Power Training: Can it Improve Functional Performance in Older Adults? A Systematic Review.

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ABSTRACT

Int J Exerc Sci 2(2): 131-151, 2009. Older adults' reduced performance in functional activities of daily living (ADL) such as gait, sit to stand or stair climbing may reflect age-related declines in muscular power more so than strength. Therefore, this review was conducted to determine if power training is effective in improving the functional ability of older adults, and if so, if it was more effective than strength training. The review was performed using Medline (PubMed), CINAHL, Sports Discus, ProQuest 5000 International and Google Scholar with the keywords "power training", "older adult" and "elder" and all derivatives. Of the 12 eligible studies identified, nine also included a strength training group. Virtually all studies reported significant increases in strength and power for the strength and power training groups. Significant improvements in functional performance were observed for the power training groups in 10 of the 12 studies and in the strength training group in four of the nine studies that also examined the effect of strength training. These results demonstrate that strength and power training can both significantly improve functional performance in older adults, and suggest that power training may be more effective than strength training in this regard. Future research in this area should involve larger sample sizes of older men and women with varying levels of pre-training strength, power and functional ability and: 1) compare the relative efficacy of strength and power training; 2) determine if the optimal training prescription differs somewhat for each functional task; and 3) examine changes in quality of life and falls rate.

KEY WORDS: activities of daily living; elders; exercise; functional ability; resistance training; review.

INTRODUCTION

The Importance of Functional Independence

Successful aging for many older adults includes the ability to live functionally independent, fully engaged lifestyles within the community. This may involve the ability to perform functional tasks or activities of daily living (ADL) such as stair climbing, walking, rising from a low chair and lifting and carrying objects with relative ease and without assistance. However many studies have shown that the aging process results in significant losses to functional ability (50, 70, 77). While this loss in functional ability may reflect many age-related changes in neuromuscular system function, it tends to be strongly associated with the onset of sarcopenia, which is defined as the significant loss of muscle mass typically seen in many older adults (13, 34).

Numerous research studies utilizing more traditional progressive resistance training approaches have focused on the development of muscular strength and increased muscle mass to slow or reverse the effects of sarcopenia in older adults. Although this type of slow to moderate-velocity resistance training can improve older adults' muscle mass, strength and high-load power (9, 23, 27, 40), this may not necessarily equate to improvements in the performance of ADL (71). Such results have lead a number of research groups to suggest that power training may be more effective in improving older adults' functional ability and reducing their falls risk than regular strength training (34, 38). Consequently, the primary aims of the current review were to determine if power training: 1) can significantly improve the functional ability of older adults in ADL such as level gait, sit to stand and stair climbing; and 2) is better than strength training in this regard.

Relationship between Muscular Strength, Power and Functional Performance in Older Adults

Alexander and colleagues (1) reported that in rising from a chair an older adult has to use a greater percentage of their knee extensor strength and power (35-87%) than a younger adult (19-49%). Such results suggest that the maintenance of strength and power by older adults is important if functional ability and independence is to be maintained. Such results suggests that the age-related decline in functional ability is associated with the loss of strength and power, and that methods that increase strength and/or power might be useful in improving the functional ability of older adults.

Strength is generally measured in Newtons (N) or kg and represents the greatest load lifted during a one repetition maximum (1RM) or the greatest force recorded in a maximum voluntary isometric contraction (MVC). By virtue of the force-velocity relationship, 1RM and MVC strength assessments are performed at a very low and zero velocities, respectively. Power is defined as the product of force (strength) and velocity (speed). The force-velocity relationship therefore indicates that power output is typically maximised with moderate loads as they allow moderate to moderately high levels of both force and velocity to be produced (18).

As high level functional performance is typically characterized by the ability to move quickly, it could be theorized that muscular power output may be of greater importance than strength to older adults. This is supported by the results of numerous studies which have shown that muscular power is more closely associated to performance in functional ADL that are essential to independent living (8, 17, 19, 25, 29, 61). Cuoco and colleagues (19) demonstrated that leg muscle power was more highly correlated to older adults' performance in ADL such as stair climbing, rising from a chair and walking than was 1RM strength. Similarly, Clemencon et al. (17) found that older adults' performance of the sit to stand, 6 m walk and stair climb was highly predicted by their muscular power and optimal velocity, where optimal velocity was defined as the velocity at which peak power occurred. Other studies have also demonstrated that decreases in muscular power are associated with an increased risk or incidence of falls (16, 72, 76). Overall, these results suggest that an improvement in the functional ability of older adults may be realized by increasing their lower body muscular power output. To maximize the effectiveness and safety of the exercise prescription it is imperative that it is based on sound physiological and biomechanical principles and is designed to counteract the primary mechanism(s) underlying the age-related changes in power and functional ability.

Physiological Changes with Aging

Aging is associated with a progressive decline in overall neuromuscular function. For example, from the age of 60 years, older adults may experience a decrease in muscular strength and power of 1.4-2.5% and ~3.5% per year, respectively (7, 30, 44, 59). The greater age-related loss of muscle power than muscle strength would appear to be a result of the definitions of each term. As power is the product of force and velocity, a small reduction in both force and velocity would result in a greater loss of power than that of force or velocity, respectively. For example, if an older adult experiences a 30% loss of both force and velocity, they only have 70% of their original strength and movement speed. This now means they now have only 49% of their original muscular power.

The age-related loss of neuromuscular function also causes a significant reduction in older adults' movement speed and force control (49, 52), although the rate of change in these abilities are less well described than for strength and power. To attenuate these age-related declines it is important to understand the mechanism(s) responsible for these changes. While the relative importance of each mechanism is not well understood, it appears that the age-related decline in muscle strength, power, velocity and force control arise from a number of similar degenerative processes affecting the muscular and neural systems (13, 24, 64).

One of the leading causes of this age-related decline in muscle function is believed to be sarcopenia, which is defined as a reduction in muscular cross sectional area (CSA) (13). Sarcopenia directly results from the atrophy or death of individual muscle fibres, particularly a reduction in the proportion, number and size of fast twitch (Type IIa and IIb) muscle fibres/motor units (26, 47). Fast-twitch, especially Type IIb muscle fibres are able to produce larger forces and contract at a higher velocity than Type I fibres (54). Thus, a reduction in the proportion, number and/or size of fast-twitch muscle fibres will substantially reduce the force potential (strength) and velocity of contraction, leading to even larger reductions in power than for strength or speed alone (35, 44, 52).

A range of neural factors also appear associated with the age-related reduction in muscle function. These may include a loss of neural drive, altered motor unit firing characteristics, increased co-activation and an inability to recruit all motor units (24, 49). Collectively, these neural changes reduce the ability of the older adult to utilize the full force- and velocity-generating capabilities of their muscular system.

While research studies continues to be performed to determine the extent to which the age-related decline in the various components of the neuromuscular system may cause the reduction in muscle function, any decline in these systems can reduce the strength, power, speed and force control of older adults. Such changes in muscular function therefore have the potential to reduce the functional ability of older adults.

Functional Ability Performance Changes with Aging

The ability to perform a range of functional activities such as walking, stair climbing and rising from a chair (sit to stand) has been shown to decline with increased age (50, 70, 77). As these activities are fundamental to living independently, any loss of ability in these tasks can severely affect the independence and quality of life of the older adult.

A reduction in the ability to perform these functional tasks may be initially observed as an increase in the time taken to complete the task and/or a change in the movement patterns and technique. For example, when rising from a chair, older adults with reduced muscle power compensate with greater flexion of the trunk to move the center of mass (CoM) forward (46). This allows them to generate increased horizontal momentum and reduces the torque (moment) that the knee extensors need to produce to stand upright (46). While this may allow the older adult to rise from the chair, this sit to stand movement is significantly slower than that observed in young adults and may place the older adult at greater risk of falling forwards due to their increased anterior velocity. The manner in which older adults walk and climb stairs may also be compromised leading to an increased risk of falls (77). Their gait is often characterized by a reduction in the support moment (sum of ankle, knee and hip moments), decreased stride length and an increase in ground contact time, all changes that appear related to a general loss of postural stability (53, 76). Other gait-related changes that are associated with an increased falls risk include increased stride to stride fluctuations (53) as well as a reduction in toe clearance during the swing phase of level walking and stair climbing (53, 76).

Irrespective of the manner in which these functional tasks are performed, a small increase in the time to perform these activities may not be a big issue for many older adults. However, a larger increase in the time to perform such functional tasks may mean that these activities are done less frequently or only when assistance is available. This reduction in the level of physical activity may accelerate the sarcopenic process resulting in a greater loss of muscle mass, strength and power. If this occurs, when these older adults need to perform these functional tasks, they are more likely to fatigue quickly and lose their balance, thus increasing their risk for falls and falls-related fracture. This proposed cascade of events is presented in Figure 1.

Thus, methods which are able to maintain the level of functional ability and physical activity of older adults appear very important. As muscular strength and power appear to be some of the primary determinants of functional ability and physical activity levels in older adults, resistance training protocols may be most

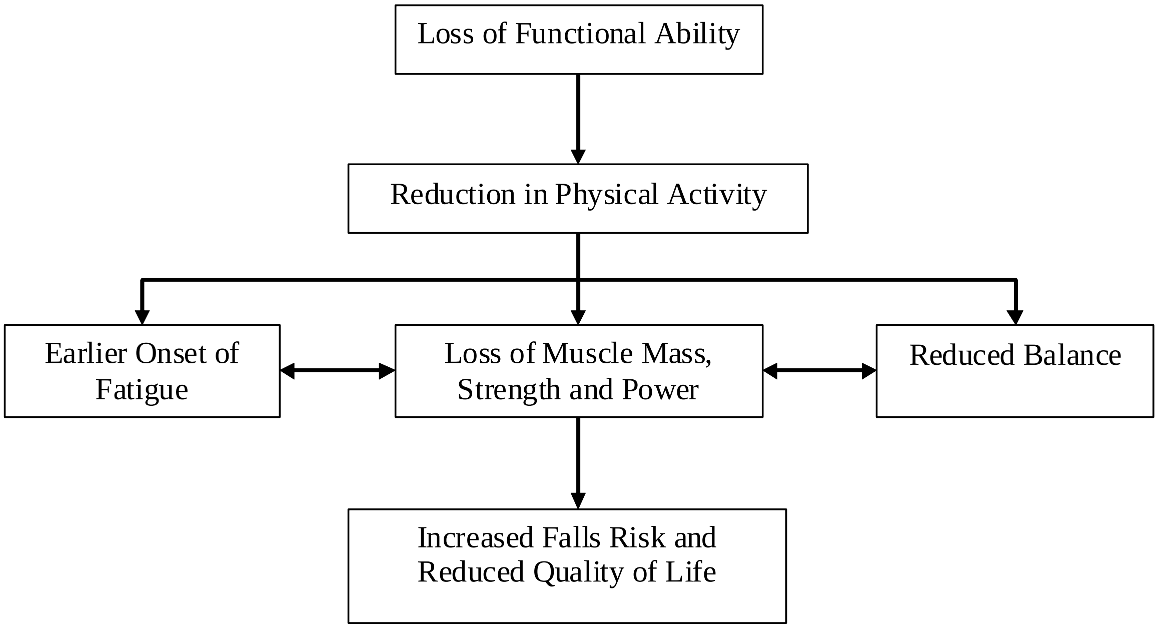

Figure 1: Proposed link between functional ability, physical activity, fatigue, muscle mass, strength, power and balance to falls risk and quality of life in older adults.

appropriate form of training. However, in order to decide what type of resistance training might be best, it is important to understand the muscular (morphological) and neural (neurological) adaptations that older adults might experience from such training as well as how to maximize the transfer of adaptation from the training to functional task(s).

Training Adaptations to Enhance Power and Functional Performance

The morphologic and neurological adaptations that the older adults may derive from power training are not widely reported in the literature. As such, most of the studies reviewed in this section are the generalized outcomes of more traditional strength training studies. While the ability of resistance training to increase older adults' strength and power is important, the potential for such training to increase movement control and functional ability is possibly even more vital (50).

Hypertrophy

As with younger adults, older adults retain the capacity for their muscles to hypertrophy in response to resistance exercise, with this apparent even in the tenth decade (30, 31, 36). Resistance training has been shown to induce hypertrophy in both type I (slow twitch) and type II (fast twitch) muscle fibres in older adults (31). With resistance training, older adults are also able to alter the expression of myosin heavy isoforms, and similar to younger adults have a decrease in the expression of type IIb fibres (IIx) and an increased expression of type IIa fibres with training (6). Interestingly, older adults may also have a tendency to increase the type I myosin heavy chains with regular strength-based resistance training, a finding dissimilar to that of younger adults (6). As the force potential and velocity of contraction is highest in Type IIb and lowest in Type I fibres (54), these changes in the myosin heavy chains for older adults would not appear to be optimal for maximising the power response to training. While it is currently unknown whether high-velocity power training may alter this response in older adults' myosin isoforms, it does raise the question about whether traditional strength training is the optimal training strategy to increase older adults' muscular power and functional performance.

Neural Adaptations

As with younger adults, older adults exhibit strength gains early on in resistance training programmes that occur in conjunction with no significant muscular hypertrophy (62). These increases in strength are therefore likely to arise from a range of neural adaptations. Such adaptations may include decreased antagonist co-activation, improved motor unit firing properties and increased neural drive to the agonist muscles (14, 33, 51, 64). It has therefore been postulated that the ability of resistance training to improve older adults' performance of functional tasks is more related to the neural than morphological adaptations (7, 74).

Transfer of Adaptations to Functional Performance

The best way to maximize the resistance training adaptations so to improve the performance of functional tasks in older adults is still not completely understood (7, 50). While a number of resistance training programs have been demonstrated to improve older adults' functional ability in a variety of gait and sit to stand tasks, these improvements are not normally as large as that of strength and power (9, 12, 39, 43, 63). Perhaps the extent to which resistance training will benefit the performance of everyday functional tasks by older adult is determined by the specificity of the exercise program, whereby an increase in performance is greatest for the ADL that are most similar to the training exercises (7, 37, 50).

REVIEW OF LITERATURE

Methodologies

A search of Medline (PubMed), CINAHL, Sports Discus, ProQuest 5000 International and Google Scholar was conducted using the keywords "power training", "older adult" and "elder" and all derivatives and all of their derivatives. Additional searches were performed using the "Related Articles" option in PubMed, the "Cited By" function in Google Scholar and perusing the reference lists of articles found in the initial searches. To be included in this review, the studies had to have: 1) included a high-velocity power training group who trained for at least eight weeks; 2) involved apparently healthy older adults (> 60 years old) who as a group were not all diagnosed with the same medical conditions e.g. stroke, osteoporosis etc; 3) been published in peer-reviewed journals; and 4) examined changes in functional performance in ADL such as gait and sit to stand tasks. Due to the relative lack of studies that met these criteria, no restriction was applied on the year in which the article was published.

Table 1: Summary of studies that investigated the effect of high-velocity power training on the strength, power and functional ADL performance of older adults.

Study	Sample	Exercise	Frequency & Duration	Load	Sets & Repetitions	Change in Performance (%)		
						Strength	Power	ADL
Bean et al. (9)	11 POW ♀77 ± 6 yr	Weight vest + machine RT	3 / wk 12 wks	> 2% BW	3 x 10	NA	+12-36*	+16-44*
	10 STR ♀79 ± 8 yr	Chair-based RT		BW	3 x 10	NA	+4-14	+9-29*
Bottaro et al. (10)	11 POW ♂67 ± 6 yr	Machine RT	2 / wk	60% 1RM	3 x 8-10	+27-28*	+31-37*	+15-43*
	9 STR ♂66 ± 5 yr		12 wks	60% 1RM	3 x 8-10	+25-27*	+7-13*	+1-6
Earles et al. (23)	18 POW ♀♂77 ± 5 yr	Weight vest free-weight + machine RT	3 / wk 12 wks	4-12% BW > 50% 1RM	3 x 10	+22*	+22-150*	+10
	22 WALK ♀♂78 ± 5 yr		6 / wk 12 wks	BW	1 x 30 min	+12	-9	-10
Henwood et	19 POW ♀♂71 ± 1 yr	Machine +	2 / wk	45-75% 1RM	3 x 8	+51*	+51*	+4-13*

al. (39)	19 STR ♀♂70 ± 1 yr	free-weight	24 wks	75% 1RM	3 x 8	+48*	+34*	+4-11
	15 CON ♀♂69 ± 1 yr	RT			3 x 8	+1	-3	-6 to +3
Henwood &	15 POW ♀♂70 ± 7 yr	Machine-	2 / wk	35-75% 1RM	3 x 8	+30-43*	+17-30*	+7-10*
Taaffe (40)	10 CON ♀♂71 ± 6 yr	based RT	8 wks			+5-8	+2	-9 to -3
Henwood &	23 POW ♀♂71 ± 5 yr	Machine +	2 / wk	45-75% 1RM	3 x 8-10	+22*	+8	+3-12*
Taaffe (41)	23 STR ♀♂70 ± 5 yr	free-weight	8 wks	75% 1RM	3 x 8	+22*	+4	+1-20*
	15 MIX ♀♂69 ± 4 yr	RT		45-75% 1RM	3 x 8-10	+26*	+2	+3-16*
	22 CON ♀♂69 ± 4 yr					-2	-2	-5 to +8
Henwood &	15 POW ♀♂72 ± 4 yr	Machine +	2 / wk	45-75% 1RM	3 x 8	+21*	+26*	+0-8
Taaffe (42)	12 STR ♀♂69 ± 4 yr	free-weight	12 wks	75% 1RM	3 x 8	+21*	+25*	-9 to
		RT						+10
Hruda et al.	18 POW ♀♂85 ± 5 yr	Free weight	3 / wk	BW	> 1 x 4-8	+25*	+60*	+31-66*
(43)	7 CON ♀♂81 ± 5 yr	RT +	10 wks			-18	-4	-3 to +1
		Therabands						
Marsh et al.	12 POW ♀♂77 ± 6 yr	Machine +	3 / wk	70% 1RM	3 x 8-10	+20-22*	+34-41*	+27*
(55)	11 STR ♀♂75 ± 5 yr	free-weight	12 wks	70% 1RM		+19-25*	+19-22*	+5
	13 CON ♀♂74 ± 5 yr	RT				+2-9	-1 to +14	+2

Miszko et al.	11 POW ♀♂72 ± 7 yr	Machine-	3 / wk	40% 1RM	3 x 6-8	+13-16*	+8	+21*
(60)	13 STR ♀♂73 ± 5 yr	based RT	16 wks	50-80% 1RM		+14-23*	+12	0
	15 CON ♀♂72 ± 7 yr					-1 to +5	-6	0
Sayers et al.	15 POW ♀♂73 ± 1 yr	Machine-	3 / wk	70% 1RM	3 x 8	NA	+97%*	0-13*
(68)	15 STR ♀♂72 ± 1 yr	based RT	16 wks	70% 1RM	3 x 8	NA	+45%*	0-10*
Seynnes et al.	6 POW ♀♂81 ± 2 yr	Machine-	3 / wk	40% 1RM	3 x 8	+37*	+11*	+8-23*
(69)	8 STR ♀♂83 ± 3 yr	based RT	10 wks	80% 1RM		+57*	+19*	+27-28*
	8 CON ♀♂81 ± 2 yr					0	-13	-5 to +3

POW = power training, WALK = walking, STR = strength training, MIX = mixed (power + strength) training; CON = control group, yr = year, RT = resistance training, wk = week, BW = bodyweight, 1RM = one repetition maximum, min = minutes, NA = not assessed, * = significant improvement ($p < 0.05$).

The studies reviewed in Table 1 present an overview of the relatively small number (12) of studies that had investigated the effect of high-velocity power training on the ADL functional ability as well as the strength and/or power capacity of older adults. It should be noted that our initial search found a number of other studies that examined the benefits of power training for older adults. While these studies reported significant increases in the strength, power, balance and quality of life of these older adults (15, 20, 21, 28, 48, 63, 66), they did not assess changes in functional ability. As such, they were unable to be included in this review.
The scientific rigour of the 12 eligible studies was generally quiet strong. The majority of training studies reviewed were randomized controlled trials involving at least 10 subjects in each group. Seven of the 12 studies employed a non-active control group. Nine of the 12 studies had a strength training as well as power training group, while Earles et al. (23) compared the benefits of walking and power training.

The older adults in these studies typically had a mean age of more than 70 years and no recent resistance training experience. The exception to this was Henwood & Taaffe (42) whose subjects were quite different to those in the other studies. Their 27 subjects were a subset of the 53 subjects who had completed a 24 week training program (39) and had then undergone 24 weeks of detraining prior to performing the 12 week re-training phase. Most studies utilized healthy older adults, although in four studies the subject group tended towards being de-conditioned and frail (43, 55, 60, 69). Although the 20 subjects in Bottaro et al. (10) were all male, it was apparent that more older females participated in these studies than older men.

The power training protocols used in these studies generally consisted of traditional resistance training exercises that were adapted via an explosive concentric phase. The exceptions were three studies that used many functional exercises in which additional resistance was provided by Thera-bands (43) or weighted vests (9, 23). While there were some variations in intervention length (8-24 weeks), frequency (2-3 times per week), loads (35-75% 1RM), sets (1-3) and repetitions (4-10) between the power training studies, these exercise prescriptions (and that for the strength training groups) were similar to published recommendations for older adults (2, 26).

Functional performance was typically assessed by the time required to complete a variety of gait and mobility tasks such as walking a set distance (e.g. 6 m) on level ground, sit to stand and stair climbing. Many of the studies assessed changes in at least two of these three broad categories of functional ability tests. The focus of these studies on utilizing lower body power training methods to improve functional ability in these ADL tasks reflects two factors. These are: 1) the significant role that walking, stair climbing and rising from a chair play in maintaining independence and quality of life in older adults; and 2) how a certain level of lower body muscular power is required for independent performance of these ADL (8, 19).

Although the focus of this review was on the changes in functional ability, the majority of these studies also assessed changes in strength and power. A range of isoinertial (isotonic) and isokinetic tests were used in this regard, with the leg press and knee extension the two most commonly used exercises. Isoinertial strength was generally assessed using 1RMs while isokinetic strength was determined by peak torque. Power was assessed by a variety of methods in these papers, although always expressed in the SI units of power (Watts – W). As with muscular strength, a range of isoinertial and isokinetic tests were used to assess changes in power. Isoinertial power assessments were most commonly performed on traditional strength exercises including the leg press (9, 10, 23, 39, 40, 42, 55), although some studies also reported stair climb (41, 69) and 30 second cycling power (60). Isoinertial power was generally calculated by multiplying force (obtained by a force transducer) and velocity (obtained by the derivative of the displacement signal collected from a potentiometer). Isokinetic testing generally was done with the knee extension at velocities ranging from 60-180^{o}.s^{-1} (43, 68). Regardless of the method which power was assessed, both mean and peak power values were often reported in these studies.

Results

Muscular strength and power were found to be significantly increased following virtually all of the resistance training programs. This was observed regardless of whether the exercises were performed with a strength or power focus or how strength and power were assessed. Such a result was consistent with previous reviews on the effects of resistance training for older adults (26, 38). However, it was most interesting to compare the magnitude of these changes in strength and power for both groups. With respect to changes in strength, it was apparent that the power (13-51%) and strength (14-57%) training groups experienced very similar increases. In contrast, the changes in power were substantially greater in the power (8-150%) than the strength (4-45%) training groups. Based on these results and the finding of previous research involving older adults whereby power is more highly correlated to functional ability than strength (8, 19, 25, 29, 61), it would appear quite likely that power training has greater potential to improve functional performance in older adults than strength training.

Even though a relatively wide variety of ADL tests e.g. gait, star climbing and sit to stand speed were used to assess the effectiveness of these training programs, 10 of the 12 power training groups showed significant improvements (10-66%) in measures of functional performance. As these studies involved a mixture of free weights, machine and weighted vest exercises, lasted for periods of between 8-24 weeks and were somewhat varied in the numbers of sets and repetitions, it suggests that a range of power training prescriptions may increase the functional ability of older adults. Interestingly, the two power training studies that did not report a significant increase in functional ability for the power training groups (23, 42) involved similar exercise prescriptions to that used by the ten successful studies. On further inspection of these two studies, it would appear that the lack of change in functional performance reflected their high pre-training levels of functional ability of the older adults in these studies. Specifically, the subjects in these studies were able to walk 400 m in ~4 minutes, had a 3-6 m habitual gait speed of 1.3-1.5 $m.s^{-1}$ and were able to complete five sit to stands in less than 12 s (23, 42).

In comparison, four of the nine strength training groups (9, 41, 68, 69) reported significant improvements (9-29%) in some tests of functional performance. Within-study comparisons revealed that the improvements in functional performance for the power training group were either significantly greater (9, 10, 55, 60) or similar to the strength training group (39, 41, 42, 68, 69). While based on a relatively small sample size, such results suggest that power training may be better than strength training in improving the functional performance of older adults.

Optimal Loading to Increase Power and Functional Ability in Older Adults

While the results of the current review offer some support for the view that power training may be more effective than regular strength training in improving the functional ability of older adults, it is currently unclear what constitutes the optimal exercise prescription for increasing power and ultimately functional performance in older adults. For example, de Vos and colleagues (20) demonstrated that explosive resistance training at light (20%), moderate (50%), and high (80%) intensities all produced similar improvements in peak power or rate of force development in healthy older adults. Somewhat similar results were observed by Fielding et al. (28) who found that the changes in leg press power across a wide spectrum of loads was greater in the group who performed their exercises as fast as possible in the concentric phase. Unfortunately neither of these studies examined changes in functional ability, so the relationship between changes in power across a spectrum of loads and functional ability in older adults are still unknown.

These inconsistencies reflect the findings of the research on the optimal load for power development in younger adults, whereby heavy, slower training and lighter, faster training have all been shown to improve muscular power (18, 37). It is possible that the inconsistencies in the optimal load for power and functional performance development in older adults reflect two main factors. The first concerns the subjects in these studies, as frailer older adults (with large deficits in muscular strength, power and functional ability) are likely to improve their muscular power and functional performance by merely getting stronger (27, 69). Another possibility is that each of the various functional tasks has specific force-power-velocity requirements. For example, due to the greater vertical CoM displacement during sit to stand and stair climbing than level walking, the two former tasks are likely to require the production of higher levels of force at lower velocities than level walking. This view is at least partially supported by the results of a number of studies. For example, Cuoco et al. (19) reported that while lower limb muscular power was significantly more highly correlated to stair climb, sit to stand and gait speed than 1RM strength, the load at which these relationship was maximized differed between the tasks. Similarly, Clemencon et al. (17) reported that the correlation between functional ability to power and optimal velocity also differed as a function of the specific functional task. On this basis, power training programs that focus on increasing high-load power output (i.e. utilize explosive contractions at higher %1RM) may preferentially improve higher force, lower velocity activities such as the sit to stand and stair climb, while those that use lower %1RM loads may improve lower force, higher velocity activities such as habitual gait speed. If these contentions can be supported by further longitudinal research, it suggests that each functional task may require somewhat specific loading. If this is the case, the exercise prescription will need to match the force and velocity characteristics of the training exercises to the demands of specific functional tasks (37).

PRACTICAL APPLICATION

Power Training Recommendations for Older Adults

Based on the methods used in many of these studies, it is recommended that power training for older adults should be preceded by a conditioning phase in which muscular strength and endurance as well as technique and confidence is emphasized. This preparatory phase should last at least two weeks, include 2-3 sessions per week and involve 1-2 sets of 8-12 repetitions per exercise with moderately light (40%-70% 1RM) loads. Similar guidelines in terms of frequency should be applied to the power training phase, although even once-weekly training has been shown to be effective in older adults (73). Based on the results of the current review, a variety of loads (i.e. 35-75% 1RM) may be effectively used in the power phase, as long as the intention is to maximize the velocity of the concentric phase. The number of sets performed per exercise should be 1-3. Although this review demonstrated that 6–10 repetitions per set resulted in significant improvements in the power and functional ability of older adults, a smaller number of repetitions per set might be advisable (5). According to Baker and Newton (5), power output during explosive exercises is maximized on the second or third repetition, maintained until the fifth repetition and then significantly reduced by the sixth repetition. Therefore, a reduction in repetitions from 6-10 to 3-5 per set might be more appropriate for the older adults' power training as it might allow the maintenance of greater velocity of movement and power outputs. Rest intervals between sets and exercises should be between 2–3 minutes in the early phases of power training but may be reduced to 1-2 minutes with increased training experience particularly if the repetitions per set are reduced (2). During the concentric phase of power training, the movement should be performed as fast as possible (<1 s), with the eccentric taking 2–3 s (28, 39, 60).

Safe Performance of Power Training for Older Adults

Only a relatively small number of the reviewed studies assessing the benefits of power training for older adults have reported data on any training and testing injuries. Seynnes et al. (69) reported no injuries in training or testing for 30 frail older adults who performed 10 weeks of either power or strength training. Henwood and Taaffe (40) also showed that 15 healthy older adults with no functional limitations completed eight weeks of lower- and upper-body power training safely and with no detrimental effects. While further research is most definitely warranted, it would appear that if the exercise prescription is based on appropriate guidelines (2) and progressed gradually, that older adults with no specific exclusion criteria can safely perform a moderate amount of power training 1-2 times a week. Nevertheless, it has been suggested that there is still some risk of injury to older adults when performing longer periods of power training with standard weight training equipment as the continual acceleration and deceleration of load imposes greater inertial forces on their bodies (32, 68). There may also been some concerns expressed with older adults performing ballistic exercises such as squat jumps, an exercise commonly performed by younger adults wishing to improve their lower body muscular power (4, 56). However, squat jumps have either been a part of older adults training programs or used as an outcome measure in a number of studies involving older adults (11, 60, 65). While there would appear to be some credence to these concerns, there is a need for longitudinal studies to examine the true danger of such training and to inform evidence-based recommendations for safe power training in older adults (38). A number of potential power training modalities will now be described.

Alternative Methods of Power Resistance Training for Older Adults

Although most of the power studies reviewed involved the use of regular free-weight and machine exercises at a high velocity, a range of other training modalities performed at a high velocity may be useful and safe power training options for older adults. The effects of these training modalities on the power output and functional abilities will be described where known, and the possible advantages and disadvantages briefly discussed.

Weighted Vests

Two of the power studies in this review utilized weighted vests as a form of resistance. When using these vests, the exercisers performed a series of ADL tasks such as walking, chair stands, toe raises, step ups and lunges, thus maximizing the potential for the training to transfer to the functional tasks (7, 37). The efficacy of this approach is currently equivocal with significant improvements (9) and no significant change (23) in functional performance both reported. The main disadvantages of this approach is that due to increasing the height of the CoM, the older adult needs to be a little cautious about the possibility of falls when performing weighted stair climbing and other ambulation exercises. Further, as the vests can only add a certain degree of additional mass to the exerciser, they may not offer sufficient loading for certain older adults when performing exercises such as the squat or sit to stand.

Air Driven Pneumatic Equipment

Air driven equipment that uses pressure rather than a weight mass to provide resistance minimizes the inertial forces experienced with traditional weight training equipment at the end of the concentric lifting phase. Research indicates that such training can significantly improve strength, power and functional performance in older adults (32, 60, 63, 68). Further, this equipment is gaining in popularity for the assessment of muscular power in older adults. Pneumatic machines are easily adjusted with the turn of a dial to change load settings and there is no need for the older adult to continually load and unload the bar. The disadvantage of this form of training is that it is generally performed in a seated or lying position and involves pushing or pulling a load that follows a pre-determined path. Thus, the older adults' balance, stability and proprioception are not too challenged in such exercise, possibly reducing the transfer to functional performance.

Thera-bands

Hruda and colleagues (43) found that frail older adults in nursing care who used Thera-bands effectively increased muscle power with-high velocity training of the lower body. Significant improvements in 8-foot up and go, 30 sec chair stand and 6 minute walk (31-66%) were observed. Although this was the only study to investigate the effects of elastic-resisted power training on the functional performance of older adults (43), a number of similar studies have been performed with younger athletic individuals (3, 45, 57). Based on the force-length relationship, Thera-bands impose greater resistance forces on the lifter as the length of the Thera-band increases (58). If the Thera-bands are attached to a bar when performing multi-joint exercises such as a squat, lunge, bench press or shoulder press, the older adult can attempt to accelerate the load through a fuller range of motion than with other free-weight training modalities (58, 75). This may better match the strength potential of the muscles across the entire ROM and result in greater strength and power improvements. Another possible advantage of Thera-band power training for older adults is that it due to the reduced mass of the resistance load, it will likely impose lower inertial forces on the lifter, meaning that it may be less likely to cause muscle or joint injury.

Functional Training

Functional power training focuses on ADL type activities that can be performed in almost any training environment from the home, to the gym to the local mall. Activities such as chair stands, stair climbing, step ups, lunges and load transfer tasks can easily be performed with increasing load and/or speed as muscular strength and power increase. A number of studies have shown that older adults can significantly improve their functional performance through this form of training and that such training may be more effective than strength training (9, 22, 23, 67). However, not all of these studies had these exercises performed at high velocity. As these exercises are normally done with no external support, it is also advisable that frailer older adults' progress to such exercise first by obtaining some strength, technique and confidence in more supported (seated) positions as they may be at increased risk of falls initially when performing challenging, resisted functional movements like stair climbing.

Aquatic Resistance

Brechue et al. (11) demonstrated that older adults can significantly improve many aspects of functional performance with a 12 week aquatic exercise program. Water provides a natural form of resistance to human motion and hence may be a useful environment for older adults looking to increase their muscular power. In accordance with the principle of fluid mechanics, a doubling of the movement velocity results in a four-fold increase in the resistance drag forces. This means that by merely moving rapidly through the water, the older adult may produce sufficiently high force and power outputs to gain a training effect. A variety of resistance training aids can also increase the drag forces as required with webbed gloves, flippers and floatation devices all useful. Another advantage of the water environment might be that there would be less deceleration at the end of the concentric range of motion and reduced impact forces due to the buoyant nature of the water. However, there does not appear to be any current research which has investigated the effect of a high-velocity, power-based aquatic exercise program on the functional performance of older adults.

Limitations of Review and Areas for Future Research

This review was not without its limitations and as such the reader should still regard some of these recommendations with a degree of caution. The primary limitations included the: 1) relatively small number of studies that met the inclusion criteria; 2) relatively small sample sizes and predominance of female subjects in these studies; 3) possibility of functional task-specific training requirements and adaptations; and 4) lack of assessment of upper body muscular power and functional ability, quality of life and falls rate. These issues will now be discussed in further detail.

While many studies have examined the benefits of power training for older adults, only 12 of these assessed changes in their functional ability. Given this relatively small number of eligible studies, the fact that most studies had ≤ 30 subjects in total and that these studies tended to have more female than male subjects, it is important that future investigations use larger population samples with a more equal representation of men and women to clarify outcome trends. Studies that compare the same training program on groups of older adults who differ based on their muscular power and functional ability would also be useful as they would describe how the degree of frailty may affect the training response.

Due to the somewhat limited number of eligible studies, we were unable to determine the effect of power and strength training on each of the individual functional tasks. As the physical demands of each functional task appear somewhat different (17, 19), it is unclear whether one type of training may be best to improve a variety of different functional tasks e.g. sit to stand and walking performance. Thus, future research will need to compare the effect of a variety of training modalities on several functional tasks to determine if a variety of training approaches (e.g. low- and high-load power training) is required to improve the all-round functional ability of older adults.

The development of upper body power would appear important to older adult functionality in terms of activities that involve lifting, carrying, pulling and pushing. However, none of the studies in this review examined the potential of power training to improve these aspects of functional performance of older adults. Future studies that investigate the role of upper body power development and functional performance in older adults are therefore also required. It was also a little surprising to note that no studies have so far examined the efficacy of power training to reduce the rate of falls in older adults and that only two studies have examined changes in quality of life (48, 68). As it could be argued that maintaining a high quality of life and reducing the number of serious falls are the most important outcome measures in these types of studies, we would hope that more studies in this area will include quality of life and falls rate as some of the primary outcome measures.

Conclusion

Traditional resistance training studies have until relatively recently focused on using strength-based interventions to slow the effects of sarcopenia and to aid the retention of functionally independent lives for older adults. More recent cross-sectional studies however, have shown that older adults' muscular power is a better predictor of their functional ability than muscular strength. Results of this review offer some support for this view, with 10 of 12 power groups showing significant improvements in functional ability, compared to only four of nine strength training groups. These results indicate that power training is at least as, and quite possibly more effective in improving the functional ability of older adults. These results suggest that developing a better understanding of how high-velocity, power training might enhance functional performance as well as improve quality of life and reduce falls rates in older adults is an important area for future research.

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