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ORIGINAL RESEARCH

Progressive Resistance Plus Balance Training for Older Australians Receiving In-Home Care Services: Cost-Effectiveness Analyses Alongside the Muscling Up Against Disability Stepped-Wedge Randomized Control Trial

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In this article, the authors assessed the cost-effectiveness of center-based exercise training for older Australians. The participants were recipients of in-home care services, and they completed 24 weeks of progressive resistance plus balance training. Transport was offered to all participants. A stepped-wedge randomized control trial produced pre-, post-, and follow-up outcomes and cost data, which were used to calculate incremental cost-effectiveness ratios per quality-adjusted life year gained. Analyses were conducted from a health provider perspective and from a government perspective. From a health-service provider perspective, the direct cost of program provision was $303 per person, with transport adding an additional $1,920 per person. The incremental cost–utility ratio of the program relative to usual care was $70,540 per quality-adjusted life year over 6 months, decreasing to $37,816 per quality-adjusted life year over 12 months. The findings suggest that Muscling Up Against Disability offers good value for the money within commonly accepted threshold values.

Keywords*:* cost–utility, effectiveness, exercise

Globally the population is aging, and with increasing age a decline in functional capacity and reduced ability to remain living independently is observed. In Australia, projections to the year 2050 suggest that the demand for home assistance and residential aged-care placement will more than triple (Productivity Commission, 2012). The Australian government Commonwealth Home Support Programme (CHSP) is an initiative that enables adults experiencing the early stages of functional decline to remain in their homes through access to supported services, such as domestic assistance and personal care. While the intention of this service is to facilitate continued independence, in practice, little exercise therapy is provided in this program to promote the rehabilitation of physical function (Commonwealth of Australia, 2017).

For adults receiving in-home care services through the CHSP, progressive resistance plus balance training has the potential to improve their physical function and physical capacity, as well as to promote independence (Henwood, Riek, & Taaffe, 2008; Liu & Latham, 2011). However, a majority of research continues to focus on low-intensity activities that do not employ the technique of progressive overload (Muramatsu et al., 2017; Muramatsu, Yin, & Lin, 2017; Sherrington, Tiedemann, Fairhall, Close, & Lord, 2011). Furthermore, little attention has been given to overcoming barriers to participation in exercise programs, such as access to transport, or to creating environments conducive to exercise for adults with aged-care needs. Cost-effectiveness data for any such exercise programs are scant, making it difficult for organizations to evaluate, select, and plan for the implementation of a specific intervention.

In this article, we assessed the cost-effectiveness of Muscling Up Against Disability, a 24-week progressive resistance plus balance training program delivered twice weekly, compared with usual care, in older Australians who were receiving in-home care services through the CHSP. Cost explorations included the provision of transport to and from the study site to overcome this particular barrier to participation. The cost savings attributable to decreased health care utilization were also explored in the analyses.

Methods

Muscling Up Against Disability was a stepped-wedge randomized control trial to assess the effect of a progressive resistance plus balance training exercise intervention on the physical and mental health of 245 older Australians receiving CHSP services. The study was conducted from August 2015 to August 2017 in Brisbane, Australia. Ethics approval for the study was obtained from the University of Queensland Human Research Ethics Committee (approval number #2015000879), and the study was registered with the Australian New Zealand Clinical Trials Registry (ACTRN12615001153505). Details of the study protocol have been published (Keogh et al., 2017).

Intervention Arm

The intervention was 24 weeks of twice-weekly, evidence-based progressive resistance plus balance training delivered at a community center in Brisbane, Queensland, Australia. An exercise area

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within the center was reserved specifically for this study. The program combined resistance exercises with specific balance training. The participants were supervised by accredited exercise physiologists experienced in exercise delivery for older adults with aged-care needs.

The sessions included a light 5-min warm-up, generally based around walking, followed by 45 min of machine-based resistance training and targeted balance exercises. The resistance exercises were the leg press, leg extension and flexion, leg abduction and adduction, chest press, seated row, and abdominal curl. The balance exercises were the box step, tightrope walk, and single-leg stand and calf raises. The exercise sessions concluded with a 5-min cooldown incorporating stretching. The resistance exercises were performed on air-pressure-driven, computer-integrated HUR equipment (HUR Labs Oy, Tampere, Finland).

Control Arm

The intervention effects were compared with usual care, plus healthy-living seminars. Usual care was chosen as it is the comparator of choice in pragmatic trials. The participants in the usual care group were instructed to continue with their usual activities and to not take up an exercise regime during the control period. The participants were provided with monthly healthy living sessions of approximately 1-hr duration, consisting of ~30-min educational seminars and a light morning tea. The rationale for including the seminars in the usual care was as an incentive for continued participation in the study by the control group participants.

Transport

Transport was provided to all of the participants who requested it to aid in overcoming a primary barrier to exercise attendance for older adults (Franco et al., 2015; Moschny, Platen, Klaaßen-Mielke, Trampisch, & Hinrichs, 2011). Transport was available between home and the study site for assessments, exercise sessions, and the healthy-living seminars. Transport included door-to-door participant mobility and transfer assistance from drivers. The transport times were entered as recurrent bookings in a fleet management system, ensuring that a vehicle would arrive unless the participant called to cancel transport on any given day (e.g., due to illness).

Participants

The participants were community-dwelling older adults receiving CHSP services. The participants were recruited from the membership database of a Brisbane community and senior citizens' center that offered, among a suite of other services, domestic assistance, personal care, day respite, and transport for older adults with government-supported aged-care packages. A letter was sent to a random selection of the organization's membership who was receiving in-home aged-care services.

From the membership mail out, 388 individuals returned an expression of interest in the study, and 349 were found eligible by telephone interview. These individuals were forwarded a study pack containing the participant information sheet, the consent form, health history questionnaire, and balance questionnaire; they were also scheduled to attend the exercise clinic for a baseline assessment. Of these, 104 withdrew from the study prior to the baseline assessment. The participant's doctor was forwarded a study brief, identifying the individual's intention to participate in the study and requesting that he or she contact the research manager with any concerns. Assessments were conducted in the same exercise clinic in which the training occurred. Following the baseline assessment, the participants were randomized to immediate exercise or wait-list control at a ratio of 1:2 using block randomization through a sealed envelope selection method. The project employed a modified stepped-wedge randomization to ensure that all participants were given the opportunity to benefit from the exercise intervention (see Supplementary Material 1 [available online]). The eligibility criteria were (a) 65 years and older, (b) community-dwelling, (c) with an Australian government aged-care package, (d) mobile with or without an aid, (e) able to follow instructions and commit to the study period, and (f) with no recent history of resistance exercise. The exclusion criteria were (a) requiring more than one person to assist with transfers, standing, and/or mobilizing, (b) medications and/or diseases with contraindications for exercise, (c) terminal illness or receiving palliative care, (d) an imminent move to residential care, (e) difficult behaviors, and (f) inability to obtain a doctor's consent to participate. Informed written consent was obtained from the participants prior to entering the study.

Costs

All costs are reported in 2016 Australian dollars. The cost of delivering the intervention and usual care were calculated from a health-service provider perspective. The direct costs for the intervention were calculated using the actual cost measured during the trial and including the cost of leasing equipment and personnel time to deliver the intervention. The overhead costs were estimated at 23% of the personnel costs, accounting for facility costs and administration personnel. The indirect costs were calculated for transport for those participants who elected to receive it to attend the study site. The research-related costs were excluded from the analyses, as they were not related to the delivery of the intervention and were, therefore, not relevant to this economic evaluation.

The estimates of health care utilization were derived from an Australian government health sector perspective. The participant use of health care services between the baseline and 48 weeks (intervention group) and 72 weeks (control group) was self-reported and collected using daily diaries. The participants recorded (yes or no) on a daily basis whether they visited their general practitioner, visited another medical specialist, went to the emergency department, or had an overnight hospital stay. In support of the use of daily diaries, Short et al. (2009) concluded that self-reported health care utilization could be relied upon as a proxy for financial outcome measures when the recall required is within 1 month. Health care costs for the emergency department and hospitalizations were derived from the Independent Hospital Pricing Authority's report for 2016 (Independent Hospital Pricing Authority, 2016), and the general practitioner and specialist fees were derived from the Australian Medical Association's list of service fees for 2016 (Australian Medical Association, 2016).

Outcome Measures

The primary outcome measure for the cost–utility analysis was the quality-adjusted life year (QALY). The QALY is a health state preference measure that combines the length of life and quality of life measured using a utility weight. Utility weights were calculated from the EuroQol 5-dimension 3-level generic health index (EQ-5D-3L) questionnaire using the published Australia-specific algorithm (Viney et al., 2011). The EQ-5D-3L has been shown to be sensitive to changes in the health status in older populations

(Lung et al., 2017; van Leeuwen et al., 2015). The EQ-5D-3L was administered verbally during individual assessments to the control group at the baseline, and to both groups at preexercise, postexercise, and the 24-week follow-up (see Supplementary Material 1 [available online]).

Australian tariff values (Viney et al., 2011) were applied to the EQ-5D-3L responses at each time point to provide EQ-5D-3L utility values, with the mean values subsequently compared across the groups and periods. Overall effectiveness of the intervention was assessed by calculating the QALYs gained during the intervention period using the area-under-the-curve method and adjusting for the baseline utility scores (Manca, Hawkins, & Sculpher, 2005).

The primary outcome for the cost-effectiveness analysis was the change in score on the short physical performance battery (SPPB). The SPPB was chosen as the outcome measure for the cost-effectiveness analysis, as it is a well-validated measure for assessing lower extremity physical function in older adults (Curb et al., 2006; Freire, Guerra, Alvarado, Guralnik, & Zunzunegui, 2012). The SPPB measures balance, gait, and lower body muscular strength. The summary score for the SPPB, ranging from 0 (*worst performance*) to 12 (*best performance*), indicates physical function (Guralnik et al., 1994).

Cost-Effectiveness Analysis

Cost-effectiveness during the intervention period was assessed by quantifying the incremental cost-effectiveness ratio (ICER; costs per extra QALY gained or extra point on the SPPB). Three scenarios were considered for the cost–utility and cost-effectiveness analyses. Scenarios 1 and 2 were from the perspective of the health-service provider. Scenario 1 was a 6-month time frame consistent with the active intervention period, and Scenario 2 was 12 months, including a follow-up. For the 12-month analysis, the follow-up data were available for the intervention group; however, the outcomes for the control group were only measured to 6 months, due to the stepped-wedge design. Hence, the control group's final values were estimated to 12 months, using last observation carried forward. Scenario 3 is from the perspective of the government health sector, with a 6-month time frame, and it includes health care costs.

As the cost-effectiveness analyses have a short-time horizon, the costs and health outcomes were not discounted.

Per-protocol and intention-to-treat approaches were completed for all analyses. Per-protocol analyses included complete cases only, whereas intention-to-treat analyses incorporated multiple imputation ($m = 10$) using the "mice" package (Buuren & Groothuis-Oudshoorn, 2011) in the R programming language to replace missing data. Imputation models included age, sex, health care resource utilization, Geriatric Anxiety Index (Pachana et al., 2007) scores, and Geriatric Depression Scale (Kurlowicz, 1999) scores. Uncertainty in the estimates were quantified using 10,000 bootstrap samples (with replacement) for the per-protocol analyses and 1,000 bootstrap samples (with replacement) for each of the 10 imputed data sets for the intention-to-treat analyses. Both the mean and median-based ICERs (Bang & Zhao, 2012) were calculated with scatterplots on the cost-effectiveness plane, used to illustrate the joint distribution of the cost and effectiveness outcomes.

Results

A total of 245 older adults met the eligibility criteria, were enrolled into the study, and were randomized into the immediate intervention ($n = 86$) and wait-list control ($n = 159$) groups. Of these, 215 participants (intervention = 86; control = 129) commenced and 30 participants (control = 30) did not commence the exercise program. Of those that commenced the exercise program, 168 participants (intervention = 67; control = 101) finished the program, and 47 participants (intervention 19; control = 28) did not finish the program. The participants who completed the exercise intervention attended, on average, 90% of the 48 sessions. Of the 168 participants who completed the exercise intervention, 119 continued to attend the exercise sessions at the center at least once a week during the follow-up period. Follow-up data were available for 129 participants. Further analysis is provided in the Supplementary Material 2 (available online).

The average age at the baseline assessment was 78.7 ± 6.4 years, and 79% of the participants were female. A total of 41% of the participants used aids to mobility (a walking stick or wheelie walker). The participants were predominately older females with multiple morbidities. There were no significant differences between the group who began exercise immediately and the wait-list control group in age ($p = .65$), mobility aid use ($p = 1.0$), number of medications ($p = .95$), number of morbidities ($p = .97$), or EQ-5D-3L score ($p = .28$). There was a significant difference in the SPPB score between the two groups ($p = .05$). The diaries were completed by 127 out of the 168 participants who completed the exercise intervention, and these diary entries were used to inform the health care usage costs. The reasons for noncompletion of the diaries were vision impairment, low literacy, and the burden of completing a daily diary over an extended period of time (48 weeks for those who randomized to immediate exercise and 72 weeks for those who randomized to be wait-list controls). There were no significant differences in the baseline measures of age, medications, morbidities, SPPB score, and EQ-5D-3L score between those who did and did not complete the diaries.

Outcomes

Health-related quality of life and physical function for the per-protocol and intention-to-treat analyses are presented in Table 1. There was a significant difference in the health-related quality-of-life utilities scores (derived from the EQ-5D-3L) between groups over the 24-week period; the control group declined slightly (–0.02 in the per-protocol and intention-to-treat analyses) from the baseline to preexercise compared with the combined intervention group, which improved by 0.06 and 0.05 (per-protocol and intention-to-treat analyses, respectively) from pre- to postexercise. The participants in the combined intervention group continued to significantly improve post completion of the program, with an average of 0.10 utility score improvement at follow-up, compared with the baseline.

Physical function, as demonstrated by the SPPB scores, did not vary in the control group from the baseline to preexercise (intention-to-treat analysis), whereas the combined group improved significantly from pre- to postexercise by 1.5 and 1.2 points (per-protocol and intention-to-treat analyses, respectively).

Costs

Table 2 shows the resource and health care events and costs used in the analyses. High-cost items include hospitalization ($2,024 per overnight hospitalization) and transport to and from the exercise clinic ($1,920 per person requiring transport). The delivery of the Muscling Up Against Disability program comprises a small proportion of the overall costs ($303 per person).

Table 1 Health-Related Quality of Life (EQ-5D-3L) and Physical Function (SPPB) for PP and ITT Analyses

Analysis	Baseline	24 weeks	48 weeks
EQ-5D-3L score			
Control (PP)	0.73 ± 0.16 (159)	0.71 ± 0.19 (128)	
Control (ITT)	0.73 ± 0.16 (159)	0.71 ± 0.19 (159)	
Intervention (PP)	0.73 ± 0.19 (214)	0.79 ± 0.19* (167)	0.83 ± 0.15* (129)
Intervention (ITT)	0.72 ± 0.19 (245)	0.77 ± 0.20* (245)	0.82 ± 0.16*,** (245)
SPPB score			
Control (PP)	7.7 ± 2.8 (159)	8.0 ± 3.2 (129)	
Control (ITT)	7.7 ± 2.8 (159)	7.7 ± 3.2 (159)	
Intervention (PP)	8.2 ± 3.0 (215)	9.7 ± 2.8* (168)	10.0 ± 2.3* (129)
Intervention (ITT)	8.0 ± 3.0 (245)	9.2 ± 3.0* (245)	9.5 ± 2.6* (245)

Note. Values are expressed as mean ± SD (*N*). *Baseline* refers to the control baseline. *Preexercise* refers to the control preexercise and intervention baseline. SPPB = short physical performance battery; PP = per protocol; ITT = intention to treat.
*Significantly different from baseline ($p < .05$). **Significantly different from 24 weeks ($p < .05$).

Table 2 Costs of Resource Items and Health Care Use

Item	Intervention	Control	Cost	Source	Included in
Resources (24 weeks)	*N*	*N*	Per person		
Exercise intervention	86	159	$245	Trail	All
Healthy living seminars	0	159	$19.12	Trail	All
Overheads[a]	86	159	$14.69	Trail	All
Equipment[b]	86	159	$61.57	Trail	All
Transport	50	73	$1,920	Trail	All
Health care use	*N* (events)	*N* (events)	Per event		
ED presentation	20 (33)	32 (68)	$531	IHPA	Scenario 3
ED presentation and admission	12 (30)	30 (64)	$955	IHPA	Scenario 3
Overnight hospital stay	19 (48)	42 (180)	$,2024	IHPA	Scenario 3
General practice visit	52 (704)	75 (1451)	$78	AMA	Scenario 3
Other specialist visit	49 (869)	71 (1763)	$166	AMA	Scenario 3

Note. *Resource costs* are mean costs per person. *Health care items* are the number of participants reporting events (total number of events reported). ED = emergency department; IHPA = independent hospital pricing authority; AMA = Australian Medical Association.
[a]Overheads included facility costs (power and cleaning) and administration personnel. [b]Equipment costs were lease expenses for the HUR pneumatic exercise equipment.

Cost-Effectiveness Analysis

The incremental cost-effectiveness ratios of the Muscling Up Against Disability program compared with usual care (plus healthy-living seminars) are presented in Table 3. Using a willingness to pay for a QALY in Australia of $64,000 (Shiroiwa et al., 2010), the base case (strict within a trial of 6 months) is unlikely to be considered cost-effective. Muscling Up Against Disability is highly likely to be cost-effective when the benefits are extrapolated over 12 months (Scenario 2). The cost-effectiveness acceptability curves are shown in Figure 1a and 1b.

Scenario 3 reduces the base-case ICER, as the health care costs were lower in the intervention group. This reduced the ICER to below the $64,000 willingness to pay threshold, with a 65% likelihood of being cost-effective (Table 3).

The model is highly sensitive to the number of participants requesting transport. In the base case, approximately half the cohort requested transport. The mean trip distance calculated for these participants was 5 km each way (range 1–14 km; median 5 km), and the average time per trip (including mobility assistance into and out of the vehicle at each end) was estimated at 30 min. Without these transport costs, the ICER over 6 months was reduced to under $20,000. If all of the participants requested transport, the ICER would be greater than $110,000 (Table 4).

Discussion

This study reported on the cost-effectiveness at 6 and 12 months of the Muscling Up Against Disability program. The findings suggest that the program offers value for the money for health-service providers, compared with usual care plus healthy-living seminars, as the ICER is below the commonly accepted willingness to pay threshold in Australia of $64,000 per QALY (Shiroiwa et al., 2010) when the benefits are continued for a 12-month period. The benefits are not as clear when measured only over the 6-month intervention period. The ICER is primarily driven by transport costs in this study. From a government perspective, the intervention can be considered to be a good value for the money across its 6-month delivery period.

The participants improved both on quality of life (EQ-5D-3L increase of 0.10) and physical function (SPPB increase of 1.5). These total improvements over 12 months were more than the minimal clinically significant differences of 0.074 for EQ-5D-3L (Walters & Brazier, 2005) and 0.80 for the SPPB (Kwon et al.,

Table 3 Results of the Cost-Effectiveness Scenarios

Analysis	No.	Intervention	Control	Cost (95% CI)	Effect (95% CI)	ICER (95% CI)	Probability cost effective[a]
Scenario 1: service provider perspective within trial (6 months)							
Cost–utility analysis							
Intention to treat	1A	245	159	$1,082 (1,040 to 1,125)	0.015 (0.012 to 0.019)	$70,540 (57,861 to 89,410)	.38
Per protocol	1B	167	128	$1,141 (1,061 to 1,220)	0.017 (0.013 to 0.021)	$68,714 (57,509 to 84,766)	.40
Cost-effectiveness analysis							
Intention to treat	1C	245	159	$1,082 (1,040 to 1,125)	1.16 (0.97 to 1.35)	$934 (795 to 1,121)	N/A
Per protocol	1D	167	128	$1,141 (1,061 to 1,220)	1.19 (1.02 to 1.37)	$976 (843 to 1,148)	N/A
Scenario 2: service provider perspective within trial with follow-up (12 months)							
Cost–utility analysis							
Intention to treat	2A	245	159	$2,166 (2,079 to 2,253)	0.057 (0.048 to 0.066)	$37,816 (32,415 to 45,307)	.95
Per protocol	2B	129	128	$2,247 (2,131 to 2,360)	0.066 (0.057 to 0.075)	$34,015 (29,589 to 39,558)	.99
Cost-effectiveness analysis							
Intention to treat	2C	245	159	$2,166 (2,079 to 2,253)	1.38 (1.18 to 1.56)	$1,574 (1,375 to 1,841)	N/A
Per protocol	2D	129	128	$2,247 (2,131 to 2,360)	1.35 (1.17 to 1.52)	$1,668 (1,459 to 1,920)	N/A
Scenario 3: government health sector perspective with health care costs (6 months)							
Cost–utility analysis							
Per protocol	3A	124	74	$859 (–419 to 1,307)	0.018 (0.015 to 0.022)	$47,747 (22,645 to 77,236)	.65
Cost-effectiveness analysis							
Per protocol	3B	124	74	$859 (–419 to 1,307)	1.12 (0.92 to 1.32)	$771 (371 to 1,224)	N/A

Note. *Cost–utility analysis outcome* was the quality-adjusted life years. *Cost-effectiveness analysis outcome* was the change in short physical performance battery score. CI = confidence interval; ICER = incremental cost-effectiveness ratio; N/A = not applicable.

[a]Probability based on a willingness to pay estimate for Australia of $64,000.

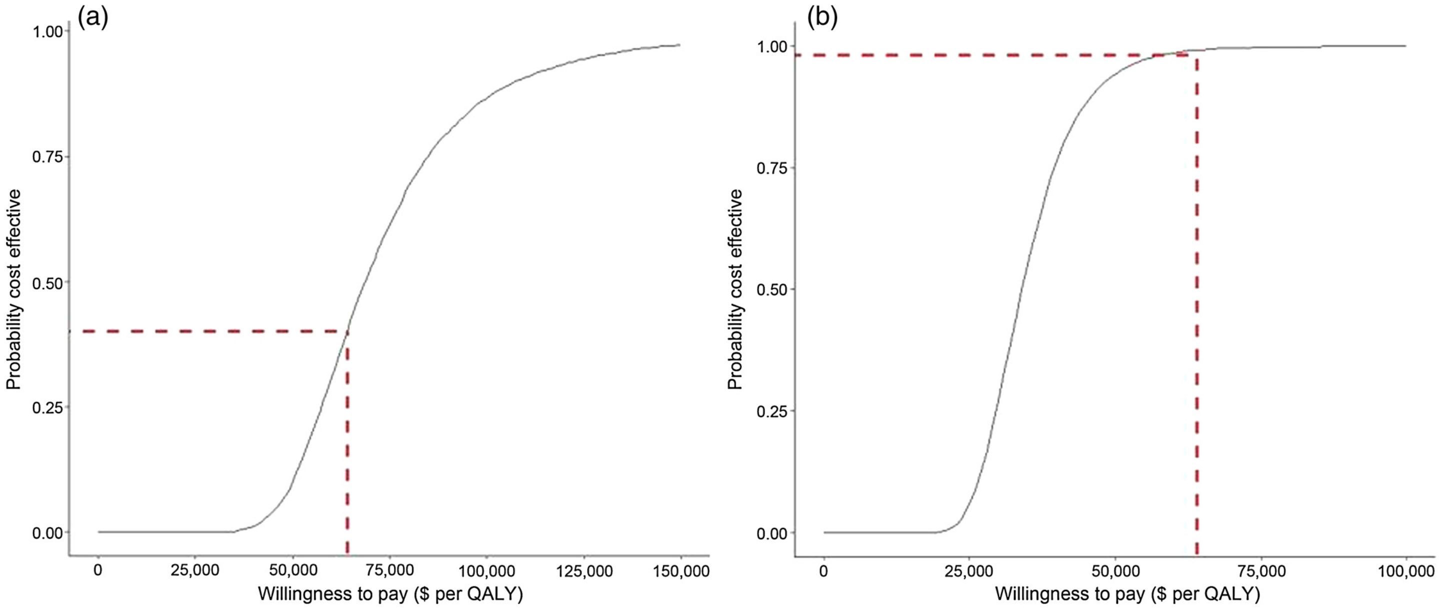

Figure 1 — Cost-effectiveness acceptability curves for (a) Scenario 1A and (b) Scenario 2A. QALY = quality-adjusted life year.

Table 4 Sensitivity Analysis

No.	Intention-to-treat analysis	Intervention	Control	Cost	Effect (95% CI)	ICER	Probability cost effective[a]
1AS1	No travel	245	159	$303[a]	0.015 (0.012–0.019)	$19,780 (16,281–24,749)	.99
1AS2	100% travel	245	159	$1,823[a]	0.015 (0.012–0.019)	$119,043 (97,988–148,949)	.01

Note. ICER = incremental cost-effectiveness ratio.
[a]Does not include cost of healthy living seminars (usual care control intervention).
[a]Probability based on a willingness to pay estimate for Australia of $64,000.

2009). Continuing improvements from postintervention to follow-up can be ascribed to the large percentage of participants who continued to exercise at the center. These improvements came at a program cost of $321 per participant. Simply put, these were large and meaningful changes over 12 months at a modest cost. The program cost for the Muscling Up Against Disability program ($321, excluding transport costs) compares very favorably with both the LIFE study, with an average cost of US$635 (A$864) for 6 months (Groessl et al., 2016), and Project *ACTIVE*, at US$1,141 (A$1,552) for 6 months of delivery (Sevick et al., 2000).

For those requesting transport to and from the study site, the additional cost was $1,920 per participant. Transport was considered integral to the success of the program. The participants had a high incidence of mobility aid usage, high morbidity count, and poor baseline performance on the SPPB, which was suggestive of frailty (Guralnik et al., 1994). Without the provision of transport, the observed effects may have been reduced, as many participants could not have accessed the site independently, and participation rates may have been impacted. Although the transport costs were high, the large and meaningful changes reported here would be far less if the participants had the functional capability to transport themselves to the venue.

Limitations

This economic evaluation has several limitations that need to be considered before generalizing these findings. This study was limited to one site in an urban area in Australia. Some of the costs used in the analysis are specific to this site. For example, the cost-effectiveness was highly sensitive to the transport costs used in this analysis. These costs were high due to the nature of the provider fleet service and are unlikely to be consistent with other settings. High costs were attributable to wage expenses for a predominantly paid driver fleet and extra time allocated to each trip to provide mobility assistance at the participants' home and at the exercise clinic. The costs for fleet administration and coordination were included in the overall transport costs. The cost-effectiveness would be considerably better than demonstrated in these findings if less expensive transport options were used. In addition, the diary data were not available for all participants who completed the intervention.

Summary

Muscling Up Against Disability, a progressive resistance plus balance training program, has been shown to be both efficacious and cost-effective. It represents a good value proposition for organizations wanting to implement an exercise programs to assist older adults experiencing functional decline and requiring in-home care services. The provision of transport is worthy of consideration for its positive impact on participation, and organizations may well be able to secure more economical options than the fleet services used in this study. In an effort to improve the cost-effectiveness of future interventions, researchers would do well to investigate alternate scenarios that overcome the expense of providing transport. This could include implementing programs such as Muscling Up Against Disability closer to the target population, in community centers and retirement living complexes.

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