned foam pad, for a total of six tests. As seen in figure 1, subjects were instructed to stand with both feet together, on one foot, or in a tandem stance (dominant foot forward), all with their eyes closed and hands on their hips. The subjects were required to remove their shoes, but socks could be worn, if preferred.

Figure 1. Balance Error Scoring System Test Positions

Each of the test trials was scored by totalling the number of errors, or deviations from the established posture. An error was noted if the subject removed their hands from their iliac crests; opened their eyes; stepped, stumbled or fell; abducted or flexed their hip beyond 30 degrees; lifted their heel or forefoot off the testing surface; or remained out of the testing position for longer than 5 seconds.

One point was assigned to each error. When multiple errors occurred simultaneously, a single error point was given. A maximum of 10 error points were allowed per surface condition. Participants who were unable to maintain the testing posture for a minimum of 5 seconds were given the maximum error score of 10 for that testing condition. Each surface condition, therefore, had an error limit of 30 points, with a total of 60 points for the two conditions combined.

Exercise Intervention

Exercise sessions were designed to provide a moderate and manageable training stimulus, appropriate for this age group, while allowing for a progressive application of loads. Each intervention session consisted of three resistance exercises using the Cybex Bravo functional trainer, the Cybex Bravo Lift, and the Cybex Eagle Leg Press.

The first exercise was a standing cable chest press on the Cybex Bravo functional trainer. Subjects stood, facing away from the weight stacks, approximately three feet from the centre of the machine. A stabilizing pad, located on the end of a horizontal support bar, was placed at the subjects' lower back, or at the proximal end of their leg. This method of stabilization was reported by Peckinpaugh and Guzell (2009) who concluded that a fully or partially supported standing chest press enabled more weight to be lifted when compared to having no postural support.

The pulley apparatus was set at shoulder height for each participant, who then pressed a bar, connected to the cables at each end, from their chest to a position at which their arms were extended in front of them. Whilst pressing the bar, subjects performed alternating leg raises, flexing their hips and knees to 90 degrees (figures 2 and 3). This action was made possible by the placement of the support pad.

Figure 2. Chest press, starting position

Figure 3. Chest press, ending position

A maximum of 6 sets of 5 – 8 repetitions was completed, whilst varying the hand width in order to offset loads and introduce variable conditions of rotational stability.

The second exercise was a deadlift on the Cybex Bravo Lift. Subjects were positioned on the lift platform, facing away from the weight stack, while holding two grab handles located on the floor, beside the platform. Their position on the platform was such that the cables were aligned with their insteps while standing in a vertical position.

The subjects then executed a squatting motion, lowering the handles towards the floor, and then returned to a standing position, lifting the handles (figures 4 and 5).

Figure 4. Deadlift, starting position

Figure 5. Deadlift, ending position

A maximum of 5 sets of 5 repetitions was performed on this exercise.

The third exercise was a leg press on the Cybex Eagle Leg Press. Subjects self-selected a seat back angle and foot plate position to suit their comfort and reach. Beginning with their hips and knees flexed, the subjects pressed into the footplate, moving the carriage backwards, until their legs were straight in front of them (figures 6 and 7).

Five sets of 5 repetitions at a moderate weight and then at a heavier weight were completed. During the heavier sets, repetitions were performed more slowly (a cadence of 14 seconds was set for the complete movement).

Figure 6. Leg press, starting position

Figure 7. Leg press, ending position

There was a one minute break between sets within exercises, and then between exercises as well. Participants were encouraged to drink water as desired during the exercise sessions.

The three exercises were performed once each week from week 1 until week 5. Loads were increased approximately 10% per week, based on the previous week's load. When this was not achieved, the participant's previous load was applied.

Week 6 was used as a de-load week during which exercise workloads were reduced by 50%, and then, weeks 7 and 8 continued in the same manner as the first five weeks.

Statistical Analysis

The SPSS (Statistical Package for Social Sciences) PASW Statistics version 17.0 computer programme was used for data analysis to interrogate the primary data collected.

A Paired T-Test for independent observations was employed to compare pre and post BESS tests and strength measures.

There was no interaction of participants with one another or other stimuli that could influence the accuracy of data collection.

RESULTS

Strength

A statistically significant gain was found in the Chest Press ($P < 0.001$), Deadlift ($P < 0.001$), and Leg Press ($P<0.001$) strength measures (table 1). Effect size calculations confirmed a very large effect of the training program on all three strength measures (table 1).

Table 1. Average changes in strength following training protocol

	Chest Press (kg)	Deadlift (kg)	Leg Press (kg)
Pre	13.67 ± 7.12	49.40 ± 20.35	56.93 ± 22.71
Post	24.33 ± 9.83 *	80.87 ± 29.35 *	82.87 ± 23.22 *
Effect Size	1.243	1.246	1.131
* P < 0.001			

Average strength gains of 10.66 kg for the standing Chest Press (figure 8), 31.47 kg for the Deadlift (figure 9) and 25.94 kg for the Leg Press (figure 10) were recorded.

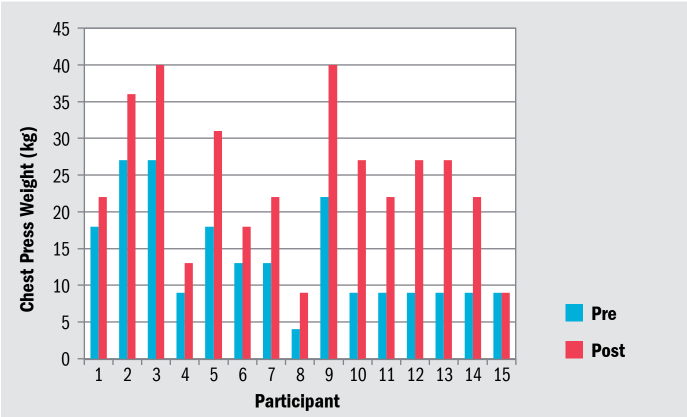

Figure 8. Increases in chest press strength for fifteen subjects following training intervention

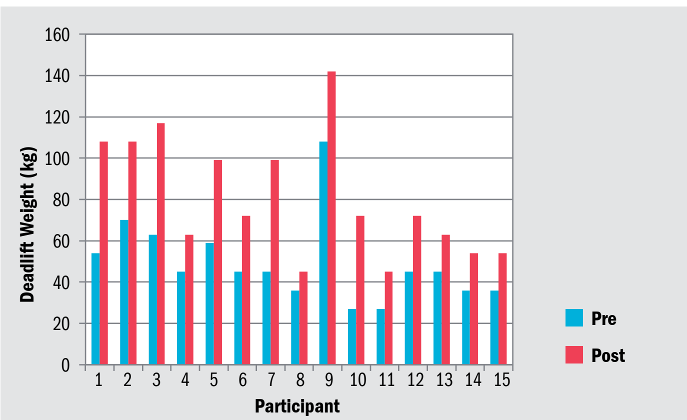

Figure 9. Increases in deadlift strength for fifteen subjects following training intervention

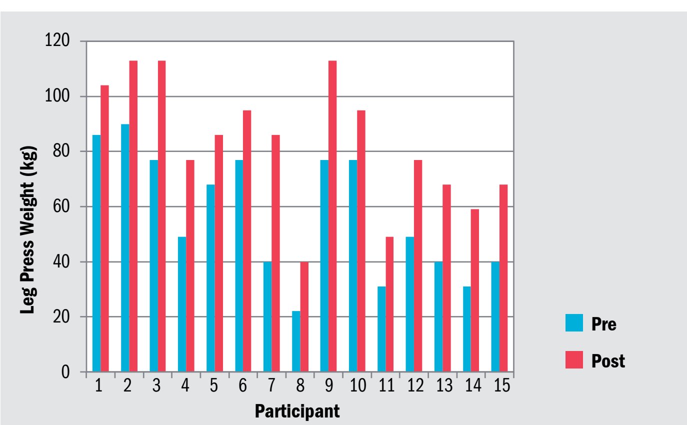

Figure 10. Increases in leg press strength for fifteen subjects following training intervention

Balance

Figure 11 shows BESS scores, pre and post intervention, for all fifteen participants. The mean pre intervention BESS test score was 38.80 (± 6.96) and the mean post intervention score was 25.53 (± 7.25).

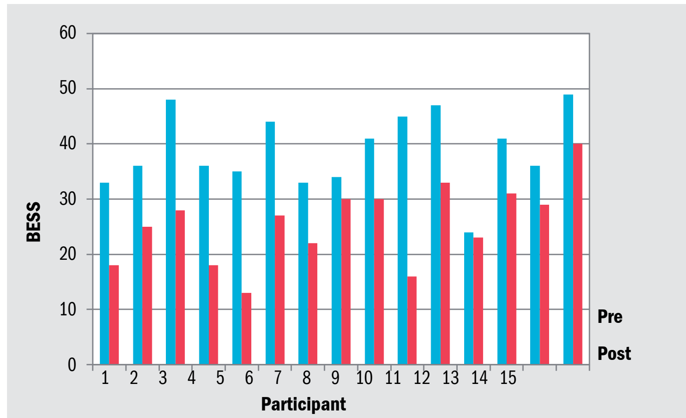

Figure 11. Balance error scoring system results for fifteen participants following training intervention

The results from the Paired T-Test indicate a significant decrease in BESS scores following the protocol (p=<0.0001) with an average improvement of 34.2%. The effect size for the difference between means was very large (d = 1.867).

DISCUSSION

Mitigating the risk of falls in ageing populations is critically important. The economic implications alone suggest that balance training interventions be given high priority.

Balance declines steadily through each decade of life. Bouillon et al (2011), for example, measured balance using the Star Excursion Balance Test, in women aged 23-39 years (N=29) and 40-54 years (N=24). The authors found that the younger group could reach 7cm farther than their older counterparts.

Similarly, Bohannon et al (1984), using a timed balance test, concluded that subjects over 60 were unable to balance on one leg, especially when their eyes were closed, for as long as younger subjects.

Chey et al (2002), looked at changes in postural stability in women aged 20-80 years (N=453) who were tested for sensory interaction and balance with their eyes open and closed. As this was one of the largest studies undertaken, its findings were particularly important as its conclusions were in line with current research suggesting that women in their 60's and 70's were more unstable than younger women.

On the other hand, strength training may be a suitable mechanism for improving balance, particularly amongst middle and advancing age groups. It has previously been determined, for instance, that strength training interventions can offset muscle weaknesses in subjects between 61 and 87 years old (Schlicht et al, 2001). The results of the current study reveal that increases in strength are accompanied by improvements in balance as well.

One of the larger questions addressed here, however, was not solely whether strength training improves strength and balance, but whether improvements could be realized at moderate training intensities. While the current fitness trends suggest that high intensity training may produce significant outcomes, the question remains as to whether people of advancing age can, or will, tolerate high intensity regimens. If not, then attempts to improve stability through these methods may be futile, especially if subjects are unable or unwilling to perform the exercises.

In this study, subjects performed just three exercises during one weekly training session. The self-selected exercise workloads were moderate, tolerable and repeatable, resulting in significant improvements in strength and balance. Thus, introducing ageing and elderly subjects to relatively low level exercise may effectively buttress the physical prerequisites of balance and stability which normally decline with age, leading to enhanced quality of life.

CONCLUSIONS

There was a significant difference ($p =< 0.001$) between pre and post intervention balance scores, with a reduction in balance errors of 34.2%. This research supports previous conclusions relating to decline in balance and stability after forty years of age; that even a short intervention can make a considerable difference for some; that improving muscle strength can aid balance and that it is possible to improve balance in subjects 40 years or older.

The stabilization system of the Cybex Bravo functional trainer made a considerable difference in this intervention. Ageing individuals unfamiliar with exercise may find it difficult to cope with traditional bench press or chest press devices. The Cybex Bravo functional trainer allows users to assume a standing posture during the pressing movement, while also providing support and comfort. Additionally, the stabilization pad provided an opportunity to establish manageable workload progressions, while simultaneously permitting leg raising exercises, thus introducing a challenge to balance at the same time.

Further research needs to be undertaken in relation to suitable interventions pre 65 years and building this into any exercise regime. Time and resources introduced at 40+ can only reduce the potential difficulties and costs later in life. There is no doubt that balance, independence and quality of life are linked and that it is always possible to improve balance and stability, in older adults, given the right intervention and the regularity of exercise.

LIMITATIONS

Whilst this intervention was once per week for eight weeks, other interventions of 3 times a week have all had positive results. The more frequent the intervention, usually, the sooner a maintenance level can be achieved. With lower numbers of participants involved it was difficult to obtain accurate data on decades from 30 to 60 years, however, a larger study that focuses on gender and age within this 40 year period would provide detailed information. Different interventions could be made and compared to see which produced the best results within a given time frame.

Similarly, accurate data on intervention period and results could also be established with frequency (how many times per week) and duration (for how many weeks would the sessions run). Likewise, balance testing could be undertaken at different times rather than just start and end of the intervention. In this way a multiple of variables could be compared and analysed.

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