Socioeconomic differences in the benefits of structured physical activity compared with health education on the prevention of major mobility disability in older adults: the LIFE study

David Bann,1 Haiying Chen,2 Chris Bonell,3 Nancy W Glynn,4 Roger A Fielding,5 Todd Manini,6 Abby C King,7 Marco Pahor,8 Shannon L Mihalko,9 Thomas M Gill,10 the Life Study investigators

ABSTRACT
Background Evidence is lacking on whether health-benefiting community-based interventions differ in their effectiveness according to socioeconomic characteristics. We evaluated whether the benefit of a structured physical activity intervention on reducing mobility disability in older adults differs by education or income.

Methods The Lifestyle Interventions and Independence for Elders (LIFE) study was a multicentre, randomised trial that compared a structured physical activity programme with a health education programme on the incidence of mobility disability among at-risk community-living older adults (aged 70–89 years; average follow-up of 2.6 years). Education (< high school (0–12 years), college (13–17 years) or postgraduate) and annual household income were self-reported (<$24 999, $25 000 to $49 999 and ≥$50 000). The risk of disability (objectively defined as loss of ability to walk 400 m) was compared between the 2 treatment groups using Cox regression, separately by socioeconomic group. Socioeconomic group × intervention interaction terms were tested.

Results The effect of reducing the incidence of mobility disability was larger for those with postgraduate education (0.72, 0.51 to 1.03; N=411) compared with lower education (high school or less (0.93, 0.70 to 1.24; N=536). However, the education group × intervention interaction term was not statistically significant (p=0.54). Findings were in the same direction yet less pronounced when household income was used as the socioeconomic indicator.

Conclusions In the largest and longest running trial of physical activity amongst at-risk older adults, intervention effect sizes were largest among those with higher education or income, yet tests of statistical interactions were non-significant, likely due to inadequate power.

Trial registration number NCT01072500.

INTRODUCTION
There is a recognised need to evaluate whether the benefits of community-based interventions differ by socioeconomic group.1–3 To the authors’ knowledge, no prior study has evaluated whether the effectiveness of interventions to prevent mobility disability among older adults differs according to socioeconomic group. This is important to investigate given the substantial individual and societal costs of mobility disability,4 and the observed differences in disability risk across socioeconomic groups: older adults with lower education or lower income, on average, have worse physical performance levels5 6 and a higher risk of mobility disability.7 8 Interventions may either widen or narrow these differences.1 2

Recent findings from the largest and longest duration randomised trial of physical activity in older adults demonstrated that a structured physical activity intervention—relative to a health education intervention—reduced the incidence of major mobility disability by 18% among at-risk community-living older adults (HR 0.82, 95% CI 0.69 to 0.98).9 We investigated whether the benefits of this intervention differed by socioeconomic group and hypothesised that the benefits would be more pronounced among more socioeconomically advantaged groups, since greater socioeconomic resources may foster exercise participation and protect against adverse events and illnesses that could impede exercise.10 11

METHODS
Study sample
The Lifestyle Interventions and Independence for Elders (LIFE) study was a phase 3 randomised controlled trial conducted at eight field centres in eight US states. The rationale, design and methods of the LIFE study have been presented in detail elsewhere,12 as have baseline characteristics.13 Participants aged 70–89 years were eligible if they were at increased risk of mobility disability (ie, a Short Physical Performance Battery score ≤9), yet were able to walk 400 m at their usual pace in 15 min without sitting, leaning or assistance from a walker/another person. Participants were additionally required to be relatively sedentary (ie, reported <20 min/week in the past month getting regular physical activity and ≤125 min/week of moderate activity). The two self-reported socioeconomic indicators were education attainment (≤ high school (0–12 years), college (13–17 years) or postgraduate) and annual household income (<$24 999, $25 000 to $49 999 and ≥$50 000). In total, 1635 participants (~67% women) were randomised, ranging from 200 to 216 per site. Ethical approval was provided by the Institutional Review Boards, and written informed consent obtained from all study participants.
The physical activity intervention consisted of moderate-intensity walking (with a 150 min goal per week), and strength, flexibility and balance training, in supervised clinical centres and at participants’ homes. The comparison arm was a health education programme comprising workshops (weekly for the first 26 weeks, then monthly thereafter) on topics (excluding physical activity) such as nutrition, healthcare systems and safe travel.

The primary outcome of the LIFE study was major mobility disability, objectively defined as loss of ability to walk 400 m. Persistent mobility disability was defined as two consecutive assessments with major mobility disability or major mobility disability followed by death. Participants were followed up every 6 months for an average of 2.6 years—from the time of enrolment and start of the interventions (February 2010 to December 2011) to the end of the interventions (December 2013).

We compared baseline demographic and health characteristics across socioeconomic groups, then compared the risk of mobility disability in each treatment group according to education or income using Cox regression models. We formally tested these differences through education or income×intervention interaction terms.14 15

RESULTS
Participants with higher compared with lower education were more frequently male, and had a lower prevalence of hypertension, yet they did not consistently differ with respect to measured physical performance (table 1—income results shown in online supplementary table). The effect estimates—showing the effect of physical activity on reducing the incidence of mobility disability—were greatest among participants with postgraduate education (HR 0.72, 95% CI 0.51 to 1.03) and weaker for those with intermediate (0.81, 0.61 to 1.06) or lowest education (0.93, 0.70 to 1.24; table 2), yet CIs overlapped. These differences were similar for persistent mobility disability. The education group×intervention interaction term was not statistically significant for either outcome (p=0.54 and 0.62, respectively). Differences in effect sizes by household income were similar (table 2), and income×intervention interaction terms were also not statistically significant (p=0.90 and 0.79, respectively).

DISCUSSION
In the largest and longest running trial of physical activity among at-risk older adults, we found no statistically significant evidence that the benefits of physical activity on reducing the risk of mobility disability differed by education or income group. The lack of differential benefit indicates that this form of intervention, if established more widely across the country, would neither widen nor narrow socioeconomic inequalities in disability incidence. However, because intervention effect sizes were largest among those with higher education or income and because the trial was unlikely to have been adequately powered to detect statistically significant interactions, it is possible that the intervention could widen socioeconomic differences in disability incidence.

Despite the large size of the LIFE study (with 246 participants experiencing major mobility disability), it may still have been underpowered to detect genuine differences in intervention benefit across socioeconomic groups, since tests for interaction require particularly high statistical power14 15—with more power than is required to test for a main intervention effect across all

Table 1 Descriptive statistics of the LIFE study sample at baseline, by education group

| Characteristic                  | Physical activity group | Health education group |
|---------------------------------|-------------------------|------------------------|
|                                 | ≤ High school (K-12)    | College (13–17)        | Postgraduate | p Value* | ≤ High school (K-12) | College (13–17) | Postgraduate | p Value* |
| N (%)                           | 273 (33.4)              | 345 (42.2)             | 199 (24.4)   |          | 263 (32.4)          | 338 (41.6)      | 212 (26.1)   |          |
| Age (years)                     | 78.5 (5.1)              | 78.7 (5.4)             | 78.9 (5.2)   | 0.73     | 79.0 (5.1)          | 79.2 (5.2)      | 78.9 (5.4)   | 0.84     |
| Women (%)                       | 207 (75.8)              | 223 (64.6)             | 116 (58.3)   | 0.001    | 199 (75.7)          | 225 (66.6)      | 126 (59.4)   | 0.001    |
| Race (% non-white)              | 85 (31.4)               | 68 (19.8)              | 37 (18.6)    | 0.001    | 65 (24.9)           | 47 (13.9)       | 40 (19.0)    | 0.003    |
| Income ≥$50k (%)                | 44 (18.4)               | 104 (33.7)             | 94 (53.4)    | 0.001    | 35 (15.1)           | 95 (32.2)       | 100 (51.8)   | 0.001    |
| BMI (kg/m²)                     | 30.5 (5.8)              | 29.9 (5.7)             | 29.7 (5.7)   | 0.25     | 31.0 (6.2)          | 29.9 (6.1)      | 30.2 (6.5)   | 0.08     |
| Conditions (%)                  |                         |                        |             |          |                         |                        |             |          |
| Hypertension                    | 210 (77.2)              | 226 (66.1)             | 137 (68.8)   | 0.009    | 207 (78.7)          | 231 (69.0)      | 139 (67.5)   | 0.009    |
| Diabetes                        | 88 (32.4)               | 86 (25.0)              | 42 (21.1)    | 0.02     | 80 (30.4)           | 92 (27.3)       | 60 (28.7)    | 0.80     |
| Myocardial infarction           | 25 (9.2)                | 24 (7.0)               | 11 (5.5)     | 0.31     | 20 (7.6)            | 27 (8.0)        | 21 (10.0)    | 0.60     |
| Stroke                          | 23 (8.5)                | 21 (6.1)               | 13 (6.5)     | 0.51     | 15 (5.7)            | 24 (7.1)        | 13 (6.2)     | 0.77     |
| Cancer                          | 55 (20.2)               | 73 (21.3)              | 50 (25.1)    | 0.42     | 49 (18.6)           | 76 (22.5)       | 65 (31.0)    | 0.006    |
| Chronic pulmonary disease       | 54 (19.8)               | 45 (13.1)              | 31 (15.6)    | 0.08     | 48 (18.3)           | 44 (13.1)       | 30 (14.3)    | 0.21     |
| 3MSE score, 0–100 scale         | 89.5 (5.7)              | 92.0 (5.2)             | 93.5 (4.8)   | 0.001    | 89.6 (5.8)          | 91.9 (4.8)      | 93.7 (4.7)   | 0.001    |
| Walking/weight activities (min/week) | 77.3 (134.5)             | 63.1 (106.8)           | 92.1 (140.6) | 0.032    | 84.6 (131.3)        | 85.8 (137.2)    | 90.1 (134.4) | 0.90     |
| Sedentary time (min/day)        | 628.1 (120.4)           | 641.2 (109.5)          | 678.5 (114.6) | 0.001    | 632.7 (110.6)       | 645.9 (114.5)   | 646.0 (107.2) | 0.37     |
| Lower light-intensity activity (min/day) | 173.7 (54.5)            | 160.7 (51.1)           | 152.1 (53.0) | 0.001    | 172.5 (51.5)        | 158.6 (51.7)    | 165.0 (52.8) | 0.02     |
| Higher light-intensity activity (min/day) | 27.7 (21.1)             | 27.4 (21.7)            | 27.0 (24.8)  | 0.96     | 28.5 (28.9)         | 27.6 (25.6)     | 28.3 (23.4)  | 0.93     |
| SPPB score                      | 7.4 (1.5)               | 7.5 (1.6)              | 7.5 (1.6)    | 0.83     | 7.3 (1.6)           | 7.3 (1.6)       | 7.4 (1.6)    | 0.65     |
| 400 m walking speed, m/s         | 0.8 (0.2)               | 0.8 (0.2)              | 0.8 (0.2)    | 0.06     | 0.8 (0.2)           | 0.8 (0.2)       | 0.8 (0.2)    | 0.50     |

Results are presented as mean (SD) or n (%).
*Comparison of education groups using ANOVA or χ² tests; all accelerometry measures were adjusted for wear time; accelerometer cut points were as follows: sedentary: 100 counts/min; lower light: 100–760 light; higher light: >760 counts/min.
3MSE, Modified Mini-Mental State Examination; ANOVA, analysis of variance; BMI, body mass index; LIFE, Lifestyle Interventions and Independence for Elders; SPPB, Short Physical Performance Battery.
Socioeconomic differences in enrolment and follow-up could also lead to socioeconomic differences in intervention benefit. Minimal loss to follow-up occurred in the LIFE study (4% per year), and recruitment was relatively successful (e.g. 59.4% of those contacted by mail13). However, we were unable to investigate socioeconomic differences in enrolment due to the lack of relevant data for non-responders. Other physical activity trials have reported lower enrolment among those of lower education or income, a pattern which could widen inequalities,16 17 yet efforts were made in the LIFE study to enable participation regardless of socioeconomic circumstances (e.g. free transport provision for some participants) which may have limited this tendency.

Strengths of this study include the use of data from a large number of older adults with extensive follow-up across the USA and objective outcome assessment. Although both education and (banded) household income were available, future studies may include more refined socioeconomic measures which better distinguish socioeconomic groups and thereby enable greater power.1

For example, continuously measured disposable income and household income were available, future studies may therefore require larger sample sizes and/or be pooled into meta-analyses. In addition, the primary outcome of this study was mobility disability—a dichotomous outcome; studies using continuous outcomes are likely to have greater power to detect differences in intervention benefit.

Socioeconomic differences in enrolment and follow-up could also lead to socioeconomic differences in intervention benefit. Minimal loss to follow-up occurred in the LIFE study (4% per year), and recruitment was relatively successful (e.g., 59.4% of those contacted by mail13). However, we were unable to investigate socioeconomic differences in enrolment due to the lack of relevant data for non-responders. Other physical activity trials have reported lower enrolment among those of lower education or income, a pattern which could widen inequalities,16 17 yet efforts were made in the LIFE study to enable participation regardless of socioeconomic circumstances (e.g., free transport provision for some participants) which may have limited this tendency.

Strengths of this study include the use of data from a large number of older adults with extensive follow-up across the USA and objective outcome assessment. Although both education and (banded) household income were available, future studies may include more refined socioeconomic measures which better distinguish socioeconomic groups and thereby enable greater power.1 For example, continuously measured disposable income and wealth may be especially relevant socioeconomic indicators in old age,18 19 while early life socioeconomic conditions may have independent effects on adult physical activity and disability risk.6 20

In the largest and longest running trial to date, we found that the benefits of a physical activity intervention in preventing mobility disability did not significantly differ by socioeconomic group, yet effect sizes of intervention benefit were largest among those with higher education or income. Our findings add to a limited number of existing studies, some of which found that physical activity interventions inadvertently increase inequalities in other outcomes at younger ages.2 These studies could ultimately be pooled to enable greater statistical power for subgroup interactions, and used to identify the characteristics of interventions which both improve average population health and reduce inequalities.

What is already known on this subject

▸ A large-scale multicentre randomised trial recently found that a physical activity intervention, compared with a health education programme, reduced disability incidence in at-risk community-dwelling older adults (the Lifestyle Interventions and Independence for Elders (LIFE) study).
▸ There is an important lack of evidence on whether health-benefiting interventions differ in their effectiveness by socioeconomic group.

What this study adds

▸ There was no statistically significant evidence that the benefits of physical activity on reducing the risk of mobility disability differed by education or income group, yet effect sizes of intervention benefit were largest among those with higher education or income.
▸ Despite being the largest physical activity trial yet conducted among older adults, there may have been inadequate power to detect genuine differences in benefit by socioeconomic group. Future studies may be designed to specifically evaluate potential socioeconomic differences in benefit, and/or pool estimates from multiple studies.
Contributors DB and TMG conceived and designed the study and developed the study objectives. HC conducted all analyses. DB, TMG and HC contributed to the analytic strategy; all authors contributed to the interpretation of data, reviewed and revised the manuscript, and approved the final version for which they are accountable.

Funding DB is supported by the Economic and Social Research Council (grant code ES/N007166/1). The Lifestyle Interventions and Independence for Elders Study is funded by a National Institutes of Health/National Institute on Aging Cooperative Agreement U01AG022376 and a supplement from the National Heart, Lung and Blood Institute U01AG022376-05A2S, and sponsored in part by the Intramural Agreement #U01AG22376 and a supplement from the National Heart, Lung and Blood Institute, NIH.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement Data are available on request to academic researchers from the following link: https://thelifestudy.org/docs/LIFE-AcknowledgementList13_2014-07_17_Full%20List_dean.pdf.

REFERENCES

1 Bonell C, Fletcher A, Morton M, et al. Realist randomised controlled trials: a new approach to evaluating complex public health interventions. *Soc Sci Med* 2012;75:2299–306.

2 Lorenc T, Petticrew M, Welch V, et al. What types of interventions generate inequalities? Evidence from systematic reviews. *J Epidemiol Community Health* 2013;67:190–3.

3 Humphreys DK, Oglvie D. Synthesising evidence for equity impacts of population-based physical activity interventions: a pilot study. *Int J Behav Nutr Phys Act* 2013;10:76.

4 Hardy SE, Kang Y, Studenski SA, et al. Ability to walk 1/4 mile predicts subsequent disability, mortality, and health care costs. *J Gen Intern Med* 2011;26:130–5.

5 Birnie K, Cooper R, Martin RM, et al. Childhood socioeconomic position and objectively measured physical capability levels in adulthood: a systematic review and meta-analysis. *PLoS ONE* 2011;6:e15564.

6 Hurst L, Stafford M, Cooper R, et al. Lifetime socioeconomic inequalities in physical and cognitive ageing. *Am J Public Health* 2013;103:1641–8.

7 Schoeni RF, Martin LG, Andreski PM, et al. Persistent and growing socioeconomic disparities in disability among the elderly: 1982–2002. *Am J Public Health* 2005;95:2065–70.

8 Minkler M, Fuller-Thomson E, Guralnik JM. Gradient of disability across the socioeconomic spectrum in the United States. *N Engl J Med* 2006;355:695–703.

9 Pahor M, Guralnik JM, Ambrosius WT. Effect of structured physical activity on prevention of major mobility disability in older adults: the life study randomized clinical trial. *JAMA* 2014;311:2387–96.

10 Phelan JC, Link BG, Tehranifar P. Social conditions as fundamental causes of health inequalities: theory, evidence, and policy implications. *J Health Soc Behav* 2010;51(Suppl):S28–40.

11 Gidlow C, Johnston LH, Crone D, et al. A systematic review of the relationship between socio-economic position and physical activity. *Health Educ J* 2006;65:338–67.

12 Fielding RA, Rejeski WI, Blair S, et al. The lifestyle interventions and independence for elders study: design and methods. *J Gerontol A Biol Sci Med Sci* 2011;66:1226–37.

13 Marsh AP, Lovato LC, Guralnik JM, et al. Lifetime interventions and independence for elders study: recruitment and baseline characteristics. *J Gerontol A Biol Sci Med Sci* 2013;68:1549–58.

14 Petticrew M, Tugwell P, Kristjansson E, et al. Damned if you do, damned if you don’t: subgroup analysis and equity. *J Epidemiol Community Health* 2012;66:95–8.

15 Yusuf S, Wittes J, Probstfield J, et al. Analysis and interpretation of treatment effects in subgroups of patients in randomized clinical trials. *JAMA* 1991;266:93–8.

16 Martinson BC, Crain AL, Sherwood NE, et al. Population reach and recruitment bias in a maintenance RCT in physically active older adults. *J Phys Act Health* 2010;7:127.

17 Chinn DJ, White M, Howel D, et al. Factors associated with non-participation in a physical activity promotion trial. *Public Health* 2006;120:309–19.

18 Pollack CE, Chideya S, Cubbin C, et al. Should health studies measure wealth? A systematic review. *Am J Prev Med* 2007;33:250–64.

19 Demakakos P, Biddulph JP, Bobak M, et al. Wealth and mortality at older ages: a prospective cohort study. *J Epidemiol Community Health* 2015;70:346–53.

20 Elhakeem A, Cooper R, Bann D, et al. Childhood socioeconomic position and adult leisure-time physical activity: a systematic review. *Int J Behav Nutr Phys Act* 2015;12:92.
Socioeconomic differences in the benefits of structured physical activity compared with health education on the prevention of major mobility disability in older adults: the LIFE study

David Bann, Haiying Chen, Chris Bonell, Nancy W Glynn, Roger A Fielding, Todd Manini, Abby C King, Marco Pahor, Shannon L Mihalko, Thomas M Gill and the Life Study investigators

*J Epidemiol Community Health* 2016 70: 930-933 originally published online April 8, 2016
doi: 10.1136/jech-2016-207321

Updated information and services can be found at:
http://jech.bmj.com/content/70/9/930

*These include:*

**References**
This article cites 20 articles, 2 of which you can access for free at:
http://jech.bmj.com/content/70/9/930#ref-list-1

**Open Access**
This is an Open Access article distributed in accordance with the terms of the Creative Commons Attribution (CC BY 4.0) license, which permits others to distribute, remix, adapt and build upon this work, for commercial use, provided the original work is properly cited. See:
http://creativecommons.org/licenses/by/4.0/

**Email alerting service**
Receive free email alerts when new articles cite this article. Sign up in the box at the top right corner of the online article.

**Topic Collections**
Articles on similar topics can be found in the following collections

- Open access (335)
- Health education (1537)
- Health promotion (1713)

**Notes**

To request permissions go to:
http://group.bmj.com/group/rights-licensing/permissions

To order reprints go to:
http://journals.bmj.com/cgi/reprintform

To subscribe to BMJ go to:
http://group.bmj.com/subscribe/