Impact of resistance training on sarcopenia in nursing care facilities: A pilot study

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Feature Article

Impact of resistance training on sarcopenia in nursing care facilities: A pilot study

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A B S T R A C T

The impact of progressive resistance training on sarcopenia among very old institutionalized adults was investigated. Residents of Nursing Care Facilities were included in a controlled trial of twice weekly resistance and balance exercise program for six months (Age: 85.9 ± 7.5 years, Time in care: 707.1 ± 707.5 days, N = 21 per group). Sarcopenia was measured based on the European Working Group on Sarcopenia in Older People criteria. Of the recruited 42 participants, 35.7% had sarcopenia at baseline, with prevalence increasing in the control group post-intervention (42.9%–52.4%). Following training, the exercise group experienced a significant increase in grip strength when compared to controls ($p = .02$), and a within-group decrease in body mass index and increase in grip strength ($p \leq .007$). Resistance and balance exercise has positive benefits for older adults residing in a nursing care facilities which may transfer to reduce disability and sarcopenia transition, but more work is needed to ensure improved program uptake among residents.

Introduction

Aging is a complex physiological process that can be influenced by intrinsic factors such as genetic, and extrinsic factors such as psychosocial behaviors and environment.[1] Aging is accompanied by the gradual decline in the regenerative properties of cell tissue and may result in a reduction in cognitive, motor and/or sensory function. It is well documented that skeletal muscle tissue has a slow cellular turnover rate and the effectiveness of skeletal muscle regeneration in later life is reduced.[2] The loss of lean tissue, and especially skeletal muscle mass (SMM), with increasing age has received significant research attention due to the disability, morbidity and mortality consequences to the individual.[3] The loss of muscle mass has been reported to begin as early as the fourth decade of life, continue at a rate of 1–2% per decade and decrease by approximately 30% across the lifespan. In contrast, maximal muscle strength capacity peaks around the second or third decade of life and begins a gradual 1.5% decline from the fifth decade culminating in a 50% loss across the lifespan.[4] These muscle strength and mass changes, when combined with a decreased level of activity and sedentary behavior, lead to disability and subsequently loss of independence.[5]

Sarcopenia is a syndrome characterized by a progressive loss of skeletal muscle mass and muscle function. It is associated with an increased risk for falls, fracture, disability, impairment in the ability to perform instrumental activities of daily living, hospitalization,

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Conflict of interest: The primary investigator in the present study (JH) was financially supported to collect the data used in this study and supported in-kind during her PhD study by the company whose equipment was used in the exercise intervention described within. However, all potential conflicts were discussed prior to the undertaking of this study with an understanding that outcomes could not be led by either part. Therefore, we are adamant all conflicts of interest have been disclosed and negated.

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poor quality of life and death.[6] Sarcopenia is not considered to be a "disease" state, but rather a condition of acute functional deficit, disability, co-morbidity and mortality. Without the presence of low muscle mass, sarcopenia is undetectable in the early stages, however, if left untreated sarcopenia has significant consequences and will lead to physical dysfunction.[7] The mechanisms underpinning sarcopenia are complex and multi-factorial, but are reported to include sedentary lifestyle, alteration in endocrine function (insulin, testosterone, growth hormone, insulin like growth factor-1, cortisol), loss of neuromuscular function, imbalance between muscle protein synthesis and breakdown, inadequate dietary protein intake, and genetic factors.[3,7,8] Palus et al[4] reported that based on current definitions over 3% of all adults 65 years and older would have a diagnosis of sarcopenia by 2015. Prevalence of sarcopenia is even greater among older institutionalized adults when compared to their community-dwelling counterparts, with recent studies reporting prevalence rates in persons over 80 years of age to range from 30 to 50%.[9,10] Australian data also suggests that many of these aged care residents have very poor muscular function,[11] with such physical limitations impacting in many ways on their mobility, independence and health status.[12]

To reduce the implications of sarcopenia and improve projected quality of later life outcomes for older adults, effective interventions are needed to counter the age associated loss of skeletal muscle mass and function.[13] One strategy that shows promise in the prevention and reversal of sarcopenia is exercise, in particular resistance training.[3,13] Work by our group has previously demonstrated that with long-term resistance exercise, community-dwelling older adults can significantly increase muscle strength and muscle mass, with gains transferring to improved physical performance.[14] In addition, a number of reviews supporting these benefits across varied populations of older adults, including the pre-frail and institutionalized,[7,15] have reported resistance exercise to be safe and effective with the benefits outweighing the risks.[16] However, while evidence appears strong that resistance training can directly benefit the components that determine sarcopenia, debate continues concerning its appropriateness and impact among older institutionalized individuals.

Supporting the concept of resistance training as a countermeasure to sarcopenia, Cruz-Jentoft et al[17] recently identified nutrition and exercise as evidence-based interventions. Nevertheless, of the seven exercise studies identified in their review all were considered only moderate quality, and of the four that delivered resistance training only two reported a change in muscle mass, the primary component in sarcopenia diagnosis. Given the quality of these works and that large significant changes in muscle mass have been reported previously,[7,8] more work is needed with greater consideration to dosage, treatment durations and the target age group. To this end, the aim of the present study was to pilot an investigation into the impact of resistance training on sarcopenia status in older adults residing in a nursing care facilities.

Methods

Design and recruitment

This investigation of the influence of resistance training on sarcopenia and its components employed a two-group controlled trial design of aged care residents to an exercise (EX) or usual care control (CON) group. Data are generated from a sub-study conducted within a larger falls prevention trial. A detailed account of the parent study protocol has been presented previously.[18] In brief, the parent study is a single-blind, two group, cluster randomized trial aiming to recruit 300 residents across 20 aged care facilities in New South Wales and South East Queensland (Australia). EX participants undertake 50 h of progressive resistance and balance training twice weekly over a six month period, with groups assessed before and after the intervention period for number of falls (primary variable), quality of life, functional performance (Short Physical Performance Battery), falls efficacy and cognitive wellbeing. The facility inclusion criteria was: high care and low care residents; $\geq$15 residents willing to participate; service manager consents to trial participation and staff time allocation for project tasks (i.e. approaching potential participants, assisting with supervision, etc.). For residents, the inclusion criteria were permanently residing in the facility, able to understand English and follow instructions, and able to supply informed or substitute decisions maker consent. Residents were excluded if they had terminal or unstable illness, significant advanced cognitive decline (Mini-mental State Examination $\leq$15),[19] hemiplegia preventing them from using the resistance training equipment, Parkinson's Disease, were permanently wheelchair or bed bound or had performed a balance and/or resistance training program in the past 12 months that was similar in design and dosage to the trial protocol. To promote project uptake and adherence, all facilities staff participating in bringing residents to and from trainings, and/or assessments, undertook project training seminars, and exercise and assessment sessions are grounded in evidence via lessons learnt by our group from previous nursing care deliveries.[20,21]

For this sub-study, four facilities agreed to participate and eligible residents from the parent study who did not have a pacemaker were recruited and consented into the study. This process involved residents being informed by staff about the project and given a participant information sheet to read. Interested residents were then requested to sign a consent form, following which they were contacted by the research team to schedule a baseline assessment. In addition, the resident's medical practitioner was contacted for a medical clearance to participate in the exercise program. This study had ethical clearance from the University of Queensland Human Research Ethics Committee.

For the parent study, following the baseline assessment a two facility computer-generated cluster randomization was undertaken allocating facilities to either the EX or CON group. For the sub-study, due to the EX group numbers being greater and to balance group sizes, individuals who were initially allocated to the EX group but attended no exercise sessions were re-allocated to the CON group for analysis.

Intervention

The EX facilities were provided with twice weekly progressive resistance and balance training up to 50 h over a six month period, while individuals in the control facilities continued with their usual care routine. Resistance training was by air-pneumatic equipment (HUR Health and Fitness Equipment, Australia) specifically designed for rehabilitation and commonly used in very old adults with disability and care needs. Lower- and upper-body, and the trunk exercises included: elbow and shoulder extension (dip), leg press, knee extension and flexion, hip abduction and adduction, abdominal curl and back extension. Following a reduced sets and repetitions two week conditioning period, participants were prescribed 2–3 sets per exercise at a resistance they could complete 10–15 times[22] with a perceived rate of exertion of 12–14 on the Borg Scale.[23] Balance exercises included: heel and toe raises, varied directional quick stepping, reaching, single leg standing, static balance, heel to toe walking and complex cross over stepping activities.[24] Exercise intensity was progressed for the resistance training exercises by increasing the load when participants could comfortably complete 3 sets of 10 repetitions or by increasing repetitions with the same load to 3 sets of 15 repetitions. For the balance exercises, progressions involved reducing hand support, narrowing the base of support, increasing the speed of the activity and/or introducing a cognitive dual-task challenge.[14,24] Sessions lasted approximately 1 h and were prescribed by a trained allied health professional, who also monitored group safety and offered verbal motivation. Exercise was conducted in groups of up to 10 individuals.

Measures

Data were collected at baseline and following the intervention period using a non-blinded assessment process, except for the demographic participant descriptors that were only collected at baseline. Participant descriptors were collected from facility records, except height (cm) and weight (kg) that were measured using standard practices. In addition, as a basic measure of delivery EX participation was tracked across the course of the intervention as session adherence.

Sarcopenia

Sarcopenia was measured based on the European Working Group on Sarcopenia in Older People (EWGSOP) criteria that requires the presence of both low muscle mass and low muscle function (muscle strength or physical performance).[25] Appropriate to institutional care and shown feasible for collection in this setting previously,[26] muscle mass was collected by Bioelectrical Impedance Analysis (BIA) (Maltron International Ltd, Rayleigh, UK), muscle strength by Jamar hand grip dynamometry (Sammons Preston Rolyan, Bolingbrook, IL) and physical performance by the Short Physical Performance Battery habitual walk over three meters. The cut-off point to determine; (1) low muscle mass was a skeletal muscle mass index (SMI) <8.87 kg/m^2 in men and <6.42 kg/m^2 in women, (2) low muscle strength was <30 kg in men and <20 kg in women, and (3) low physical performance was a walking speed $\leq .8$ m/s.[25] SMI was derived from the division of SMM by the individuals height in meters squared and SMM calculated from BIA Resistance (Ω) and the validated equation by Janssen et al.[27] Fat free mass (kg), percent body fat and body mass index (BMI) data were generated by BIA assessment. BIA data were collected with participant's supine on their own beds and using the standardized electrode placement protocol. Muscle strength was measured with participants seated, the dynamometer in their dominant hand, with their elbow locked at 90° and at their side. They were instructed to perform a maximal isometric contraction and the best of three trials were kept for analysis.[28] In the three meter walk, participants walked from a standing start following the command to commence. Time was converted to m/s. Participants undertook two trials and the best was used for analysis.

Statistical analysis

Participant characteristics were analyzed using a modified intention-to-treat design where those EX participants who attended zero training session were allocated to the CON group. This was employed to establish equality in group numbers.[29] Data were carried forward for all individual who were unable to attend or would not assent to the follow-up assessment. Descriptive statistics are presented as mean and standard deviation (SD). Total cohort data were generated by descriptive and frequency analysis, and baseline group (EX and CON) differences by t-test. Between groups analysis was by 2 × 2 repeated measures Analysis of Covariance (ANCOVA) and 1 × 2 repeated measures ANOVAs were employed to define within group differences. In addition, to determine if differences existed among zero attenders (0 sessions), low-attenders ($\leq$50% of sessions) and high-attenders ($>$50% of session) a one-way ANOVA and Bonferroni Post-Hoc test was undertaken. Percent change was calculated on individual data. In addition, a Chi Squared analysis was conducted for categorical data (yes/no: sarcopenia, low muscle mass, low muscle strength and low physical performance). All data were processed in SPSS version 22.0 (SPSS Inc., Chicago, IL, USA). A $p < .05$ was considered to be statistically significant.

Results

Participants

Forty five participants residing at four different nursing care facilities were enrolled into the parent study (females = 29). Three found to have pacemakers were excluded from the sub-study due to potential BIA contradictions,[30] one of whom died prior to the follow-up assessment. Data are reported on 42 participants (Age: 85.9 ± 7.5 years, Time in care: 707.1 ± 707.5 days, N = 21 per group) at baseline. Seven individuals from the parent study EX group attended 0 exercise session and were re-allocated to the CON for the analysis of this sub-study, bringing group numbers to even (EX − 28 in the parent study to 21 in the sub-study; CON − 17 in the parent study plus seven allocated to CON minus three pacemakers = 21 in the sub-study). At baseline EX were 85.7 ± 7.0 years and had been in care 643.5 ± 409.0 days (range 105–1710 days) and CON were 86.1 ± 8.2 years and had been in care 770.6 ± 922.2 days (range 6–3405 days). Five individuals who did not attend or assent to the follow-up assessment had their data carried forward from baseline for analysis (EX, N = 2) and one individual died (EX).[29] No significant between group difference were found at baseline.

Sarcopenia

At baseline, 81.0% of participants had low muscle strength, 88.1% had low physical performance and 35.7% had low muscle mass, and in turn sarcopenia. Chi squared analysis revealed no between group differences for sarcopenic status ($\chi^2 = .933$, df = 1, $p = .334$) or its components ($\chi^2 = .618$–2.043, df = 1, $p > .153$). At post-intervention, sarcopenia prevalence remained the same in the EX group and increased in the CON group (42.9%–52.4%). Sarcopenia data are given in Table 1. Chi squared analysis revealed significant group differences post-intervention for the proportion of participants with below normal muscle strength (EX = 12 v CON = 20) ($\chi^2 = 7.424$, df = 1, $p = .006$) and physical performance (EX = 15 v CON = 21) ($\chi^2 = 5.979$, df = 1, $p = .014$). No significant differences was observed in the proportion of participants with sarcopenia

Table 1
Sarcopenia status and its components in the whole cohort at baseline and by group at baseline and follow-up.

	Original cohort (N = 42)		Exercise group (N = 21)				Control group (N = 21)			
	Baseline		Baseline		Follow up[a]		Baseline		Follow up	
	N	%	N	%	N	%	N	%	N	%
Low muscle mass	15	35.7	6	28.6	8	40.0	9	42.9	11	52.4
Low muscle strength	34	81.0	16	76.2	12	60.0	18	85.7	20	95.2
Low physical performance	37	88.1	17	81.0	15	71.4	20	95.2	21	100.0
Sarcopenia	15	35.7	6	28.6	6	30.0	9	42.9	11	52.4

N = number.
[a] N = 20. One death before follow-up.

(EX = 6 v CON = 11) or below normal muscle mass (EX = 8 v CON = 11) (χ^2 = .631–2.114, df = 1, p > .146).

Body composition, muscle strength and physical performance

Between group analysis revealed a significant group by time effect for grip strength (p = .002) with EX getting stronger and CON weaker. In addition, a group effect emerged for gait speed (p = .019) indicating the exercise group had a greater walking speed at both baseline and post-assessment when compared to controls. Examination of the within group effects revealed that the EX group experienced a significant decrease in BMI and body weight (p < .044) and an increase in grip strength (p = .007) with training. In contrast, the CON group experienced no significant changes in any measured variables, although many outcomes tended to decline over the course of the study. All pre and post group data and the within group effect size for individual variables is given in Table 2.

EX adherence

Among the exercise group, training was associated with no adverse events. In relation to adherence, 52.4% of participants (n = 11) completed between 10% and 50% of the training protocol, six of whom did 25% or less, and only 28.4% of the group completed more than 75% of the protocol. No differences in age, time in care, BMI, muscle mass, muscle strength or physical performance was found between zero (0 sessions), low- (≤50% of sessions) and high-attenders (>50% of session).

Discussion

This study shows that with resistance and balance exercise older adults residing in aged care can improve their muscle strength and reduce their body fat. While the EX group had no significant increase in muscle mass or physical performance, the non-exercising controls experienced negative trends across all component variables of sarcopenia as well as an increase in group sarcopenic prevalence. In addition, the CON group were identified as having a greater number of participants with below normal muscle strength and below normal physical performance post-intervention. However, to more accurately investigate this form of intervention in the nursing care setting, attention is needed to a number of factors, with program attendance and adherence being primary among these.

Our findings revealed that the prevalence of sarcopenia, based on the EWGSOP suggested algorithm, is high (35.7%) among adults older Australians living in aged care facilities. This level of prevalence is consistent with Landi's et al[31] work among older institutionalized Italians, but not as high as that suggested by Rodriguez-Rejon et al[32] for older institutionalized Spanish (55.5%). On the later, the authors went so far as to suggest that prevalence in aged care may be even higher again given the number of participants exclude.[32] Within the aged care environment large numbers of residents are often excluded from targeted research involvement due to issues that precludes them from participation. These may include behavioral issues, comatose and palliative status, mobility and continence issue to name a few. In the present study, we excluded those with pacemaker due to a potential contraindication to BIA, as well as those not mobilizing and with a significant physical or cognitive disease status as part of the parents study exclusion. Senior et al[33] recently attempted to overcome this, excluding only those with an advance terminal status or those with behavioral issue and reported a prevalence as high as 40.2%. While the exclusion criteria issue is difficult to overcome as part of an intervention study, from this work we have demonstrated that with resistance training the progression into sarcopenia can be stifled in the aged care setting.

Our study supports previous work that has demonstrated that resistance exercise can increase muscle strength even among very old institutionalized adults.[34,35] However, and even in light of important benefits, resistance exercise continues to be underutilized as a tool in the promotion of physical health in the nursing home environment. While muscle strength and physical performance gains are consistently reported with resistance and weight bearing exercise, it would appear gains in muscle mass among the very old are less common,[22] as was observed in our study. This observation may suggest that among the very old, resistance training improves the neural and/or metabolic efficiency of muscles and muscle quality per unit mass with little impact on cross sectional area.[36] Sarcopenic status is determined primarily by having below normal muscle mass and secondarily by having below normal muscle function (muscle strength or physical performance).[25] The transition to this revised definition criteria is a product of greater understanding of that losses in muscle mass do not occur in parallel to losses in muscle strength, and that low muscle mass has a more direct association to chronic disease than declining muscle strength that is influential of increasing disability.[37] This and other studies in the nursing care setting are suggestive that a reversal of disability in later life care is not dependant on gains in muscle mass or change in sarcopenic status.[15] A plethora of works has emerged on the back of the 2010 revised sarcopenic definition, as well as a body of work seeking to explore and identify the nutritional and protein requirements of

Table 2
Within group effect sizes and between group differences for exercise and control group baseline and post-intervention data.

	Exercise group (N = 20)			Control group (N = 21)			F	p[b]
	Baseline	Follow-up	r[a]	Baseline	Follow-up	r[a]		
Height (cm)	159.1 ± 9.6	159.0 ± 10.0	.001	158.0 ± 10.0	156.9 ± 10.5	.215	3.192	.082
Weight (kg)	71.9 ± 13.6	70.4 ± 14.1	.198	69.5 ± 17.4	68.7 ± 19.3	.059	.376	.544
Body fat (%)	37.6 ± 8.3	35.8 ± 8.4	.221	35.4 ± 7.9	35.8 ± 8.1	.005	2.519	.121
Body mass index (kg/m^2)	28.5 ± 4.9	27.4 ± 4.5	.327	27.7 ± 4.2	27.5 ± 4.9	.020	2.623	.113
Skeletal muscle index (kg/m^2)	7.7 ± 2.1	7.7 ± 2.0	<.001	8.2 ± 3.1	7.7 ± 72.1	.074	1.244	.271
Lean mass (kg)	44.7 ± 10.1	44.9 ± 9.9	.007	45.3 ± 12.8	43.8 ± 11.9	.125	.024	.878
Grip strength (kg)	18.8 ± 8.1	21.0 ± 7.0	.403	17.9 ± 7.4	15.9 ± 7.9	.136	10.711	.002
Gait speed (m/s)	.62 ± .29	.66 ± .31	.002	.48 ± .17	.43 ± .21	.095	2.90	.097

Data are expressed as mean ± standard deviation.
N – number, cm – centimeter, kg – kilogram, m – meters, s – seconds.
[a] Within groups effect size calculated from Wilcoxon analysis. Strength assumption based on Cohen (.2 = small, .5 = moderate, .8 = large).
[b] Groups*time ANOVA.

institutionalized older adults. Given that disability is the determinant of care, the concept that increased muscle strength and physical performance are more realistic goals has important implications for researchers and clinicians concerned about aged care residents wellbeing.

Nevertheless, the lack of muscle mass gain may have been influenced by a number of factors including nutrition, vitamin D exposure and physical activity external to the exercise participation, none of which were tracked in the present study. Recent investigations of dietary protein supplementation suggest that higher dosages (≥1.25 g/kg/day) staggered throughout the day are advantageous for maintenance of muscle mass and gain, particularly when complimenting with weight bearing activity among older adults.[38] Also of consideration is that if participants were low in vitamin D, as is common in the nursing home setting, muscle growth may have been reduced.[39] Another consideration is that the parent study was designed to reduce falls[40] rather than increase muscle mass.[40] It is therefore possible that resistance exercise at a moderate intensity and with a focus on balance exercise is not of a high enough dosage to reverse the primary component of sarcopenia, muscle mass, but was sufficient to stimulate strength gains. This concept has been observed by our group and others previously that with training an increased learning effects and improved neural input can drive muscle strength gains without changes in muscle mass.[14,41] A final consideration is that the specificity of training to gains may have also played a role in the lack of change in physical performance, measured here by gait speed. Within the intervention, participants did exercises such as leg press and extension that may have had greater impact on alternative measures such as chair stand or timed up and go capacity, but had no transfer to mobility.[42] These are important considerations for future exercise delivery in the nursing home context.

Possibly of greatest concern from the present study was that seven of the original EX group, who volunteered and consented to participate, reneged from exercise participation following the baseline assessment and more than half of the remaining EX participants (11 of 21) attended 50% or less of the training sessions. As has been demonstrated by our group and others previously, poor levels of attendance and adherence are not uncommon in nursing home research studies.[20,35] Aware to this risk, into the parent study a number of precautionary steps and activities had been put in place. These included, targeted staff training across both the level of participant contact and of facility responsibility, the employment of evidence-based activities and delivery modified specific to the facility, open project disclosure for facility staff and participants, and the consistent presence of an allied health professional across the program delivery. It has been noted previously, embracing these principles can accentuate staff and participant ownership of the program, and promote uptake and adherence.[43] While for this sub-study it appears more needed to be done, it is worth noting that these processes have offered an improved level of participation success at other facilities recruited into the parent study.

When we look at the varied reasons for non-attendance, of the eleven participants who attended 50% or less of the sessions: two decided against exercise participation soon after the intervention commenced and dropped out of the study; one passed away during the study period; attendance was sporadic for five due to sicknesses and hospital admissions related to pre-existing conditions; and three relied heavily on facility staff to attend sessions so attended irregularly if this support was unavailable. It is reported nursing home dropout and low adherence is prevalent among older unhealthier participants.[44] In the present study, no differences were found across the zero, low (≤50%) or high (>50%) attenders. However, while we did not account for disease or other risk factors due to the pilot nature of the work, suggestive of poorer health is that nine of the 11 who were low attenders were either hospitalized, had health issues, died or were mobility dependant during the course of the intervention. Furthermore, it is not incomprehensible that of the seven who were zero attenders, even though they appreciate the benefits of participation on consent, when faced with participation felt it was beyond their capabilities or interest. This may be reflect of a range of intrinsic factors including poor postural stability, polypharmacy and poor cognition that have been shown to influence motivation to continue.[45] In refection, a broad scope of concepts were put into place to heighten treatment fidelity that potentially failed here due to low staff and facility ownership of the program. With aged care budgets tight, and therefore resource stretched, participating staff and facility may not have priorities the project at such a level as to ensure participant prompting on training days, delivery to and from training, and continued reinforcement of the value of participation.[43,46] To address this however, from a project support perspective would have require funding beyond the scope of this project.

Our study had several limitations. Participants in the present study were higher functioning residents and therefore not a true cross-section of all residents in aged care. However, given the expectation of exercise, residents competent in following directions and ambulatory were identified for inclusion based on safety and GP consent. As a pilot trial delivered as a sub-study within the parent study, limited variables were collected and the sample size was small. This goes against suggested rules of treatment fidelity, in that the study was delivered to a convenience sample with measures and outcomes set by opportunity rather than within a targeted design.[43] Nevertheless, our study reflects a number of other investigations in this setting which have had trouble with adherence and staff delivery, even in the lights of a quality methodology.[15,20] While this paper supports that training can be delivered safely, it also demonstrates that tracking nutrition, vitamin D and ensuring resident support to attend sessions are consideration for future delivery.

Despite the positive evidence, resistance training remains underutilized in institutional care as a pathway to resident health. In the present study we demonstrated that with resistance training older aged care residents may be able to stop their transition into sarcopenia, as well as increase their muscle strength and reduce their BMI. While gains in muscle mass did not occur, this is not uncommon, but as the primary component of the geriatric syndrome sarcopenia, future interventions need to address this if sarcopenic prevalence is to be reduced in this setting. As a pilot, this study demonstrates that resistance exercise is safe and beneficial for very old aged care residents, but that future deliveries need to consider staff project ownership as well as resident dietary habits, physical activity patterns and vitamin D exposure. This work adds to the positive research showing that resistance exercise has important implications for adults in residential care.

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