Peer coaching as a population approach to increase physical activity in older adults

Vijver, P.L. van de

PEER COACHING

AS A POPULATION APPROACH TO INCREASE PHYSICAL ACTIVITY IN OLDER ADULTS

PAUL VAN DE VIJVER

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PEER COACHING

AS A POPULATION APPROACH TO INCREASE PHYSICAL ACTIVITY IN OLDER ADULTS

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De wil tot weten is het fundament voor alle kunde.

Papa

CONTENTS

CHAPTER 1

General introduction

Paul van de Vijver

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INTRODUCTION

The world population is ageing. In the past 160 years, average life expectancy increased from 40 to 80 years.[1] This success is the result of advances in sanitation, income, medicine and nutrition.[1,2] In the same period, presumed boundaries in the increasing life-expectancy have always been broken.[1] Several countries that experienced a stagnation of the increasing trend in life expectancy, have caught up in the last years.[3] Current projections also predict with high probability that female life expectancy at birth will break the 90 year barrier by 2030 in South Korea.[4] In addition, in the first decades after the Second World War life expectancy increased rapidly in the Western World.[5] So, regardless of the exact trends and limits in future life expectancy, the number and proportion of adults aged over 65 will increase in almost all countries of the world.[6,7]

As a consequence, many countries nowadays face a high prevalence of age-related diseases. Increasing prevalence of diabetes, cardiovascular disease and risk factors for these diseases has been seen in the past decades almost everywhere.[8-10] In 2019, the global cardiovascular disease prevalence was estimated to be 523 million people. Global diabetes prevalence was estimated to 463 million in 2019.[10] Additionally, the risk factors hypertension, hypercholesterolemia and obesity have a high prevalence, especially in the high income regions of the world.[11-13]

Many of the age-related diseases are modifiable by lifestyle. Healthy lifestyle is associated with a 66% reduced risk on cardiovascular disease.[14] An unhealthy lifestyle increases diabetes risk with 75% compared to a healthy lifestyle.[15] Major components of lifestyle are physical activity, diet, alcohol consumption, smoking behaviour, stress, sleeping pattern and personal hygiene.

Physical activity is consistently identified as one of the best means to impact healthy ageing.[16-21] Daily physical activity has been found effective at preventing and treating many age-related diseases and risk factors such as cardiovascular disease, diabetes, hypertension, obesity, osteoporosis, and sarcopenia.[16-18] In older adults it also reduces depression, anxiety, the risk of falls and increases mobility, quality of life and longevity.[18-20] According to the World Health Organisation (WHO), the recommended level of physical activity is 150 minutes of moderate-intensity aerobic physical activity or 75 minutes of vigorous-intensity aerobic physical activity a week for older adults (>64 years).

However, an estimated 31% of the global population does not reach the recommended level of physical activity.[22] Physical inactivity is a driving force behind the high prevalence and incidence in age-related diseases and mortality.[23,24] It is estimated that physical inactivity causes 5.3 million deaths worldwide annually.[25] Physical activity is negatively associated with age. The estimated number of older adults not reaching the recommended level of physical activity ranges between 17 – 97.6% and increasing age is associated with a higher risk of physical inactivity.[26-28] Perceived barriers for the adoption or maintenance of physical activity in older adults are age, poor health, unsafe environment, distance from recreational facility, lack of knowledge and understanding of physical activity, lack of company, lack of interest, lack of opportunities and lack of transport.[29,30] Facilitators for physical activity included the motivation to maintain physical and mental health, increased self-efficacy, social support, group cohesiveness, and access to affordable, convenient, and stimulating physical activity options.[30-32]

Interventions are effective in increasing physical activity behaviour in older adults during the intervention period.[20,33,34] This increase in physical activity subsequently also has effect on clinical meaningful outcomes.[33,35] However, long term effects of interventions are scarce, when the intervention period ends physical activity behaviour often declines.[20,36-38] Long term effects on physical activity behaviour after an intervention depend on intervention technique, intervention duration, physical activity intensity during intervention and self-efficacy.[39,40] Behaviour, or social-cognitive change techniques focusing on increasing self-efficacy and physical activity do increase the long term effect of interventions, but not indefinitely.[41,42] To obtain sustainable effect, physical activity interventions must be permanent. However, there are not enough professionals and financial resources to deliver physical activity interventions permanently to all inactive older adults.

New intervention strategies are needed to promote and support physical activity. These interventions need to successfully promote physical activity, be able to reach large numbers of older adults and have a sustainable effect on physical activity behaviour. Expensive interventions using scarce professionals are inherently unfitted to meet these three requirements.

One alternative solution that has been suggested to solve this problem are eHealth interventions. Online physical activity promotion is a method that could be suitable to sustainably increase physical activity in large numbers of older adults. However, results of these studies do not show long term effectivity yet and fail to engage large numbers of older adults.[43-46] New studies need to focus on how to increase effectiveness and adherence of these interventions, especially in older adults.

Furthermore, most of these studies are not specially designed for older adults.[47,48] Phone-based interventions show promising effects.[49] However, phone-based interventions with professionals are unable to reach large numbers of older adults because they are conducted one on one. Phone-based interventions without the use of professionals could be a promising solution.

Studies show that the preference of face-to-face contact during intervention is especially present in older adults.[50-53] Classic face-to-face group interventions with a professional are too expensive to be sustainable and are limited by the scarcity of professionals. Similar to phone-based interventions, classic face-to-face group interventions could be a promising solution without the dependency on professionals. Removing professionals from physical activity interventions is a new and emerging philosophy. Replacements of these professionals are, in the case of eHealth, webpages, apps or algorithms. In phone-based or face-to-face interventions, professionals can be replaced by volunteers or peers.

Peer coaching is a particular promising solution to avoid the use of costly and scarce professionals.[54-57] Peer coaching is a face-to-face intervention to reach a common goal given by a non-professional, who has a common background with the recipient, either through a similar life experience or other shared characteristics.[58] The strength of peer-coaching lies in empathy and using the experiential knowledge of the peer coach, to understand the other peers wishes, motivations, possibilities and limitations. The most successful and widely-known peer coaching initiative is Alcoholics Anonymous, with more than two million members spread over 150 countries.[59-61]

In physical activity interventions, empathy from peer coaches could help improving long term maintenance of physical activity.[62] Also, unsupervised peer coaches showed similar effects regarding physical activity promotion compared to professionals, students and supervised peer coaches.[57,63] Additionally, the handful of studies that do report on adverse events show no difference in the number of adverse events between peers and professionals.[64] These insights make peer coaching a suitable delivery method for physical activity interventions for older adults.

Thus far, no study has investigated peer coached physical activity interventions where peer coaches are also responsible for the organization of the intervention. A completely sustainable intervention must be able to operate independently of expensive and scarce professionals. Also, the intervention must be able to be self-supporting and not dependent on financial resources from the public or private sector.

AIM OF THIS THESIS

In this thesis we investigate the possibility of a face-to-face group intervention exercising outside to sustainably increase physical activity in older adults. By replacing the professional with a peer coach, there are in theory no limitations in terms of reach and sustainability due to scarcity of professionals and high structural costs. By using the public space there is no need for expensive and scarce venues. In principle, each neighbourhood or community could start a peer coach physical activity intervention. However, there was no study regarding the effect, reach and sustainability of such an intervention. Moreover, implementation strategies of this intervention were also unknown. All these aspects are studied and described in this thesis. Additionally, possible referral schemes in primary care and ways to structure future umbrella organization are explored.

The goal is to show first proofs of effect and feasibility of a peer coach physical activity intervention for community dwelling older adults. In this thesis we first study the effectivity of such an intervention. Secondary, we study the feasibility of implementation of this intervention. Thirdly, we study a possible referral scheme from primary care to this intervention. Finally, we describe a possible structure of a nationwide implementation of this intervention.

The intervention studied in this thesis is unique as it is not depending on a specific sector. This is important because many means to population change are in different sectors than healthcare. For example the sectors urban planning, transportation, education, employment and politics.[65] Secondly, the implementation of this intervention does not need many resources and high executive power and implementation of intervention often happens at levels with poorer resources and lower executive power.[65]

TERMINOLOGY

Using peers in physical activity promotion comes with a variety of terms and ideas. It is important to note that in this thesis we follow the typology of Matz-Costa et al.[58] A peer coach is strategy-planner and motivator. Similar to a professional gym teacher during gym class at school. The primary objective of a peer coach is to plan exercise sessions and encourage participants to complete these exercises. This is how the role of a peer coach was implemented in the intervention. A peer coach can also fulfil the roles of a peer mentor or peer support where he or she acts as an experienced other or a moral support-provider. These are secondary roles that can happen when peers are grouped together, but this was not implemented in the intervention.

Matz-Costa et al. also make a distinction between peer-delivered interventions, where the peer directly delivers the physical activity program content or a portion of the content, and peer-assisted interventions, where the peer assists in the delivery of the program content or a portion of the content.[58] Matz-Costa et al. do mention that an intervention can be a hybrid form of these two and that this distinction has not been explicitly made in the literature. The physical activity intervention in this thesis is peer-delivered, as the peer coaches deliver the program content directly to the participants.

OUTLINE OF THIS THESIS

This chapter, **chapter one,** provides a general introduction to the thesis

Chapter two investigates the relationship between the timing and magnitude of physical peak performance and life expectancy. This relation is based on life-history theory. A theoretical framework that seeks to explain how natural selection shapes key life events of an organism's life. These key life events, including growth, sexual maturation, behaviour and lifespan, are intertwined and the timing of one event influences the other. Physical activity is an important factor that influences health, but this study also shows there is a biological predisposition for timing and magnitude of physical peak performance and lifespan regardless of an individual's efforts.

Chapter three describes a proof-of-principle of a peer coach physical activity intervention of community dwelling older adults. This self-organising intervention, created and organised by older adults themselves, is a successful example of long-term physical activity promotion. In this chapter we describe the components of the intervention and the effects on health and well-being. This chapter is the basis when implementing new physical activity interventions for a feasibility study.

After chapter three, the question arises if healthcare professionals could create a self-organizing peer coach physical activity intervention. **Chapter four** describes a feasibility study. It studies the process of implementing a new peer coach physical activity intervention and making them self-organizing after a short period of time. This part gives insight if the self-organizing physical activity intervention, that was previously created by older adults themselves, can be actively implemented by healthcare professionals in different settings.

Although chapter four showed that healthcare professionals can implement a self-organizing physical activity intervention, there was no active recruitment strategy to reach older adults. The peer coach physical activity intervention is successful by itself it was largely based on healthy older adults in the neighbourhood. Linking the intervention to primary care could increase the recruitment of older adults that benefit form daily physical activity the most. **Chapter five** describes the experiment that tested the effect of a primary care referral scheme. Prevention is becoming an increasingly important objective in primary care. A successful physical activity intervention at the disposal of primary care physicians could increase prevention efforts.

The future of peer coach physical activity interventions as a population approach is described in **chapter six**. Here, we describe the *Círculos de Abuelos*, a Cuban example of a population approach to increase physical activity in older adults. The organizational structure and success of the *Círculos de Abuelos* can act as inspiration for policy makers and healthcare professionals to implement physical activity promotion on a population level.

Chapter seven summarises the main conclusion and discusses possible considerations of this thesis. Additionally, several implications of the results of the study are stated. Finally, several recommendations for future studies are discussed.

REFERENCES

1. Oeppen J, Vaupel JW. Broken limits to life expectancy. *Science.* 2002;296:1029-1031.
2. Riley JC. *Rising life expectancy: a global history.* Cambridge University Press; 2001.
3. Ho JY, Hendi AS. Recent trends in life expectancy across high income countries: retrospective observational study. *bmj.* 2018;362.
4. Kontis V, Bennett JE, Mathers CD, Li G, Foreman K, Ezzati M. Future life expectancy in 35 industrialised countries: projections with a Bayesian model ensemble. *The Lancet.* 2017;389:1323-1335.
5. Sugiura Y, Ju Y-S, Yasuoka J, Jimba M. Rapid increase in Japanese life expectancy after World War II. *Biosci Trends.* 2010;4:9-16.
6. Bloom DE, Canning D, Lubet A. Global population aging: Facts, challenges, solutions & perspectives. *Daedalus.* 2015;144:80-92.
7. Fehlings MG, Tetreault L, Nater A, et al. The aging of the global population: the changing epidemiology of disease and spinal disorders. *Neurosurgery.* 2015;77:S1-S5.
8. Harding JL, Pavkov ME, Magliano DJ, Shaw JE, Gregg EW. Global trends in diabetes complications: a review of current evidence. *Diabetologia.* 2019;62:3-16.
9. Jagannathan R, Patel SA, Ali MK, Narayan KV. Global updates on cardiovascular disease mortality trends and attribution of traditional risk factors. *Current diabetes reports.* 2019;19:1-12.
10. Roth GA, Mensah GA, Johnson CO, et al. Global burden of cardiovascular diseases and risk factors, 1990–2019: update from the GBD 2019 study. *Journal of the American College of Cardiology.* 2020;76:2982-3021.
11. Morgen CS, Sørensen TI. Global trends in the prevalence of overweight and obesity. *Nature Reviews Endocrinology.* 2014;10:513-514.
12. Mills KT, Bundy JD, Kelly TN, et al. Global disparities of hypertension prevalence and control: a systematic analysis of population-based studies from 90 countries. *Circulation.* 2016;134:441-450.
13. Farzadfar F, Finucane MM, Danaei G, et al. National, regional, and global trends in serum total cholesterol since 1980: systematic analysis of health examination surveys and epidemiological studies with 321 country-years and 3· 0 million participants. *The Lancet.* 2011;377:578-586.
14. Barbaresko J, Rienks J, Nöthlings U. Lifestyle indices and cardiovascular disease risk: a meta-analysis. *American journal of preventive medicine.* 2018;55:555-564.
15. Zhang Y, Pan X-F, Chen J, et al. Combined lifestyle factors and risk of incident type 2 diabetes and prognosis among individuals with type 2 diabetes: a systematic review and meta-analysis of prospective cohort studies. *Diabetologia.* 2020;63:21-33.
16. Penedo FJ, Dahn JR. Exercise and well-being: a review of mental and physical health benefits associated with physical activity. *Current opinion in psychiatry.* 2005;18:189-193.
17. Warburton DE, Nicol CW, Bredin SS. Health benefits of physical activity: the evidence. *Canadian medical association journal.* 2006;174:801-809.
18. Vogel T, Brechat PH, Leprêtre PM, Kaltenbach G, Berthel M, Lonsdorfer J. Health benefits of physical activity in older patients: a review. *International journal of clinical practice.* 2009;63:303-320.
19. Gremeaux V, Gayda M, Lepers R, Sosner P, Juneau M, Nigam A. Exercise and longevity. *Maturitas.* 2012;73:312-317.

20. Taylor A, Cable N, Faulkner G, Hillsdon M, Narici M, Van Der Bij A. Physical activity and older adults: a review of health benefits and the effectiveness of interventions. *Journal of sports sciences.* 2004;22:703-725.
21. Taylor D. Physical activity is medicine for older adults. *Postgraduate medical journal.* 2014;90:26-32.
22. Kohl 3rd HW, Craig CL, Lambert EV, et al. The pandemic of physical inactivity: global action for public health. *The lancet.* 2012;380:294-305.
23. Al Tunaiji H, Davis JC, Mackey DC, Khan KM. Population attributable fraction of type 2 diabetes due to physical inactivity in adults: a systematic review. *BMC Public Health.* 2014;14:1-9.
24. de Rezende LFM, Rabacow FM, Viscondi JYK, do Carmo Luiz O, Matsudo VKR, Lee I-M. Effect of physical inactivity on major noncommunicable diseases and life expectancy in Brazil. *Journal of Physical Activity and Health.* 2015;12:299-306.
25. Lee I-M, Shiroma EJ, Lobelo F, et al. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. *The lancet.* 2012;380:219-229.
26. Sun F, Norman IJ, While AE. Physical activity in older people: a systematic review. *BMC public health.* 2013;13:449.
27. Gomes M, Figueiredo D, Teixeira L, et al. Physical inactivity among older adults across Europe based on the SHARE database. *Age and ageing.* 2017;46:71-77.
28. Watson KB, Carlson SA, Gunn JP, et al. Physical inactivity among adults aged 50 years and older—United States, 2014. *Morbidity and Mortality Weekly Report.* 2016;65:954-958.
29. Moschny A, Platen P, Klaaßen-Mielke R, Trampisch U, Hinrichs T. Barriers to physical activity in older adults in Germany: a cross-sectional study. *International Journal of Behavioral Nutrition and Physical Activity.* 2011;8:1-10.
30. Schutzer KA, Graves BS. Barriers and motivations to exercise in older adults. *Preventive medicine.* 2004;39:1056-1061.
31. Bethancourt HJ, Rosenberg DE, Beatty T, Arterburn DE. Barriers to and facilitators of physical activity program use among older adults. *Clinical medicine & research.* 2014;12:10-20.
32. Bauman AE, Reis RS, Sallis JF, et al. Correlates of physical activity: why are some people physically active and others not? *The lancet.* 2012;380:258-271.
33. Chase J-AD, Phillips LJ, Brown M. Physical activity intervention effects on physical function among community-dwelling older adults: a systematic review and meta-analysis. *Journal of aging and physical activity.* 2017;25:149-170.
34. Hobbs N, Godfrey A, Lara J, et al. Are behavioral interventions effective in increasing physical activity at 12 to 36 months in adults aged 55 to 70 years? A systematic review and meta-analysis. *BMC medicine.* 2013;11:1-12.
35. Blake H, Mo P, Malik S, Thomas S. How effective are physical activity interventions for alleviating depressive symptoms in older people? A systematic review. *Clinical rehabilitation.* 2009;23:873-887.
36. Hall KS, Sloane R, Pieper CF, et al. Long-term changes in physical activity following a one-year home-based physical activity counseling program in older adults with multiple morbidities. *Journal of aging research.* 2011.
37. van der Bij A, Laurant M, Wensing M. Effectiveness of physical activity interventions for older adults: a review. *American journal of preventive medicine.* 2002;22:120.

38. Harland J, White M, Drinkwater C, Chinn D, Farr L, Howel D. The Newcastle exercise project: a randomised controlled trial of methods to promote physical activity in primary care. *Bmj.* 1999;319:828-832.
39. McAuley E, Morris KS, Motl RW, Hu L, Konopack JF, Elavsky S. Long-term follow-up of physical activity behavior in older adults. *Health Psychology.* 2007;26:375.
40. McAuley E, Jerome GJ, Elavsky S, Marquez DX, Ramsey SN. Predicting long-term maintenance of physical activity in older adults. *Prev Med.* 2003;37:110-118.
41. French DP, Olander EK, Chisholm A, Mc Sharry J. Which behaviour change techniques are most effective at increasing older adults' self-efficacy and physical activity behaviour? A systematic review. *Annals of behavioral medicine.* 2014;48:225-234.
42. Wolff JK, Warner LM, Ziegelmann JP, Wurm S. What do targeting positive views on ageing add to a physical activity intervention in older adults? Results from a randomised controlled trial. *Psychology & Health.* 2014;29:915-932.
43. Maher CA, Lewis LK, Ferrar K, Marshall S, De Bourdeaudhuij I, Vandelanotte C. Are health behavior change interventions that use online social networks effective? A systematic review. *Journal of medical Internet research.* 2014;16:e40.
44. Norman GJ, Zabinski MF, Adams MA, Rosenberg DE, Yaroch AL, Atienza AA. A review of eHealth interventions for physical activity and dietary behavior change. *American journal of preventive medicine.* 2007;33:336-345. e316.
45. Han M, Lee E. Effectiveness of mobile health application use to improve health behavior changes: a systematic review of randomized controlled trials. *Healthcare informatics research.* 2018;24:207.
46. Giustini D, Ali SM, Fraser M, Boulos MNK. Effective uses of social media in public health and medicine: a systematic review of systematic reviews. *Online journal of public health informatics.* 2018;10.
47. Devi R, Powell J, Singh S. A web-based program improves physical activity outcomes in a primary care angina population: randomized controlled trial. *Journal of medical Internet research.* 2014;16:e186.
48. Richards J, Thorogood M, Hillsdon M, Foster C. Face-to-face versus remote and web 2.0 interventions for promoting physical activity. *Cochrane Database Syst Rev.* 2013;9:Cd010393.
49. Muller AM, Khoo S. Non-face-to-face physical activity interventions in older adults: a systematic review. *Int J Behav Nutr Phys Act.* 2014;11:35.
50. McNeill LH, Kreuter MW, Subramanian S. Social environment and physical activity: a review of concepts and evidence. *Social science & medicine.* 2006;63:1011-1022.
51. Booth ML, Bauman A, Owen N, Gore CJ. Physical activity preferences, preferred sources of assistance, and perceived barriers to increased activity among physically inactive Australians. *Preventive medicine.* 1997;26:131-137.
52. Burton NW, Khan A, Brown WJ. How, where and with whom? Physical activity context preferences of three adult groups at risk of inactivity. *British Journal of Sports Medicine.* 2012;46:1125-1131.
53. Short CE, Vandelanotte C, Duncan MJ. Individual characteristics associated with physical activity intervention delivery mode preferences among adults. *Int J Behav Nutr Phys Act.* 2014;11:25.
54. Pérez-Escamilla R, Hromi-Fiedler A, Vega-López S, Bermúdez-Millán A, Segura-Pérez S. Impact of peer nutrition education on dietary behaviors and health outcomes among Latinos: a systematic literature review. *Journal of nutrition education and behavior.* 2008;40:208-225.
55. Rossman B. Breastfeeding peer counselors in the United States: helping to build a culture and tradition of breastfeeding. *Journal of midwifery & women's health.* 2007;52:631-637.

56. Joseph DH, Griffin M, Hall RF, Sullivan ED. Peer coaching: an intervention for individuals struggling with diabetes. *The Diabetes Educator.* 2001;27:703-710.
57. Ginis KAM, Nigg CR, Smith AL. Peer-delivered physical activity interventions: an overlooked opportunity for physical activity promotion. *Translational behavioral medicine.* 2013;3:434-443.
58. Matz-Costa C, Howard EP, Castaneda-Sceppa C, Diaz-Valdes Iriarte A, Lachman ME. Peer-based strategies to support physical activity interventions for older adults: A typology, conceptual framework, and practice guidelines. *The Gerontologist.* 2019;59:1007-1016.
59. Humphreys K, Blodgett JC, Wagner TH. Estimating the efficacy of Alcoholics Anonymous without self-selection bias: An instrumental variables re-analysis of randomized clinical trials. *Alcoholism: Clinical and Experimental Research.* 2014;38:2688-2694.
60. Kaskutas LA. Alcoholics Anonymous effectiveness: Faith meets science. *Journal of addictive diseases.* 2009;28:145-157.
61. Wilson B. *Alcoholics Anonymous: Big Book.* AA World Services; 2015.
62. Buman MP, Giacobbi Jr PR, Dzierzewski JM, et al. Peer volunteers improve long-term maintenance of physical activity with older adults: a randomized controlled trial. *Journal of Physical Activity and Health.* 2011;8:S257-S266.
63. Dorgo S, King GA, Bader JO, Limon JS. Outcomes of a peer mentor implemented fitness program in older adults: A quasi-randomized controlled trial. *International journal of nursing studies.* 2013;50:1156-1165.
64. Castro CM, Pruitt LA, Buman MP, King AC. Physical activity program delivery by professionals versus volunteers: the TEAM randomized trial. *Health Psychology.* 2011;30:285.
65. Pratt M, Varela AR, Salvo D, Kohl III HW, Ding D. Attacking the pandemic of physical inactivity: what is holding us back? In: BMJ Publishing Group Ltd and British Association of Sport and Exercise Medicine; 2020.

CHAPTER 2

Early and extraordinary peaks in physical performance come with a longevity cost

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ABSTRACT

Life history theory postulates a trade-off between development and maintenance. This trade-off is observed when comparing life histories of different animal species. In humans, however, it is debated if variation in longevity is explained by differences in developmental traits. Observational studies found a trade-off between early and high fecundity and longevity in women. Development encompasses more than fecundity and also concerns growth and physical performance. Here, we show a life history trade-off between early and above average physical performance and longevity in male Olympic athletes. Athletes who peaked at an earlier age showed 17-percent increased mortality rates (95% CI 8-26% per SD, $p<0.001$) and athletes who ranked higher showed 11-percent increased mortality rates (95% CI 1-22% per SD, $p=0.025$). Male athletes who had both an early and extraordinary peak performance suffered a 4.7-year longevity cost. (95% CI 2.1-7.5 years, $p=0.001$). This is the first time a life history trade-off between physical performance and longevity has been found in humans. This finding deepens our understanding of early developmental influences on the variation of longevity in humans.

INTRODUCTION

Generalized life history theory postulates a trade-off between development and maintenance explaining the considerable variation of traits like age at maturation, age at first reproductive event, number of offspring, size and lifespan across and within species.[1-3] It is debated whether the variation in human lifespan can also be explained by such trade-offs. Observational studies in women have shown early and above average fecundity to come at a cost of longevity.[4-8] The life history of men has no distinct mark of the end of development as menarche in women, but negative correlations between number of offspring and life-span after age 50 have also been reported for males.[7,8] This could be explained as males invest more in physical strength and growth, which is associated with attractiveness and dominance, two traits important for male fitness.[9,10]

Professional athletes push their physical performance to the maximum and keep accurate track of these achievements. Consequently, their personal record is an accurate representation of the age of their peak performance. Under the assumption that professional athletes train at maximum intensity, this peak performance is an accurate read-out of the maximal physiological capacity of the individual. Because athletes compete intensely, the rank of peak performances is an accurate comparison of these maximal physiological capacities of athletes. According to theory of life history regulation, the period before the peak performance could be considered as development, while the decline in physical capabilities after setting a personal record is a hallmark of the ageing process.[11,12]

RESULTS

We used a unique historical cohort of 1055 Olympic track and field athletes from 41 different nationalities from the Olympic Games from 1896 through 1936.[13] Track and field is a large group of similar sports for individual performance where the results are measured on a continuous scale. Technological advancements contribute only little to basic body functions like running, throwing and jumping, which are critically dependent on physical strength and coordination. Athletic games are therefore an ideal group of sports to use in this study. Of these Olympic athletes 958 were men and 97 women, competing in 58 disciplines. Most historical athletes competed in several disciplines and therefore we had information on 2320 personal records. Mean age at personal record was 24.9 years (SD 3.8). The year of birth ranged between 1864 and 1913, and the year of death ranged between 1901 and 2010. Mean age at death was 72.1 years (SD 16.9). (See Supplementary Information)

To compare peak performance of athletes from different disciplines and sexes we standardized age at, and rank of the personal record per discipline and sex. Athletes who had a peak performance one standard deviation earlier showed 17-percent increased mortality rates compared to those who reached their personal record later in life (95% CI 8-26%, $p<0.001$). Independent of the age of their personal record, athletes who ranked one standard deviation higher than their peers showed 11-percent increased mortality rates compared to those who were ranked lower (95% CI 1-22%, $p=0.025$).

Figure 2.1 presents outcomes of various additional analyses. First, we analyzed males and females separately. Because of the small number of women in the early Olympic Games under study here, the risk estimates for women have very wide confidence intervals, but were not significantly different from men. Second, to exclude the influence of accidental causes of mortality directly related to professional sports, we analyzed survival from age 50 onwards. The outcomes did not differ. Third, instead of compiling their multiple personal records, we only analyzed the personal record in the athlete's primary discipline, the highest ranking discipline, which provided similar outcomes. Fourth, we performed analyses in which we standardized the personal records not per Olympic discipline but per cardiovascular intensity category as classified by the American college of cardiology, and per category as classified by the IAAF as we have done earlier.[14-16] The estimates were unaffected. Finally, we considered whether the outcomes could have been influenced by any kind of performance enhancing drugs. The first doping that was proven effective was developed in 1935; we therefore assumed

that before that year an effect of doping was excluded.[17,18] Using the 92% of the observations that were achieved before 1935 yielded similar results (Figure 2.1). It is important to note that cocaine was available since the first Olympic games and could have played a role in the association.

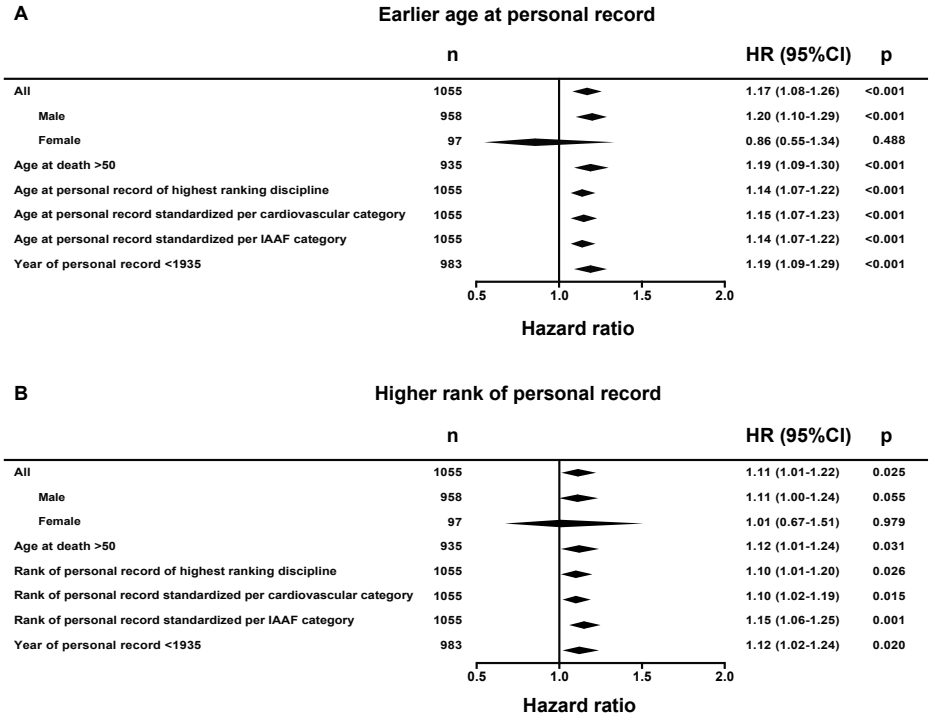

Figure 2.1. Hazard ratio (HR) for mortality of all Olympic athletes under study and several additional analyses. (**A**) Hazard ratio per standard deviation younger age at personal record and (**B**) per standard deviation higher of rank of personal record. Hazard ratios were derived from a multivariate left truncated Cox' regression model, adjusted for nationality, sex, year of birth and respectively rank of personal record or age at personal record. Main analysis is with all 1055 Olympic athletes. 'Age at death >50' indicates that all athletes who died before age 50 were excluded. For the 'Age of personal record of the highest ranking discipline' analysis, we used an athlete's relative best discipline to calculate age and rank of peak performance. In the analyses 'Standardized per cardiovascular category and IAAF category', we grouped and standardized age and rank of personal record per cardiovascular intensity or per IAAF category (see methods). In the 'Year of personal record <1935' analysis, all personal records set after the year 1935 were excluded.

Life history regulation presumes a compromise between variations in the age at, and the extent of physical development and longevity (see Figure 2.2A).[19] Figure 2.2 also presents the average age at death depending on the age and the rank of the personal record. Since hazard ratios of mortality for women were not significant associated with age or rank of personal record, the following estimates were calculated in males only. Male athlete's age at death increased from 73.4 (SE 1.3) years in those who had their peak performance in the 25% youngest age range to 77.9 (SE 1.2) years in athletes who reached their personal record in the 25% oldest age range (panel B, $p<0.001$). Panel C shows the association between the rank of the personal record and the age at death. The age at death decreased from 76.8 (SE 1.7) years in those who had their peak performance in the 25% lowest ranks to 74.1 (SE 1.4) years in male athletes who reached their personal record in the 25% highest ranks ($p=0.028$). Panel D shows the joint effect of age at, and rank of the personal record. We found that the mean age at death was lowest (72.8, SE 1.4) for those male athletes whose personal record was in the earlier half of age and better half of rank. Male athletes who peaked at a later age and had a relatively minor rank died at a mean age of 77.5 (SE 1.2), resulting in a 4.7 (SE 1.4) year difference in life expectancy between the two groups ($p=0.001$).

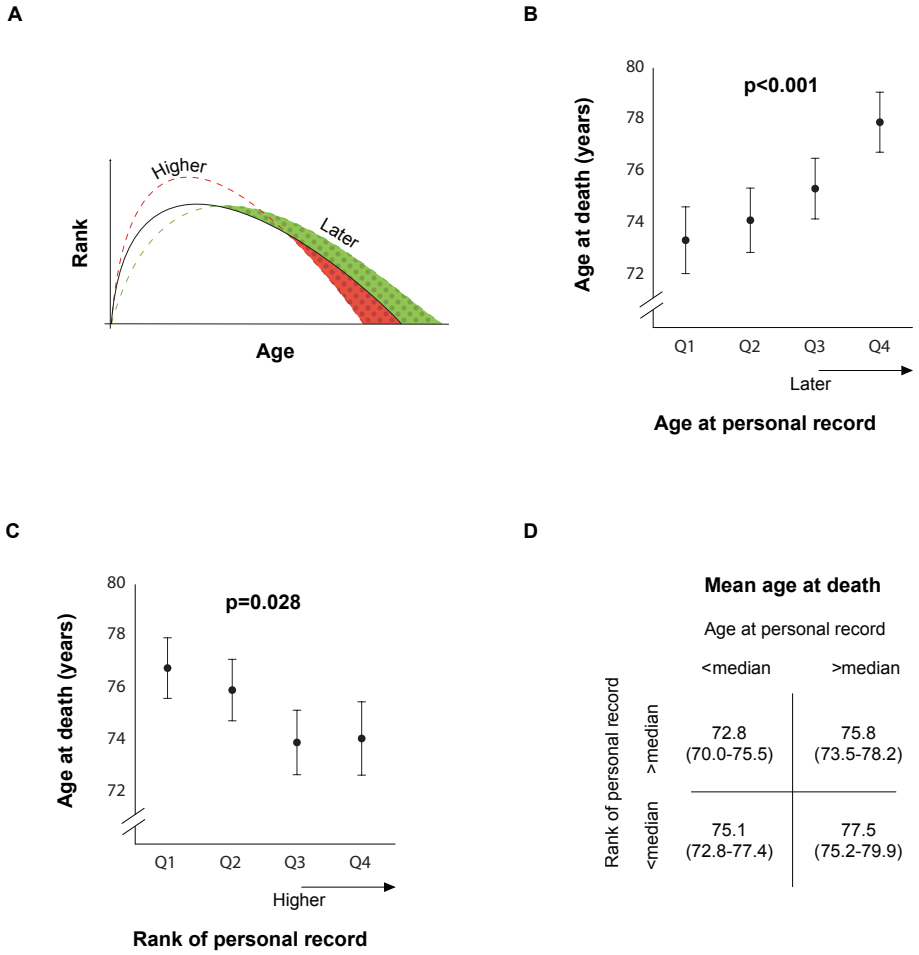

Figure 2.2. Age at death of male athletes dependent on the age and rank of their personal record. (**A**) Predicted scenarios by life history theory with a later age at personal record and a higher performance score of personal record. (**B**) Estimated mean age at death per quartile of age at personal record and (**C**) estimated mean age at death per quartile of performance score of personal record. Error bars denote one standard error. (**D**) Estimated mean age at death and between brackets the corresponding 95% confidence interval shown for four different groups. All estimates are derived from a linear mixed model with only males who died after age 50, adjusted for sex, year of birth, nationality and respectively rank of personal record or age at personal record.

DISCUSSION

Several factors have to be considered when interpreting the present findings. First, differences in socioeconomic status could have distorted the observations as wealthier athletes may have had better training and therefore gained better personal records at an earlier age. An affluent environment during development is not only likely to contribute to earlier and better physical performance, wealthy people on average live longer than poor people. We did not have information on the socioeconomic position of the athletes, but differences are unlikely to explain for the observed trade-off, for they would have worked in the opposite direction and, if anything, they may have masked the associations and any true biological relation would even be stronger. We also had no information on the height of athletes.

Early cessation of training and competition of individual athletes could have resulted in an underestimation of the age, and the rank of the personal record. Personal records however, have been recorded not only at the Olympic Games but also at every other official competition, and we assumed that all athletes were determined to maximize their performance over a prolonged period and would only stop prematurely in rare instances. Even if early cessation was frequent, it would have weakened the observed association between peak performance and age at death and again, any true relation would be stronger than we observed here.

According to expectation, we observed a gradual increase in life expectancy of athletes from later birth cohorts (data not shown). Moreover, a recent year of birth was also related to a better personal record at an earlier age. This ongoing professionalization of sports thus masked the observed trade-off; we therefore adjusted for birth cohort.

It is difficult to interpret the outcomes among women. One possibility is that there is a sex dimorphism and the effect is smaller in women, but we were not able to study this properly because of the relatively small number of female athletes. The alternative is that the variance is greater but the effect size is not different. It has already been shown that early sexual maturation and high fertility of females, which can also be considered a peak physical performance, come at a longevity cost.[4-6] Especially under adverse environmental conditions, the average lifespan of fertile women is reduced by fatal consequences of pregnancy and childbirth. Moreover, experimental models and observations in humans also provide evidence that increases in fecundity come with a longevity cost.[7,8,20,21]

Whereas previous studies on the cost of sexual development and success could only reliably be estimated in women, we here show for the first time that early and extraordinary peaks in physical performance trades off at longevity in men. Physical excellence and sports may have a direct cost due to intense training and fierce competition, especially when there is a high risk of bodily collision or levels of physical contact.[16] It is less likely that these direct costs explain the observed trade-off between early and extraordinary physical performance and longevity, since we showed a similar trade off when analyzing residual life expectancy from age 50. This finding supports the idea that early and extraordinary peak performance comes with a higher pace of ageing.[22,23] It is tempting to speculate about the underlying biological mechanisms of this developmental constraint. Some have suggested that growth and subsequently, larger size, result in a body which costs more energy to maintain, explaining the higher pace of ageing.[24,25] The mTOR pathway, which regulates growth in early life and pace of ageing in late life, is a potential molecular pathway that can explain for the observed trade off.[26-28] Others have suggested that hormonal regulation of development and maintenance could play a role, as has been observed for the GH-IGF signaling pathway explaining the size-life span trade off in domestic dogs, and the muscle mass-immune competence trade-off mediated by testosterone observed in primates and other species.[10,29-32] All mechanistic explanations are plausible and it needs to be studied which pathways are causal, and at which we can intervene to secure longer and healthier lives.

METHODS

Experimental design

This study is an observational cohort study to investigate the effect of the age at, and relative rank of personal record on age at death in Olympic track and field athletes.

Study population

Data on year of birth, year of death, discipline, year of personal record, performance score of personal record and nationality were retrieved from the continuously updated and most comprehensive online database on Olympic athletes: Sports Reference database, in April 2014.[13] We used this database previously to determine the difference in mortality between disciplines with different cardiovascular intensity.[16] We included all Olympic track and field athletes with a known personal record. This group consisted of 3671 athletes. First, we excluded 2274 athletes who were born after 1913 to ensure that we had a cohort of individuals with a complete life history. Second, we excluded 126 athletes with an unknown date of birth and 216 athletes with an unknown age of death. In an additional analysis, we excluded athletes who died before age 50 (n=120), to minimize the effect of survival bias and extrinsic or accidental causes of mortality. For one of the analyses, we excluded all personal records set after the year 1935, effectively before the effective doping became available. Recording of personal records was not bound to the Olympic Games and also include every official competition, excluding trainings.

Disciplines

The track and field category consisted of 58 disciplines. In the throwing and jumping disciplines we used distance as a measure, in the running disciplines we converted time over a fixed distance to average speed for reasons of comparison, and in the pentathlon and decathlon we used the number of points. Variation in the number of points in the pentathlon and decathlon was high enough to be a good reflection of the athlete's performance.

The performance score of personal record was average speed (m s-1) for the running or walking disciplines, distance (m) for the throwing and jumping disciplines or number of points for the pentathlon and decathlon.

When categorizing the various disciplines per cardiovascular intensity category we used the classification of sports published in the Journal of American college of cardiology, as we have used before [15,16].[15,16] In the analysis where we grouped multiple disciplines according to the International Association of Athletics Federation (IAAF) classification before standardization, we categorized the disciplines in a short, middle, long, jumping and throwing category.[14]

Statistical analysis
For means of comparison between disciplines we standardized age and performance score of the personal records. We divided the deviation from the mean age at personal record of the discipline and sex for each discipline and sex separately. The same was done for the performance score of the personal record to derive the relative rank of the personal record. Additionally, we grouped personal records per cardiovascular intensity category or per IAAF category, as described earlier, and standardized age and performance score in these groups to derive an alternative method for estimating the relative age and rank of the personal record.

Most athletes had more than one personal record and had therefore more than one age and performance score of personal record. For the primary analysis we calculated the average age and rank of the personal record for each of the disciplines, all after standardizing. As an additional analysis we used the best personal record of an athlete, their primary discipline, using the record with the highest rank.

We used a left truncated cox proportional hazard model to calculate hazard ratios for mortality from the age of the peak performance forward. We used estimated marginal means from a linear mixed model to estimate the mean age at death in groups. The linear mixed model was applied on the subset of 844 male athletes who died after age 50, to artificially left truncate the linear mixed model. All estimates were adjusted for sex, year of birth and nationality where possible.

All analyses were performed using IBM SPSS Statistics 22.0 (IBM Corp., Armonk, NY).

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REFERENCES

1. Harvey PH, Zammuto RM. Patterns of mortality and age at first reproduction in natural populations of mammals. *Nature.* 1985;315:319-320.
2. Ingram DK, Reynolds MA, Les EP. The relationship of genotype, sex, body weight, and growth parameters to lifespan in inbred and hybrid mice. *Mechanisms of ageing and development.* 1982;20:253-266.
3. Rollo CD. Growth negatively impacts the life span of mammals. *Evolution & development.* 2002;4:55-61.
4. Jacobsen B, Oda K, Knutsen S, Fraser G. Age at menarche, total mortality and mortality from ischaemic heart disease and stroke: the Adventist Health Study, 1976–88. *International journal of epidemiology.* 2009;38:245-252.
5. Jacobsen BK, Heuch I, Kvåle G. Association of low age at menarche with increased all-cause mortality: a 37-year follow-up of 61,319 Norwegian women. *American journal of epidemiology.* 2007;166:1431-1437.
6. Lakshman R, Forouhi NG, Sharp SJ, et al. Early age at menarche associated with cardiovascular disease and mortality. *Journal of Clinical Endocrinology & Metabolism.* 2009;94:4953-4960.
7. Westendorp RG, Kirkwood TB. Human longevity at the cost of reproductive success. *Nature.* 1998;396:743-746.
8. Wang X, Byars SG, Stearns SC. Genetic links between post-reproductive lifespan and family size in Framingham. *Evolution, medicine, and public health.* 2013;2013:241-253.
9. Fink B, Neave N, Seydel H. Male facial appearance signals physical strength to women. *American Journal of Human Biology.* 2007;19:82-87.
10. Muehlenbein MP, Bribiescas RG. Testosterone-mediated immune functions and male life histories. *American journal of human biology : the official journal of the Human Biology Council.* 2005;17:527-558.
11. Donato AJ, Tench K, Glueck DH, Seals DR, Eskurza I, Tanaka H. Declines in physiological functional capacity with age: a longitudinal study in peak swimming performance. *Journal of Applied Physiology.* 2003;94:764-769.
12. Ericsson KA. Peak performance and age: an examination of peak performance in sports. In: Baltes PB, Baltes MM, eds. *Successful aging: Perspectives from the behavioral sciences.* Vol 4. Cambridge University Press; 1993:164-196.
13. Sports Reference LLC. Olympics at Sports-Reference.com - Olympic Statistics and History. http://www.sports-reference.com/. Accessed April 2014.
14. International Association of Athletics Federation. IAAF: Disciplines. http://www.iaaf.org/disciplines. Accessed April 2016.
15. Mitchell JH, Haskell W, Snell P, Van Camp SP. Task Force 8: classification of sports. *Journal of the American College of Cardiology.* 2005;45:1364-1367.
16. Zwiers R, Zantvoord F, Engelaer F, Van Bodegom D, van der Ouderaa F, Westendorp R. Mortality in former Olympic athletes: retrospective cohort analysis. *BMJ.* 2012;345:e7456.
17. Holt RI, Erotokritou-Mulligan I, Sönksen PH. The history of doping and growth hormone abuse in sport. *Growth Hormone & IGF Research.* 2009;19:320-326.
18. Yesalis CE, Bahrke MS. History of doping in sport. *Performance enhancing substances in sport and exercise Champaign: Human Kinetics.* 2002:1-20.

19. Promislow DE, Harvey PH. Living fast and dying young: A comparative analysis of life-history variation among mammals. *Journal of Zoology.* 1990;220:417-437.
20. Lycett JE, Dunbar R, Voland E. Longevity and the costs of reproduction in a historical human population. *Proceedings of the Royal Society of London B: Biological Sciences.* 2000;267:31-35.
21. Meeûs D. Human longevity at the cost of reproductive success: evidence from global data. *Journal of Evolutionary Biology.* 2000;13:409-414.
22. Baudisch A. The pace and shape of ageing. *Methods in Ecology and Evolution.* 2011;2:375-382.
23. Finch CE. *Longevity, senescence, and the genome.* University of Chicago Press; 1994.
24. Wensink MJ, van Heemst D, Rozing MP, Westendorp RG. The maintenance gap: a new theoretical perspective on the evolution of aging. *Biogerontology.* 2012;13:197-201.
25. Blagosklonny MV. Big mice die young but large animals live longer. *Aging.* 2013;5:227-233.
26. Leontieva OV, Paszkiewicz GM, Blagosklonny MV. Mechanistic or mammalian target of rapamycin (mTOR) may determine robustness in young male mice at the cost of accelerated aging. *Aging.* 2012;4:899-916.
27. Blagosklonny MV. Why men age faster but reproduce longer than women: mTOR and evolutionary perspectives. *Aging.* 2010;2:265-273.
28. Blagosklonny MV, Hall MN. Growth and aging: a common molecular mechanism. *Aging.* 2009;1:357-362.
29. Berryman DE, Christiansen JS, Johannsson G, Thorner MO, Kopchick JJ. Role of the GH/IGF-1 axis in lifespan and healthspan: lessons from animal models. *Growth Hormone & IGF Research.* 2008;18:455-471.
30. Greer KA, Canterberry SC, Murphy KE. Statistical analysis regarding the effects of height and weight on life span of the domestic dog. *Research in veterinary science.* 2007;82:208-214.
31. Kraus C, Pavard S, Promislow DE. The size–life span trade-off decomposed: why large dogs die young. *The American Naturalist.* 2013;181:492-505.
32. Sutter NB, Bustamante CD, Chase K, et al. A single IGF1 allele is a major determinant of small size in dogs. *Science.* 2007;316:112-115.

CHAPTER 3

Vitality Club: A proof-of-prinicple of peer coaching for daily physical activity by older adults

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ABSTRACT

Many age-related diseases can be prevented or delayed by daily physical activity. Unfortunately, many older adults do not perform physical activity at the recommended level. Professional interventions do not reach large numbers of older adults for a long period of time. We studied a peer-coach intervention, in which older adults coach each other, that increased daily physical activity of community dwelling older adults for over 6 years. We studied the format and effects of this peer coach intervention for possible future implementation elsewhere. Through interviews and participatory observation we studied the format of the intervention. We also used a questionnaire (n=55) and collected 6-min walk test data (n=261) from 2014 to 2016 to determine the motivations of participants and effects of the intervention on health, well-being and physical capacity. Vitality Club is a self-sustainable group of older adults that gather every weekday to exercise coached by an older adult. Members attend on average 2.5 days per week and retention rate is 77.5% after 6 years. The members perceived improvements in several health measures. In line with this, the 6-min walk test results of members of this Vitality Club improved with 21.7 meters per year, compared with the decline of 2-7 meters per year in the general population. This Vitality Club is successful in durably engaging its members in physical activity. The members perceive improvements in health that are in line with improvements in a physical function test. Because of the self-sustainable character of the intervention, peer coaching has the potential to be scaled up at low cost and increase physical activity in the increasing number of older adults.

INTRODUCTION

Many age-related diseases can be prevented or delayed by a healthy lifestyle.[1-4] Especially daily physical activity has been found effective at preventing and treating many age-related diseases and risk factors such as cardiovascular disease, hypertension, obesity, type 2 diabetes, osteoporosis, and sarcopenia.[5-7] In older adults it also reduces depression, anxiety, the risk of falls and increases mobility, quality of life and longevity.[7-9] Unfortunately, most older adults do not reach the recommended level of 150 min of physical activity per week.[10-12] As a result, physical inactivity is currently a major cause of age-related health problems.[13] Different professional interventions to increase physical activity given by physicians, physiotherapists, and nurses are successful during the intervention period and have been found to have substantial health benefits. However, these professional interventions generally only reach a small part of the target population. Furthermore, when the intervention stops, physical activity returns to baseline and the beneficial effects vanish in most participants.[14,15] Due to a scarcity of time, money and healthcare professionals, older adults cannot receive a continuous professional intervention for the rest of their lives.[16,17] Therefore, other more sustainable options to increase daily physical activity for the rising number of older people have to be explored.

Among the alternatives are online interventions, but the first intervention studies in this field have not been able to increase daily physical activity for large numbers of people.[18,19] Furthermore, most of these studies are not specially designed for older adults.[20,21] Phone based intervention is another option that has been studied in older adults and has proven effective in promoting physical activity in some studies.[22] However, studies show that face-to-face social support and buddy systems are successful in increasing physical activity and most preferred by older people.[23-26] One particularly promising intervention not constraint by a scarcity of professionals is peer coaching.[27-30] Peer coaching is a face-to-face intervention to reach a common goal given by a non-professional, who has a common background with the recipient, either through a similar life experience or other shared characteristics. The strength of peer-coaching lies in empathy and using the experiential knowledge of the peer coach, to understand the other peers wishes, motivations, possibilities and limitations. The most successful and widely-known peer coaching initiative is Alcoholics Anonymous, with more than two million members spread over 150 countries.[31-33] Although this initiative is secondary prevention, peer coaching could also be effective in primary prevention such as increasing physical activity in older adults.

We studied how peer coaching is used to sustainably increase daily physical activity of a group of older adults in a proof-of-principle in Ulft, a rural town in The Netherlands, where a group of older adults gathers daily for 1 hr physical activity coached by a peer. Here, we describe the FreeWheel club, the first Vitality Club, by examining the format, the motivations of the members and the effects of participation on health, well-being, and physical capacity. The analysis of this successful proof-of-principle could provide a basis for future implementation elsewhere.

METHODS

Format of the intervention

The *FreeWheel* club was founded by an older adult in September 2010 as a public benefit organization. At the time of the study the club consisted of 69 older adults, of which 63 were member and 6 were founder or peer coach. The *FreeWheel* club is situated in a rural area with around ten thousand inhabitants. The goal of the *FreeWheel* club was to be a self-sustainable, easily accessible and low-cost club with daily exercise especially tailored for older adults, but people of all ages were allowed to participate.

The setting, daily routine and social interaction of the group was documented through participatory observation. Semi-structured in-depth interviews were conducted by the first author with the two initiators of the *FreeWheel* club and the four peer coaches. Removed additionally, membership administration was used to identify date of enrolment of members. Exact date of enrolment and disenrollment of former members was unknown. Based on the interviews, a questionnaire was designed and sent to all 63 members of the *FreeWheel* club (55 respondents). The questionnaire was divided in three sections. The first section was to assess personal characteristics about the behaviour of the member. What days did the member attend sessions of the *FreeWheel* club, how often did they drank coffee after a session and what members did they know before joining the *FreeWheel* club.

Motivations

To study the motivations to join the *FreeWheel* club and to continue to participate we used free-form questions in the questionnaire (n=55). The second section of the questionnaire assessed the experienced motivations and barriers to become a member and keep attending the *FreeWheel* club. Participants could provide as many reasons as they could think of. The full questionnaire is available in English in the supplementary information. The original questionnaire was in Dutch. Ethical approval was obtained from the Institutional Review Board of the Leyden Academy on Vitality and Ageing. All participants provided informed consent on paper.

Effects of the intervention

To assess the effect of the *FreeWheel* club we used the questionnaire and data on 6-min walk tests (6MWT), which measures the maximum distance a person can walk in 6 min. The questionnaire was used to assess self-reported effects. In the third section of the questionnaire, members rated their health and well-being to

reflect the status before membership and their current status. Health and well-being included weight, social events per week and quality of life. All aspects can be seen in table 3.2. The sub-sample size of the self-reported effects are similar to the size of the motivation analysis.

The 6MWT was used to objectively asses the effects of the *FreeWHeel* club on functional capacity. This test is commonly used to measure functional capacity in older adults and is associated with all-cause mortality.[34-36] A person is told to walk the largest distance possible in 6 min without running. The test is conducted over a distance of 50 meters that can be covered multiple times back and forth. Participants get feedback concerning the remaining time. The *FreeWheel* club conducted this test during sessions between November 2014 and April 2016 at 13 timepoints. Resulting in 261 results from 53 unique members. The test was an initiative of a peer coach. They wanted to conduct the test monthly, but the time interval was not strict, and together with the summer break, it resulted in 13 tests in 18 months.

Differences in self-perceived general health and well-being were analyzed using a paired sample *t*-test. The effect of membership of the *FreeWheel*club on the 6-min walk test was analyzed using a multi-level regression model. The determinants in level one of the model were location of the test and time in years from first measurement, which was at November 21, 2014. The level two determinants in the analysis were weight, height, gender, age at enrolment and years of membership at first measurement. Level one determinants change within an individual for each measurement, level two determinants are static within an individual and only vary between individuals. All predictors in the models were treated as fixed effects except for the intercept, which had a random effect in the model. For additional analyses, we stratified the study group by age at enrolment and 6-min walk distance at first measurement by dividing the group at the 50th percentile for the three variables. We stratified membership duration at first measurement in two groups, the first group had a membership duration of less than 1 year at first measurement and the other group had a longer membership duration. There was no missing data in the survey. Missing data in the 6-min walk test was *missing at random* and was not considered problematic for the MIXED model analysis.[37] Statistical analyses are performed with IBM SPSS Statistics for Macintosh, Version 22.0, Armonk, NY: IBM Corp.

RESULTS

Format of the intervention

Table 3.1 shows the characteristics of the members. All persons actively involved in the creation of the *FreeWheel* club and the regular peer coaches were interviewed individually once and excluded from the questionnaire. Of the remaining 63 people that were eligible for the questionnaire, 55 members (87.3%) responded. There are more women (73%) than men (27%) in the *FreeWheel* club. Next, the majority is unemployed (72%), mostly because of retirement. The formal age of retirement in the Netherlands was 65 up until 2013 and is gradually increasing to 67 in 2021. Also, there are more low educated members than middle or high educated. The median net disposable income of *FreeWheel* club members lies between 2,000 and 2,500 euro, which is similar to the general population in the Netherlands.[38] Finally, at the moment of the study the membership duration was on average 2.8 years (*SD* 1.8).

Table 3.1 Characteristics of *FreeWheel* club members

FreeWheel club members, n	63
Completed 6MWT at least once, n (total measurements)	53 (261)
Survey respondents, n (%)	55 (87%)
Gender, n (%)	
Male	15 (27%)
Female	40 (73%)
Age in years, mean (SD)	65.5 (6.2)
Male	68.1 (3.7)
Female	64.5 (6.6)
Body Mass Index[a], mean (SD)	25.5 (5.2)
Male	26.0 (2.8)
Female	25.3 (6.1)
Marital status, n (%)	
Unmarried and never married	2 (4%)
Married	48 (87%)
Divorced	1 (2%)
Widowed	4 (7%)
Employed status, n (%)	
Employed	9 (17%)
Unemployed	3 (6%)

Table 3.1 Continued

FreeWheel club members, n	63
Retired	35 (66%)
Other	6 (11%)
Educational level, n (%)[b]	
Low	26 (48%)
Middle	15 (28%)
High	13 (24%)
Disposable income per household, n (%)	
<500	4 (11%)
500 – 1000	4(11%)
1000 – 1500	3 (9%)
1500 – 2000	5 (14%)
2000 – 2500	5 (14%)
2500 – 3000	3 (9%)
>3000	11 (31%)
Number of sessions attended per week[d], mean (SD)	2.5 (1.0)
Years of membership, n (%)	
<1 year	9 (16%)
1 – 2 years	20 (36%)
2 – 3 years	5 (9%)
3 – 4 years	6 (11%)
4 – 5 years	8 (15%)
5 – 6 years	7 (13%)

Characteristics of *FreeWheel* club members. Some categories do not add up to 55 because of missing data. [a] Based on self-reported weight and height. [b] Low educational level is an educational degree not higher than lower secondary education. Middle educational level is everything between low and high educational level. High educational level defined as having a degree from a University or Higher Professional Education. [c] Disposable income per household is total income per household minus taxes and social fees. [d] Self-reported attendance

Figure 3.1 shows the growth of the *FreeWheel* club over the past 6 years. The first session was preceded by advertisements in the community paper and flyers at the local soccer club. Moreover, friends and family of the initiators were asked to

join the session. This resulted in ten people. Members of the *FreeWheel* Club live no further than 6 kilometres from the rendezvous. A total of 89 people ever joined the *FreeWheel* club, of which 20 members stopped, resulting in a group of 69 older adults at the time of the study. This means the *FreeWheel* club has a retention rate of 77.5% over a period of 6 years.

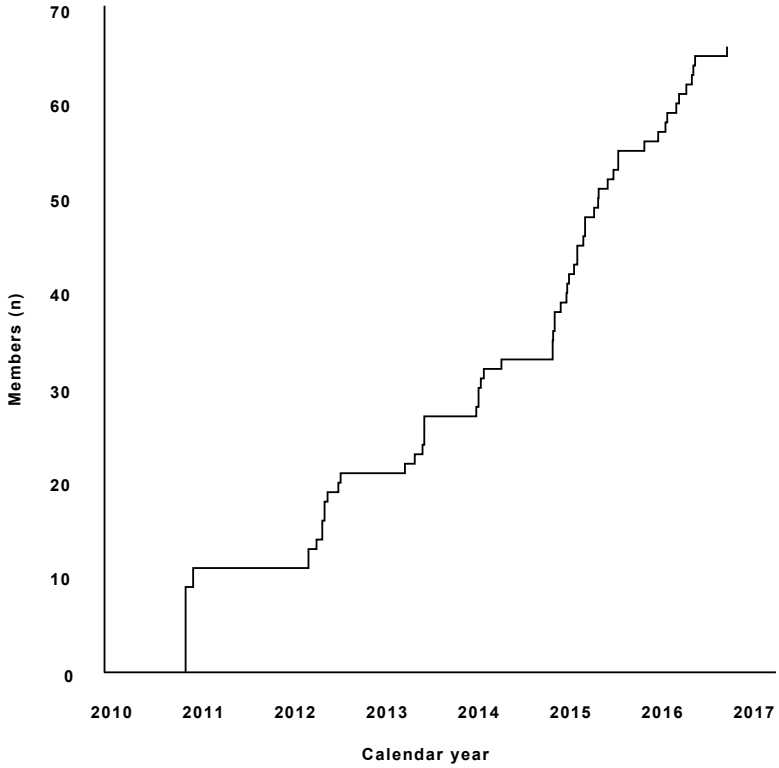

Figure 3.1. Growth of the FreeWheel club The line shows the cumulative number of members in time.

The *FreeWheel* club gathers every weekday, at 9 o'clock AM at the local soccer club or athletic association. On average, 28 people exercise together for an hour instructed by a peer. Every meeting, an average of 55% of the people stay afterwards for a coffee. For most members, this social interaction with fellow members is an integral part of the *FreeWheel* club. If the weather conditions are too bad to exercise outside, the group moves to the sports canteen or stadium stands and exercises there. The regular peer coaches both lead 2 days. One day is different from the other days as the *FreeWheel* club goes walking together and that nonmembers are also allowed to participate.

The first peer coach is 79 years old. He makes sure that shoulder, chest, abdomen, back, pelvis, and leg muscles will be used at least once during training. The second regular peer coach is 68 years. He is a retired athletic trainer, who focuses on strength, flexibility, speed, coordination, and stamina to ensure optimal function in activities of daily living. He is assisted by his wife during the sessions. The two regular peer coaches are substituted during the summer holiday by two extra peer coaches. All peer coaches have experience in giving training to groups, either as instructor of some sport or yoga teacher. There was no program manual, and all peer coaches used their own experience to develop a physical activity program. The flexibility and differences between the sessions of different peer coaches could be an essential part of the *FreeWheel* club.

In the beginning the *FreeWheel* club received a donation of 3,000 euros from the local soccer club. This money was used to buy a collection of sports materials. Structural costs come from the rent for the soccer field and the peer coaches. The regular peer coaches receive a small fee of five euros per hour, which is the maximum allowed fee for volunteers in the Netherlands. Members must pay one euro per week for membership and two euros per quarter for the rent of the soccer field, totaling at 15 euros per quarter.

Motivations

The three most common motivations for joining the *FreeWheel* club sessions were the wish to become physically fitter (n=46 [84%]), to have social interaction (n=18 [33%]) and the fact that the *FreeWheel* club exercised outside (n=10 [18%]). The three most common motivations to continue attending the *FreeWheel* club sessions were similar to the motivations to join the *FreeWheel* club, however social interaction was mentioned almost twice as much. The most mentioned reason to stay a member was the positive change in physical capacity experienced by the members (n=51 [93%]). Second and third most common motivations were again social interaction and the outside setting (n=34 [62%] and n=15 [27%], respectively).

Effects of the intervention

Table 3.2 shows the self-reported effects on health and well-being after joining the *FreeWheel* club. There was a significant increase in days of physical activity. Females reported a significant decrease in weight. Self-rated measures of quality of sleep, quality of life, physical capacity, and knowledge of healthy lifestyle all improved significantly.

Table 3.2 Self-reported effects on health and well-being after joining the *FreeWheel* club

	Before (SE)	After (SE)	p
Days with more than 30 minutes of physical activity per week (n)	1.8 (0.3)	3.5 (0.2)	**<0.01**
BMI			
Male	26.0 (0.8)	25.6 (0.7)	0.47
Female	25.3 (1.1)	24.4 (0.8)	**0.02**
Days per year ill (n)	2.1 (0.5)	1.5 (0.3)	0.57
Falls per year (n)	2.0 (1.7)	0.2 (0.1)	0.30
General practitioner consults per year (n)	1.8 (0.3)	1.7 (0.2)	0.80
Social events per week (n)	3.2 (0.4)	3.6 (0.4)	0.12
Days feeling lonely per week (n)	0.1 (0.1)	0.0 (0.0)	0.32
Quality of sleep (score 1-10)	7.1 (0.2)	7.4 (0.2)	**0.01**
Physical capacity (score 1-10)	6.7 (0.2)	7.6 (0.1)	**<0.01**
Knowledge of healthy lifestyle (score 1-10)	7.3 (0.1)	7.8 (0.1)	**<0.01**
Quality of life (score 1-10)	7.9 (0.1)	8.1 (0.1)	**<0.01**

Boldface indicates statistical significance (p<0.05). P-values are derived from a paired sample t-test.

As an objective measure of physical capacity, a total of 13 6MWT over a period of one and a half year were conducted during regular sessions with members who were present at that session. A total of 261 6MWT results of 53 unique members were collected. Only including the first test, members of the *FreeWheel* club walked on average 670 meters in 6 min (*SD* 54.1 m). We used a multilevel regression model to estimate the effect of membership of the *FreeWheel* club on 6-min walk distance. During November 2014 and April 2016, the period when the 6-min walk tests were conducted, results increased with 21.7 meters per year (95% CI 10.8-32.6, p<0.001). In a stratified analysis dividing the group in the 50th percentile for age, both younger (age 40.4-63.7) and older (age 64.0-74.1) members had similar increments of respectively 20.7 (95% CI 6.4-35.0, p=0.005) and 21.3 meters per year (95% CI 3.5-39.1, p=0.020). Stratification by 6-min walk distance at first measurement (550 m-670 m vs. 675 m-785 m) yielded similar results. Members who were in their first year of membership at first measurement benefitted more than those who were member for a longer period at first measurement, 37.5 meter per year (95% CI 22.8-52.2, p<0.01) and 9.7 meter per year, respectively (95% CI −6.5-25.8, p=0.24). Additionally, members that stayed for coffee afterwards in more than half of the attended sessions benefitted more (26.6 meters per year, 95% CI 9.8-41.4, p<0.01) compared to those who stayed for coffee less than half of the attended sessions (16.9 meters per year, 95% CI 2.0-

31.8, p=0.03). As a final analysis, we also studied whether people who attended more often had higher increases in 6-min walking test. We found that every extra day of average weekly attendance resulted in an increase of walking distance of 8.2 meters, although this was not significant (95% CI −12.7-29.1, p=0.43).

Figure 3.2 shows the effect of membership of the *FreeWheel* club on the 6-min walk distance. Data points connected by a dashed line represent one individual. The straight line represents the average increase as calculated by the multilevel regression.

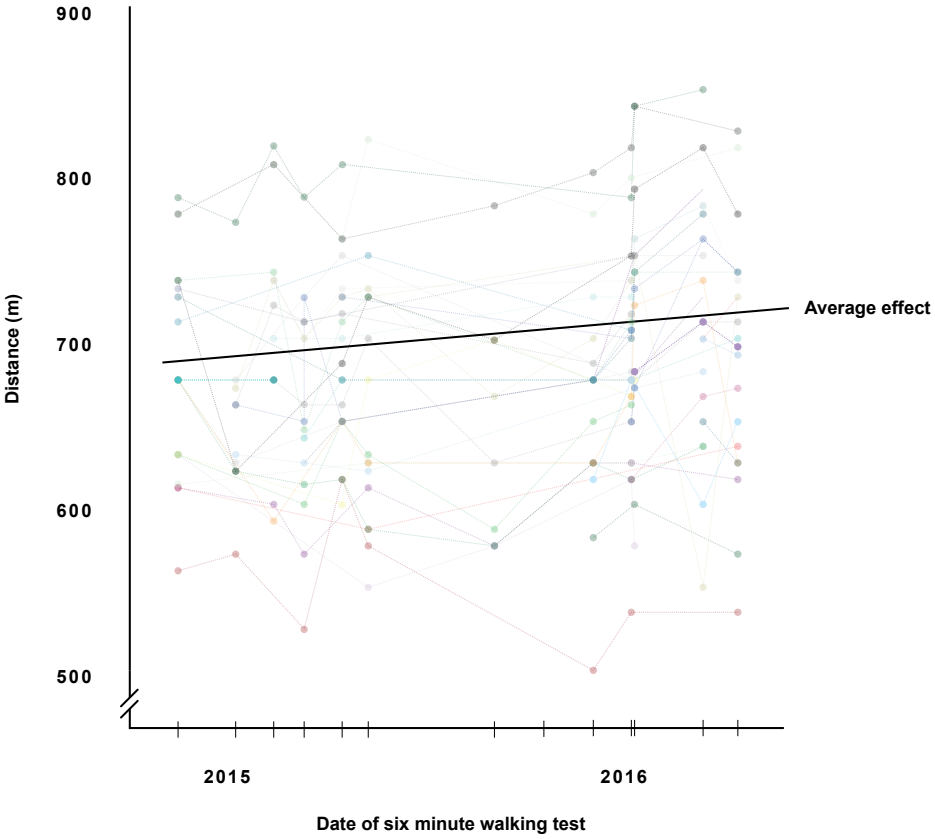

Figure 3.2. Participation in the FreeWheel club and 6-min walk distance. On the x-axis are the timepoints when the FreeWheel club conducted the 6-min walk tests. On the y-axis the distance walked in 6 min (meters). Data points connected by a dashed line represent one individual. The straight line is the average increase in 6-min walk distance of all members during the study period calculated by a multi-level regression model adjusted for age at enrolment, years between enrolment and first measurement, that is, November 21, 2014 (membership duration), sex, height, weight, and location of test (soccer field or all-weather running track).

DISCUSSION

The *FreeWheel* club is a peer coaching initiative that increases daily physical activity in 69 older adults and has been self-sustainable for almost 6 years. There is a high representation of lower educated individuals, which is important because low educated individuals are less physically active, have higher disease burden and are less likely to be reached by traditional interventions.[39-41] The members perceive improvements in health and well-being since they became member of the *FreeWheel* club. In line with this, the members of the *FreeWheel* club improve their 6-min walk distance with 21.7 meters every year. While in the general population there is a decline of 2–7 meters per year.[42-44] Several studies show that distance walked in 6 min is associated with all-cause mortality and that declining results is an independent predictor.[35,36] Even though 6MWT results are associated with mortality risk, improving the 6MWT results is likely, but not certainly, improving the mortality risk.

Several limitations need to be considered in this proof-of-principle. First, the *FreeWheel* club originated spontaneously in the community through the initiative of older people and the use of older peercoaches. The downside however, is that it was never set up as a study from the beginning and some measures could therefore only be taken retrospectively. Second, the *FreeWheel* club is situated in a rural town. Small towns are known for having tight communities and high levels of social control. It is unclear whether this is of influence on the *FreeWheel*club, and in what direction this effect works. However, in Cuba there are 12,903 *Circulos de Abuelos*, which are clubs similar to the *FreeWheel* club, with 820,976 members in 2011.[45,46] This suggests that the reproduction of the initiative in more places and on a larger scale is possible. Finally, we observed a single club, therefore there was no way to compare different clubs and find common factors of success. Substantial part of this proof-of-principle was retrieved from interviewing the initiator, cofounder, and four peer-coaches. They had to recall most answers from memory. To reduce the chance of an optimistic presentation and events being omitted, we conducted more than one extensive in-depth interview and used objective data, such as the membership administration and the 6-min walk test, to support statements where possible.

The self-reported effects of the *FreeWheel* club need to be interpreted carefully. Results could be influenced by recall bias, because several members joined the *FreeWheel* club under the assumption that the *FreeWheel* club would yield them a health benefit. Consequently, they are more likely to report a health benefit in the self-perceived score. Most importantly, the 6-min walk test also showed a

significant improvement in physical capacity. Even though the objective measures are in line with the self- reported measures, the self-reported measures before and after the *FreeWheel* club were placed on the same page in the survey, which could have increased the possibility that members reported socially desirable answers on the self-reported measures of health and well-being. However, it is generally accepted that daily physical activity improves health, so it is likely that the perceived improvements are based on real physical improvements.

Where most studies show a moderate decline in 6-min walk distance of 2–7 meter per year in the general population, the participants in our study show an increase of 21.7 meters per year.[42-44] Both older and younger members experience a similar improvement when joining the *FreeWheel*club. We did find that members of the *FreeWheel* club improved more in the first year of membership than later. This suggests that part of the ageing process is due to detraining. Therefore, members improve the most in the beginning when they go from unfit to fit and after that year they maintain their fitness. Finally, members who more often stayed for a cup of coffee seemed to improve more than those who stayed less often for coffee, suggesting an important role of the social engagement of the *FreeWheel*club.

Four limitations must be taken into account about the 6-min walk tests. First, the tests have been conducted at 13 timepoints between November 2014 and April 2016 while the *FreeWheel* club already started in 2010. Therefore, some members are tested in their fourth or fifth year of membership duration while others are tested in their first year of membership, and we find that first year members improve more than longer members. Second, higher attendance rate was associated with higher increases in the 6-min walking test, although this was not significant. Third, we do not know the number of dropouts during November 2014 and April 2016. It is more likely that dropouts are people with declining physical capacity and health. In total we estimated a dropout rate of 22.5% in 6 years, which is relatively low compared to other interventions of physical activity and exercise referral schemes, where the attrition rate could be as high as 80% per year.[47,48] Finally, the 6-min walk tests are conducted during regular sessions, meaning that members that attended more sessions per week were more likely to be present during a 6-min walk tests. This could result in an overrepresentation of more active members in the 6-min walk tests and consequently an overestimation of the beneficial effect of the intervention on 6-min walk test. However, the 53 members that performed the 6-min walk test once or more had an average attendance rate of 2.7 days per week, which is only slightly higher than the average of the whole group.

CONCLUSION

We conclude that the *FreeWheel* club has shown successes in retaining engagement in this group of older adults and may have a similar effect among other older adults. The members perceive improvements in health that are in line with improvements in a physical function test. It seems likely that the concept can be implemented elsewhere, but the design of the current study was not suitable to investigate this. To study reproducibility, a new Vitality Club must be founded in another place based on the format of the *FreeWheel* club and studied over time. If successful, this format can be scaled up and more groups of older adults could start their own group and deliver a self-sustainable, low cost and effective intervention to increase daily physical activity to older adults everywhere. This would be a preventive equivalent of successful peer coach intervention such as the Alcoholics Anonymous and an answer to the demographic challenge in modern time with the increasing age-related health problems, loneliness, and healthcare costs.

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REFERENCES

1. Knoops KT, de Groot LC, Kromhout D, et al. Mediterranean diet, lifestyle factors, and 10-year mortality in elderly European men and women: the HALE project. *Jama.* 2004;292:1433-1439.
2. O'Flaherty M, Buchan I, Capewell S. Contributions of treatment and lifestyle to declining CVD mortality: why have CVD mortality rates declined so much since the 1960s? *Heart.* 2013;99:159-162.
3. Paffenbarger Jr RS, Hyde RT, Wing AL, Lee I-M, Jung DL, Kampert JB. The association of changes in physical-activity level and other lifestyle characteristics with mortality among men. *New England Journal of Medicine.* 1993;328:538-545.
4. Lindström J, Peltonen M, Eriksson J, et al. Improved lifestyle and decreased diabetes risk over 13 years: long-term follow-up of the randomised Finnish Diabetes Prevention Study (DPS). *Diabetologia.* 2013;56:284-293.
5. Penedo FJ, Dahn JR. Exercise and well-being: a review of mental and physical health benefits associated with physical activity. *Current opinion in psychiatry.* 2005;18:189-193.
6. Warburton DE, Nicol CW, Bredin SS. Health benefits of physical activity: the evidence. *Canadian medical association journal.* 2006;174:801-809.
7. Vogel T, Brechat PH, Leprêtre PM, Kaltenbach G, Berthel M, Lonsdorfer J. Health benefits of physical activity in older patients: a review. *International journal of clinical practice.* 2009;63:303-320.
8. Gremeaux V, Gayda M, Lepers R, Sosner P, Juneau M, Nigam A. Exercise and longevity. *Maturitas.* 2012;73:312-317.
9. Taylor A, Cable N, Faulkner G, Hillsdon M, Narici M, Van Der Bij A. Physical activity and older adults: a review of health benefits and the effectiveness of interventions. *Journal of sports sciences.* 2004;22:703-725.
10. World Health Organisation. Prevalence of insufficient physical activity. 2010.
11. World Health Organisation. Global Recommendations on Physical Activity for Health. 2010.
12. Sun F, Norman IJ, While AE. Physical activity in older people: a systematic review. *BMC public health.* 2013;13:1.
13. Blair SN. Physical inactivity: the biggest public health problem of the 21st century. *British journal of sports medicine.* 2009;43:1-2.
14. Hall KS, Sloane R, Pieper CF, et al. Long-term changes in physical activity following a one-year home-based physical activity counseling program in older adults with multiple morbidities. *Journal of aging research.* 2010;2011.
15. van der Bij A, Laurant M, Wensing M. Effectiveness of physical activity interventions for older adults: a review. *American journal of preventive medicine.* 2002;22:120.
16. Rimmer A. Shortage of doctors across Europe may be caused by migration to UK. *BMJ careers.* 2014.
17. Aluttis C, Bishaw T, Frank MW. The workforce for health in a globalized context–global shortages and international migration. *Global health action.* 2014;7:23611.
18. Maher CA, Lewis LK, Ferrar K, Marshall S, De Bourdeaudhuij I, Vandelanotte C. Are health behavior change interventions that use online social networks effective? A systematic review. *Journal of medical Internet research.* 2014;16:e40.

19. Norman GJ, Zabinski MF, Adams MA, Rosenberg DE, Yaroch AL, Atienza AA. A review of eHealth interventions for physical activity and dietary behavior change. *American journal of preventive medicine.* 2007;33:336-345. e316.
20. Devi R, Powell J, Singh S. A web-based program improves physical activity outcomes in a primary care angina population: randomized controlled trial. *Journal of medical Internet research.* 2014;16:e186.
21. Richards J, Thorogood M, Hillsdon M, Foster C. Face-to-face versus remote and web 2.0 interventions for promoting physical activity. *Cochrane Database Syst Rev.* 2013;9:Cd010393.
22. Muller AM, Khoo S. Non-face-to-face physical activity interventions in older adults: a systematic review. *Int J Behav Nutr Phys Act.* 2014;11:35.
23. McNeill LH, Kreuter MW, Subramanian S. Social environment and physical activity: a review of concepts and evidence. *Social science & medicine.* 2006;63:1011-1022.
24. Booth ML, Bauman A, Owen N, Gore CJ. Physical activity preferences, preferred sources of assistance, and perceived barriers to increased activity among physically inactive Australians. *Preventive medicine.* 1997;26:131-137.
25. Burton NW, Khan A, Brown WJ. How, where and with whom? Physical activity context preferences of three adult groups at risk of inactivity. *British Journal of Sports Medicine.* 2012;46:1125-1131.
26. Short CE, Vandelanotte C, Duncan MJ. Individual characteristics associated with physical activity intervention delivery mode preferences among adults. *Int J Behav Nutr Phys Act.* 2014;11:25.
27. Pérez-Escamilla R, Hromi-Fiedler A, Vega-López S, Bermúdez-Millán A, Segura-Pérez S. Impact of peer nutrition education on dietary behaviors and health outcomes among Latinos: a systematic literature review. *Journal of nutrition education and behavior.* 2008;40:208-225.
28. Rossman B. Breastfeeding peer counselors in the United States: helping to build a culture and tradition of breastfeeding. *Journal of midwifery & women's health.* 2007;52:631-637.
29. Joseph DH, Griffin M, Hall RF, Sullivan ED. Peer coaching: an intervention for individuals struggling with diabetes. *The Diabetes Educator.* 2001;27:703-710.
30. Ginis KAM, Nigg CR, Smith AL. Peer-delivered physical activity interventions: an overlooked opportunity for physical activity promotion. *Translational behavioral medicine.* 2013;3:434-443.
31. Humphreys K, Blodgett JC, Wagner TH. Estimating the efficacy of Alcoholics Anonymous without self-selection bias: An instrumental variables re-analysis of randomized clinical trials. *Alcoholism: Clinical and Experimental Research.* 2014;38:2688-2694.
32. Kaskutas LA. Alcoholics Anonymous effectiveness: Faith meets science. *Journal of addictive diseases.* 2009;28:145-157.
33. Wilson B. *Alcoholics Anonymous: Big Book.* AA World Services; 2015.
34. Casanova C, Celli B, Barria P, et al. The 6-min walk distance in healthy subjects: reference standards from seven countries. *European Respiratory Journal.* 2011;37:150-156.
35. Yazdanyar A, Aziz MM, Enright PL, et al. Association Between 6-Minute Walk Test and All-Cause Mortality, Coronary Heart Disease–Specific Mortality, and Incident Coronary Heart Disease. *Journal of aging and health.* 2014;26:583-599.
36. Ingle L, Cleland JG, Clark AL. The long-term prognostic significance of 6-minute walk test distance in patients with chronic heart failure. *BioMed research international.* 2014.
37. Ibrahim JG, Molenberghs G. Missing data methods in longitudinal studies: a review. *Test.* 2009;18:1-43.
38. Statistics Netherlands Statline. Income, consumption, wealth of households: key figures; National Accounts [Dataset]. In. http://statline.cbs.nl/2014.

39. Shaw BA, Spokane LS. Examining the association between education level and physical activity changes during early old age. *Journal of aging and health.* 2008.
40. Droomers M, Schrijvers CTM, Mackenbach J. Educational level and decreases in leisure time physical activity: predictors from the longitudinal GLOBE study. *Journal of epidemiology and community health.* 2001;55:562-568.
41. Frohlich KL, Potvin L. Transcending the known in public health practice: the inequality paradox: the population approach and vulnerable populations. *American journal of public health.* 2008;98:216-221.
42. Britto RR, Probst VS, Andrade AF, et al. Reference equations for the six-minute walk distance based on a Brazilian multicenter study. *Brazilian journal of physical therapy.* 2013;17:556-563.
43. Troosters T, Gosselink R, Decramer M. Six minute walking distance in healthy elderly subjects. *The European respiratory journal.* 1999;14:270-274.
44. Iwama AM, Andrade GNd, Shima P, Tanni SE, Godoy Id, Dourado VZ. The six-minute walk test and body weight-walk distance product in healthy Brazilian subjects. *Brazilian Journal of Medical and Biological Research.* 2009;42:1080-1085.
45. Benítez Pérez ME. Envejecer en Cuba: mucho más que un indicador demográfico. *Revista Novedades en Población.* 2015;11:0-0.
46. Quiñones RG, de Armas MA. Envejecimiento, políticas sociales y sectoriales en Cuba. *Ponencia presentada en Seminario Internacional sobre Políticas gerontológicas, Buenos Aires, Argentina.* 2010.
47. Gidlow C, Johnston LH, Crone D, James D. Attendance of exercise referral schemes in the UK: a systematic review. *Health Education Journal.* 2005;64:168-186.
48. Wallace J, Raglin J, Jastremski C. Twelve month adherence of adults who joined a fitness program with a spouse vs without a spouse. *The Journal of sports medicine and physical fitness.* 1995;35:206-213.

CHAPTER 4

Self-organizing peer coach groups to increase daily physical activity in community dwelling older adults

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ABSTRACT

Many older adults do not reach the recommended level of physical activity, despite many professional-delivered physical activity interventions. Here we study the implementation of a novel physical activity intervention for older adults that is self-sustainable (no financial support) and self-organizing (participants act as organizers) due to peer coaching. We implemented three groups and evaluated process and effect using participatory observations, questionnaires, six-minute walk tests and body composition measures from October 2016 to September 2018. The intervention was implemented by staff without experience in physical activity interventions. Facilitators were a motivated initiator and a non-professional atmosphere for participants to take ownership. Barriers were the absence of motivated participants to take ownership and insufficient participants to ensure the presence of participants at every exercise session. The groups exercised outside five days a week and were self-organizing after 114, 216 and 263 days. The initial investments were 170€ for sport equipment and 81–187 h. The groups reached 118 members and a retention of 86.4% in two years. The groups continue to exist at the time of writing and are self-sustainable. Quality of life increased 0.4 on a ten-point scale (95% CI 0.1-0.7, $p=0.02$) and six-minute walk test results improved with 33 m (95% CI 18-48, $p<0.01$) annually. Self-organizing peer coach groups for physical activity are feasible, have positive effects on health and require only a small investment at the start. It is a sustainable and potentially scalable intervention that could be a promising method to help many older adults age healthier.

INTRODUCTION

Daily physical activity is effective at preventing many age-related diseases such as diabetes and cardiovascular diseases and improving mobility and mental health.[1] In spite of these health benefits, approximately half of adults older than 60 worldwide do not meet the recommended level of physical activity.[2,3] Many interventions aiming to increase or intensify physical activity are proven effective in studies, but rarely reach practice.[2,4] Transferring effective programs into real world settings and maintaining them there is a complicated, long-term process depending on how well the program is implemented, and whether the program is sustainable.[4] Thorough implementation increased effect sizes of intervention on average two to three times.[4] However, over the past thirty years only 3% of physical activity studies focussed on implementation and dissemination.[5] A study shows that the decision to adopt an intervention by policy makers is depending on data on effectiveness, reach and costs of operating at scale.[6] To increase the likelihood of successful implementation and scale up of population physical activity interventions elsewhere, characterizing parameters of implementation setting, identifying stakeholder and identifying barriers and facilitators of interventions is necessary.[7]

Factors affecting the implementation process are the intervention (e.g. compatibility, adaptability), the provider of the intervention (e.g. perceived need, perceived benefits, self-efficacy, skills), the organization (e.g. innovation, work climate, communication) and the community (e.g. politics, funding, policy).[4,7,8] Of these factors, one of the main barriers for successful sustainable implementation at scale are costs and scarcity of professionals to deliver these intervention.[9-11] Physical activity interventions for older adults can cost 1000 dollar or more per participant.[12] Peer coaching, in which participants act as coach and organizer is a novel method without these barriers.[13-15] A systematic review showed substantial health benefits for a variety of peer interventions, although not in all.[16] Further research showed that peer-based interventions benefit if they are (co-)developed by peers.[17] Moreover, the use of peers increased the long term maintenance of physical activity interventions.[18] Another study suggested however that peers need regular supervision.[17] In a previous study we described the Vitality Club, a self-organizing physical activity intervention that exercises outside five days a week and sustainably activated a group of 70 older adults for over 6 years. Participants attended on average two and a half days a week and perceived both subjective and objective improvements in health and well-being.[19] The first Vitality Club started in 2010 by older adults themselves and at the time of writing continues to exist with over 150 members without any professionals or financial support involved.[19] This local intervention managed to

increase physical activity in large numbers of older adults in a sustainable way, but to improve population health it must be delivered at scale.[8] The initial Vitality Club was created by already motivated older adults who are still organizing it, and the question remains if it is feasible for healthcare professionals to implement a similar self-organizing physical activity intervention in a real-world setting that eventually will be sustained and organised by participants themselves.

Therefore, we studied the implementation of a peer coach physical activity intervention for older adults in a real-world setting and evaluate factors affecting implementation, effectiveness on health and well-being, costs, implementation setting and stakeholders. We initiated three new peer coach groups in different neighbourhoods in Leiden. This implementation study is necessary for future dissemination of the intervention. Also, the results can have important implications for the wider use of peer coaching in health promotion or disease management, where peer coaching could also be a novel method of intervention delivery for its promising sustainable and low-cost characteristics.

METHODS

Study Design

The study took place from October 2016 till September 2018. We implemented three peer coach groups in three neighbourhoods in Leiden, a medium sized town in The Netherlands with 120 000 inhabitants. Number of inhabitants in the neighbourhoods ranged from 11 149 to 21 467. The proportion of inhabitants older than 65 ranged from 11.8 to 18.1% in the neighbourhoods. Leiden is a city in a densely populated area with a different demographics than the original setting, which was a large village in one of the more rural areas of the Netherlands. Social cohesion tends to weaker in cities and neighbours do not know each other. This makes it an interesting location to implement an intervention that is dependent on social cohesion.

The following practical implementation steps were conducted. Firstly, we identified and contacted public places suitable for exercise in the neighbourhood, with a possibility to store a small box with sport equipment. Secondly, we supplied sport equipment for the first ten participants, including 1kg dumbbells, mini soccer balls and elastic bands. The costs per set were around 17 EUR. Thirdly, we recruited participants using a less formal and low budget recruitment strategy with flyers, free advertorials in local newspapers and neighbourhood associations. There was no formal age requirement, but advertisement mentioned that the exercise intensity was aimed at people aged older than 55. There was no required baseline level of physical activity, but participants had to come to the Vitality Club independently. Finally, peer coaches were recruited from the participants as the groups grew. To empower participants to take ownership we created an atmosphere where participants were free in the way they organised the exercise sessions. We always stressed that it was not a professional intervention, but a group of neighbourhood peers exercising together. All participants that volunteered to take the role of peer coach could become a peer coach, and they distributed the exercise sessions among the peer coaches. During the implementation phase, exercise sessions for which no peer coach was available were led by the researchers until a peer coach was recruited. The switch from staff to peer coach was done during one session in which staff and peer coach together led the session. The groups gathered 5 days a week from 09.00 to 10.00 in the morning. The exercises were free format, but mostly of moderate intensity. Most coaches focused on cardiovascular exercises, muscle strengthening exercises and exercises for stability and flexibility. However, because of the free format, each coach could choose any kind of exercise. Peer coaches received only a non-formal training through observing sessions led by researchers and other peer coaches. Researchers were recently graduated medical doctors who did not received special training to

guide exercise sessions. Peers only received supervision when requested. To make the peer groups fully self-sustainable (financially independent) a voluntary fee of 1 EUR per week was installed. The peer groups themselves managed the funds and used it to cover expenses and buy additional sports equipment as the groups grew. Participants were made aware that attendance was at their own risk and health issues would be handled similar as all outside injuries would, minor injuries at home or the general practitioner, major issues by calling the emergency number.

We made participatory observations and conducted semi-structured interviews to identify facilitators and barriers for the implementation of the peer coach group. All participants also received a questionnaire at baseline and every four months to assess personal facilitators and barriers. We recorded daily presence and conducted a six-minute walk test and bioelectrical impedance analysis (BIA) at baseline and every four months. Participants that did not participate in the exercise group for 90 days were considered drop-outs. For the BIA, the OMRON BF511 body composition monitor was used (Omron Healthcare Ltd., Kyoto, Japan). The questionnaire was similar to the questionnaire we used before and included questions on demographic characteristics, physical activity frequency and quality of life (Supplementary S1).[19] At the fifth participation we requested informed consent for participation in the study since we did not want to interrupt the real-world setting and wanted people to be able to join the club without participating in the study. After people joined the Vitality Club, consent was always asked to be included in the study. All study participants in the study provided written informed consent before assessment started.

Statistics

We analysed the intraindividual change over time using a Linear Mixed Model. This model separates within-person change and between-person differences in outcomes over time.[20] The model showed that 79% of the variance in outcome is attributed to differences between individuals, warranting the use of this model. The model had a slightly better fit using a quadratic regression, but the change after one year was similar in the quadratic and linear regression. Therefore, we used a linear regression because the estimates are more easily interpreted. The model was adjusted for sex, age at baseline, height and weight with unstructured covariance and intercept and time as a random variable. The analysis of body composition change was not adjusted for weight. Predicted six-minute walk test results were calculated using the regression of Troosters et al. (1999) and were used as reference values.[21] Statistical analyses are performed with IBM SPSS Statistics for Macintosh, Version 25.0, Armonk, NY: IBM Corp.

RESULTS

The practical implementation strategy was flexible in different settings and easy to conduct by staff without experience in physical activity interventions. This implementation strategy resulted in three peer coach groups with the essential elements of the intervention (exercising, self-organizing and sustainable). The stakeholders of the intervention are the initiator, the participants, the peer coaches and the owner of the exercise/storage location. Implementation facilitators are collaborative stakeholders, a well-informed and motivated initiator and a non-professional atmosphere for participants to take the role of peer coach. The barriers are the absence of motivated participants willing to take over the exercise sessions and insufficient number of participants to ensure the presence of participants at every exercise session. To overcome these barriers the peer coach group needs to be of a sufficient size, which could take time due to the less formal recruitment strategy. An initiator needs to stay motivated until the group reaches a critical mass.

Table 4.1 shows baseline characteristics of participants and peer coaches. In total 132 people were asked for informed consent, 118 people provided informed consent for the study, resulting in an inclusion rate of 89%. Average age was 66.9 (SD 6.4) year, 74% of participants were female, 73% was retired and 33% was living alone. Of all participants 56% had a high educational level. Monthly disposable income was under €1000 for 12% of participants, between €1000 and €3000 for 63% and more than €3000 for 25% of participants.

At the start, 47% of participants were recruited by an article in the local newspaper, 15% via word of mouth and 8% via a flyer delivered at home. Throughout the study period, most participants were recruited via word of mouth (39%). Figure 4.1 shows the number of participants of the peer coach groups over time. We identified several facilitators and barriers for joining and remaining with the peer coach group from our semi structured interviews and questionnaires. The main facilitators were exercising outside, exercising early morning, the feeling of social obligation to the group, variations in exercises due to different peer coaches, low participation fee, the fact that no formal enrolment was required and that the participants were of similar age. Personal barriers to join were the distress of joining a new group of people and not being sure of having the adequate physical fitness to participate, a lack of motivation and the early timing of the sessions. Motivational facilitators for the peer coaches were the satisfaction of helping peers live healthier, being in charge of the intervention and being able to adjust exercises to personal preferences. A barrier to becoming a peer coach was the perceived stress of leading a group.

Table 4.1 Baseline characteristics of study participants

	Peer coaches		All participants	
Number	13		118	
Age in years, mean (*SD*)	68.8	(2.6)	66.7	(6.6)
Women, n (%)	9	(69%)	87	(74%)
Retired, n (%)	12	(92%)	82	(73%)
Educational level, n (%)[a]				
Low	1	(8%)	22	(20%)
Middle	3	(23%)	27	(24%)
High	9	(69%)	62	(56%)
Disposable income, n (%)[b]				
<€1000	1	(13%)	9	(12%)
€1000 - €3000	4	(50%)	46	(63%)
>€3000	3	(37%)	18	(25%)
Living alone, n (%)	1	(8%)	37	(33%)

Total number of participants varies due to missing data. [a]Low educational level is International Standard Classification of Education (ISCED) 0-2. Middle educational level is ISCED 3-4. High educational level is ISCED 5-8. [b]Disposable income per household is total income per household minus taxes and social fees.

The peer coach groups became completely self-organizing 114 (group 1), 216 (group 2) and 263 (group 3) days after the start. At the time of writing, the groups exercise five times a week and are still growing without any supervision from the researchers for 1156 (group 1), 733 (group 2) and 610 (group 3) days after becoming completely self-organizing. Until the groups became self-organizing, the researcher invested one hour a day to lead the group exercises. The time investment of the researcher gradually declined when a peer coach was recruited from the participants for one or several weekdays. Total investment per group was 170€ for sport equipment and 81 (group 1), 154 (group 2) and 187 (group 3) hours. On average participants attended the peer group 1.5 (SD 0.8) days per week. The median number of participants on a regular day was 6 (range 0-18). On a weekly basis the median number of unique participants was 28 (range 11-56). During the study period 16 participants were absent for more than 90 days and were considered dropouts, resulting in a retention of 86.4% during the study period of 2 years. The attrition rate was 0.19 per person-year of observation (total of 82.1 person-years of observation). Only 3 participants returned after an absence of 90 days, but were still considered drop-outs. There were 4 participants that were absent for more than 60 days, but less than 90 days when the study ended and were not considered drop-outs. There were

between 3 and 5 peer coaches per group at any time. One peer coach had to stop due to illness. It was easier to replace an absent peer coach (e.g. illness) with more available peer coaches. Some participants preferred the teaching style of a certain peer coach and selectively participated in the peer group on days when that peer coach was coaching.

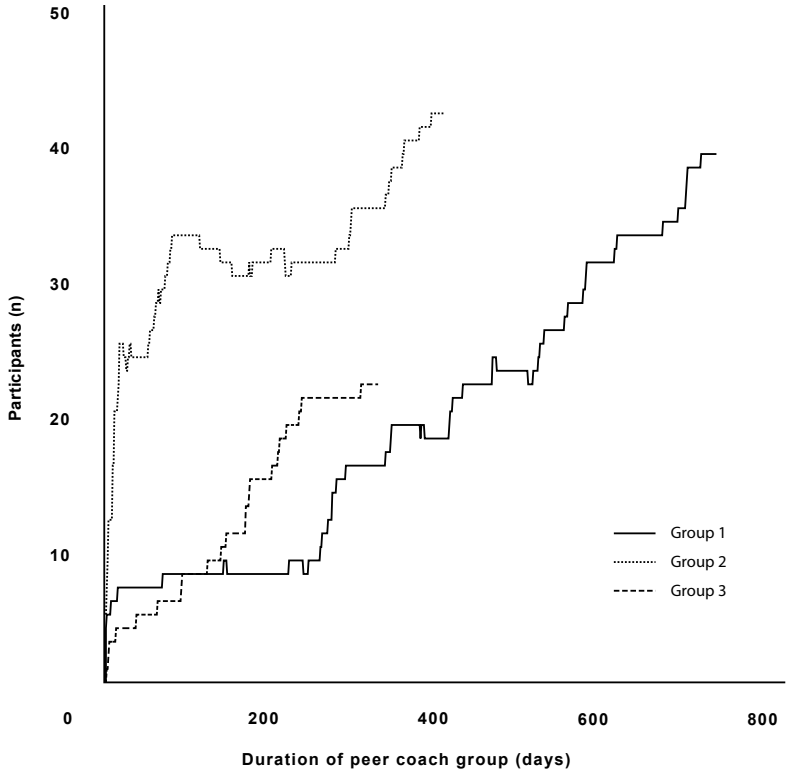

Figure 4.1 Growth of the peer coach groups. The number of participants of the peer coach group over time October 2016 to September 2018. Group 1 started in October 2016, group 2 started in August 2017 and group 3 started in November 2017. Only participants that provided informed consent are included. Participants that did not participate in the last three months were considered a drop-out.

Table 4.2 shows baseline characteristics and yearly change of health and well-being. We had 244 measurements for the 118 participants, an average of 2.1 measurements per participant. Participants reported an annual increase of 1.8 days per week of physical activity > 30 minutes (95% CI 1.0-2.5, p<0.01). Self-reported quality of life improved with 0.4 points on a ten-point scale per year (95% CI 0.1-0.7, p=0.02). Six-minute walk test results increased with 33 meters per year (95% CI 18-48, p<0.01).

Participants lost 1.4 kg annually (95% CI −2,6-−0.3, p=0.01). BMI reduced with 0.5 points (95% CI −0.9-−0.1, p=0.02). In the general population six-minute walk test results decline on average 5 meters a year due to ageing.[21] The group started with a 6MWT result close to the predicted result for their respective age, gender and height, 99% of predicted and improved with 6.2 percent points (95% CI 3.8-8.5, p<0.01) after one year. Participants improved independent of their baseline results.

Table 4.2 Baseline characteristics and yearly change of health and well-being

	Baseline (SD)		Yearly change (SE)[a]		p-value
Self-reported days per week >30 minutes PA	2.5	(1.8)	+1.8	(0.3)	<0.01
Quality of life (1-10)	7.7	(1.0)	+0.4	(0.1)	0.02
Observed 6MWT result in meters	607	(71)	+32.9	(7.3)	<0.01
Predicted 6MWT result in meters[b]	614	(55)	-5.3	(0.0)	
Observed / predicted 6MWT * 100%	99.3	(12.1)	+6.2	(1.2)	<0.01
Body weight (kg)	74.5	(12.6)	-1.4	(0.6)	0.01
BMI (kg/m^2)	25.9	(3.6)	-0.5	(0.2)	0.02
Fat percentage	32.8	(9.5)	-1.0	(0.6)	0.08
Muscle percentage	28.9	(4.5)	-0.1	(0.5)	0.89
Visceral fat score (1-20)	9.1	(3.4)	+0.4	(0.2)	0.82

[a]Estimates derived from a linear mixed model adjusted for sex, age at baseline, height and weight, using 244 measurement moments from 118 participants. The analysis of body composition change was not adjusted for weight. [b]Predicted six-minute walk test distance calculated from the equation of Troosters et al. (1999). Data collected from October 2016 to September 2018. PA=physical activity, 6MWT=six-minute walk test, BMI=body mass index.

We also analysed a dose-response relation. Participants improved 0.3 meters per participated session (95% CI 0.1-0.5, p=0.01). No serious injuries were reported during the study period. Six participants (4%) reported a minor sport related injury. There was full recovery of all injuries.

DISCUSSION

This study shows a feasible implementation strategy to initiate peer groups as a daily physical activity intervention for community dwelling older adults. The peer coach groups became completely self-organizing after the initial researcher-led period and at the time of writing continued to exist and grow.

The implementation of peer coach groups comprised of practical steps that can be performed in a lot of different settings by different people. This study has been performed in the cultural background of West-Europe, but similar initiatives can be seen in South-America and Asia.[22] However, depending on cultural etiquette, changes need to be made to the implementation strategy. There are several recommendations for others who want to implement this intervention. Key factors are the number of participants and empowerment of participants to take ownership. The first factor can be achieved with the same less formal recruitment strategy used in this study, but this method takes considerable time and initiators should be made aware of this from the start. The groups mostly grew through word of mouth, which does not require action but is hard to predict. The second factor depends on the atmosphere created by the initiator. We learned that the participants must be informed from the start that it will be a peer-led intervention. It must be stressed that almost all participants are able to lead an exercise session. Otherwise, participants will not feel empowered to take ownership. This study showed that when a group does take ownership, it is resilient and can exist for a long period without any supervision.

The sustainability of peer coach groups for physical activity in older adults can be understood from several theoretical perspectives. Firstly, peer coaches bring several advantages which are derived from social support, experiential knowledge, helper-therapy principle, social learning theory and social comparison theory.[23] Secondly, the groups are self-organizing and self-sustainable increasing self-efficacy and internal locus of control, which in turn are strong predictors of adherence.[24] Lastly, social interaction is an essential part of this physical activity intervention, which has additional benefits on adherence and on the well-being of participants.[25,26]

From a practical perspective, as there are no paid professionals or costly sporting accommodations required, there are no fixed expenses for the intervention. Moreover, because the intervention is not dependent on scarce and costly professionals and can be set up anywhere in the public space, it is potentially scalable.

A limitation is that the intervention mostly attracts healthy active older adults with a high socioeconomic background. However, research on the first peer coach group that existed for over 6 years at the time showed that 50% of participants had low educational status.[19] Also, healthy participants will become more frail due to ageing in the following years. We did not record race in this study. We are currently conducting a study with peer coach group for older adults with a migratory background in which we also include race. Another limitation is that this study tests the feasibility of only three peer coach groups in Leiden. To make the results more generally applicable we used neighbourhoods with three different average socioeconomic statuses to set up the peer coach groups. However, they are all situated in the same city thus being relatively similar. Additionally, due to small number of peer groups we were unable to formally compare different implementation processes to distinguish the optimal strategy. Finally, the effects of the peer coach intervention on its participants were not compared with a control group and causal relations must be taken cautiously. However, daily physical activity of participants increased while daily physical activity in older adults in general decline with increasing age.[3]

The unique aspect of this form of intervention is the absence of a professional. A common argument against peer coaching is that it is inferior and unsafe to use peers instead of professionals to lead the intervention. A systematic review however, showed that peer-based physical activity interventions were equally effective as interventions led by professionals for increasing physical activity.[27] Additionally, no study have shown a difference in safety between interventions delivered by peers or professionals.[28] Furthermore, in a randomized controlled trial comparing peers to professionals in a physical activity intervention, peer coaches were found to be equally or superior to professionals in levels of intervention implementation.[18]

Peer support is already used widely in disease prevention in diabetes, cardiovascular disease and cancer patient groups, to quit smoking or to stay sober in the Alcoholics Anonymous. However, most physical activity interventions still use a professional as primary leader of the intervention. We like to stress the possibility of increasing the role of the peers in physical activity intervention. This does not come with a decrease in quality and brings the big benefits of peer support, low costs, scalability and could reach a part of the population currently not reached by classic interventions.

CONCLUSION

It is feasible for healthcare professionals to implement a peer coach physical activity intervention for older adults that eventually is self-organizing and self-sustainable. A small investment of 170€ and 81-187 hour is needed to create a group that is self-supporting after 114-263 days. After this initial investment the groups are self-organizing and self-supporting and resilient for a long period. This novel form of intervention delivery could be a promising alternative model to curtain increasing healthcare expenditure and could potentially help large numbers of older adults age healthier.

REFERENCES

1. Vogel T, Brechat PH, Leprêtre PM, Kaltenbach G, Berthel M, Lonsdorfer J. Health benefits of physical activity in older patients: a review. *International journal of clinical practice.* 2009;63:303-320.
2. Hallal PC, Andersen LB, Bull FC, et al. Global physical activity levels: surveillance progress, pitfalls, and prospects. *The lancet.* 2012;380:247-257.
3. Sun F, Norman IJ, While AE. Physical activity in older people: a systematic review. *BMC public health.* 2013;13:449.
4. Durlak JA, DuPre EP. Implementation matters: A review of research on the influence of implementation on program outcomes and the factors affecting implementation. *American journal of community psychology.* 2008;41:327-350.
5. Milat AJ, Bauman AE, Redman S, Curac N. Public health research outputs from efficacy to dissemination: a bibliometric analysis. *BMC Public Health.* 2011;11:934.
6. Milat AJ, King L, Newson R, et al. Increasing the scale and adoption of population health interventions: experiences and perspectives of policy makers, practitioners, and researchers. *Health research policy and systems.* 2014;12:18.
7. Koorts H, Eakin E, Estabrooks P, Timperio A, Salmon J, Bauman A. Implementation and scale up of population physical activity interventions for clinical and community settings: the PRACTIS guide. *International Journal of Behavioral Nutrition and Physical Activity.* 2018;15:51.
8. McKay HA, Sims-Gould J, Nettlefold L, Hoy CL, Bauman AE. Implementing and evaluating an older adult physical activity model at scale: framework for action. *Translational Journal of the American College of Sports Medicine.* 2017;2:10-19.
9. Hall KS, Sloane R, Pieper CF, et al. Long-term changes in physical activity following a one-year home-based physical activity counseling program in older adults with multiple morbidities. *Journal of aging research.* 2010;2011.
10. van der Bij A, Laurant M, Wensing M. Effectiveness of physical activity interventions for older adults: a review. *American journal of preventive medicine.* 2002;22:120.
11. De Ponte G, Mans L, Di Sisto M, Van de Pas R. Health workforce shortages and international mobility in the EU. *Health Workers for all and all for Health Workers.* 2014.
12. Groessl EJ, Kaplan RM, Blair SN, et al. A cost analysis of a physical activity intervention for older adults. *Journal of Physical Activity and Health.* 2009;6:767-774.
13. Matz-Costa C, Howard EP, Castaneda-Sceppa C, Diaz-Valdes Iriarte A, Lachman ME. Peer-based strategies to support physical activity interventions for older adults: A typology, conceptual framework, and practice guidelines. *The Gerontologist.* 2019;59:1007-1016.
14. Thom DH, Ghorob A, Hessler D, De Vore D, Chen E, Bodenheimer TA. Impact of peer health coaching on glycemic control in low-income patients with diabetes: a randomized controlled trial. *The Annals of Family Medicine.* 2013;11:137-144.
15. Sokol R, Fisher E. Peer support for the hardly reached: a systematic review. *American journal of public health.* 2016;106:e1-e8.
16. Ramchand R, Ahluwalia SC, Xenakis L, Apaydin E, Raaen L, Grimm G. A systematic review of peer-supported interventions for health promotion and disease prevention. *Prev Med.* 2017;101:156-170.

17. Raja S, Teti M, Knauz R, et al. Implementing peer-based interventions in clinic-based settings: Lessons from a multi-site HIV prevention with positives initiative. *Journal of HIV/AIDS & Social Services.* 2008;7:7-26.
18. Buman MP, Giacobbi Jr PR, Dzierzewski JM, et al. Peer volunteers improve long-term maintenance of physical activity with older adults: a randomized controlled trial. *Journal of Physical Activity and Health.* 2011;8:S257-S266.
19. Van de Vijver PL, Wielens H, Slaets JPJ, Van Bodegom D. Vitality club: a proof-of-principle of peer coaching for daily physical activity by older adults. *Translational behavioral medicine.* 2018;8:204-211.
20. Shek DT, Ma C. Longitudinal data analyses using linear mixed models in SPSS: concepts, procedures and illustrations. *The Scientific World Journal.* 2011;11:42-76.
21. Troosters T, Gosselink R, Decramer M. Six minute walking distance in healthy elderly subjects. *The European respiratory journal.* 1999;14:270-274.
22. González Ramos RM, Madrazo Ordaz DE, Osorio Núñez M. Conocimientos sobre salud bucal en los círculos de abuelos. *Revista Cubana de Estomatología.* 2013;50:284-291.
23. Solomon P. Peer support/peer provided services underlying processes, benefits, and critical ingredients. *Psychiatric rehabilitation journal.* 2004;27:392.
24. McAuley E, Jerome GJ, Elavsky S, Marquez DX, Ramsey SN. Predicting long-term maintenance of physical activity in older adults. *Prev Med.* 2003;37:110-118.
25. McAuley E, Blissmer B, Marquez DX, Jerome GJ, Kramer AF, Katula J. Social relations, physical activity, and well-being in older adults. *Preventive medicine.* 2000;31:608-617.
26. Smith GL, Banting L, Eime R, O'Sullivan G, Van Uffelen JG. The association between social support and physical activity in older adults: a systematic review. *International Journal of Behavioral Nutrition and Physical Activity.* 2017;14:56.
27. Ginis KAM, Nigg CR, Smith AL. Peer-delivered physical activity interventions: an overlooked opportunity for physical activity promotion. *Translational behavioral medicine.* 2013;3:434-443.
28. Castro CM, Pruitt LA, Buman MP, King AC. Physical activity program delivery by professionals versus volunteers: the TEAM randomized trial. *Health Psychology.* 2011;30:285.

CHAPTER 5

Linking a peer coach physical activity intervention for older adults to a primary care referral scheme

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ABSTRACT

Physical inactivity has contributed to the current prevalence of many age-related diseases, including type 2 diabetes and cardiovascular disease. Peer coach physical activity intervention are effective in increasing long term physical activity in community dwelling older adults. Linking peer coach physical activity interventions to formal care could therefore be a promising novel method to improve health in inactive older adults to a successful long-term physical activity intervention. We evaluated the effects of linking a peer coach physical activity intervention in Leiden, The Netherlands to primary care through an exercise referral scheme from July 2018 to April 2020. Primary care practices in the neighbourhoods of three existing peer coach physical activity groups were invited to refer patients to the exercise groups. Referrals were registered at the primary care practice and participation in the peer coach groups was registered by the peer coaches of the exercise groups. During the study, a total of 106 patients were referred to the peer coach groups. 5.7% of patients showed up at the peer coach groups and 4 out of 6 people remained participating during the 1 year follow up. The number needed to refer for 1 long term participant was 26.5. The mean frequency of participation of the referred participants was 1.2 times a week. Linking a peer coach physical activity intervention for older adults to a primary care referral scheme reached only a small fraction of the estimated target population. However, of the people that came to the peer coach intervention a large portion continued to participate during the entire study period. The number needed to refer to engage one older person in long term physical activity was similar to other referral schemes for lifestyle interventions. The potential benefits could be regarded proportional to the small effort needed to refer.

INTRODUCTION

The proportion of older adults in the world's population has increased and is expected to reach 2 billion in 2050.[1] Additionally an estimated 31% of the global population does not meet the recommended level of physical activity.[2] Together, they have contributed to the current rise of age-related diseases obesity, diabetes and cardiovascular disease.[2] Interventions that increase physical activity are effective in activating older adults.[3] However, it is difficult to achieve sustained, long-term behavioural change after the intervention period.[4-6] It is not a feasible strategy to permanently offer costly and labour-intensive interventions to the 25% of older adults world-wide that do not achieve sufficient levels of physical activity.[7] A scalable, sustainable and affordable physical activity intervention with a large reach could be an answer to the physical inactivity challenge.

Peer coaching has been studied as a promising scalable, sustainable and affordable physical activity intervention method for older adults.[8-10] A peer coach physical activity groups are self-sustaining groups in which the training sessions are not led by professionals but by peers, people who are participants of the intervention. Our earlier research showed that this particular peer coaching intervention is a safe effective method for increasing physical activity, that the adherence to the intervention is high and that the intervention is sustainable.[11-13] Finally, peer coach groups do not depend on costly professionals and can be set up anywhere in the public space. However, peer coaching itself does not facilitate a method to involve the people that are highly likely to benefit from participating and harder to reach. Primary care practices can play an important role in advising and referring patients who are likely to benefit from increasing their physical activity. A study on the attendance in exercise programs based on an exercise referral schemes (ERS) in formal care revealed that costs, location (an intimidating gym atmosphere) and an inconvenient timing of sessions were most often reported as barriers for participation.[14] The fact that peer coach physical activity groups are low-cost, located in the public space and can take place daily are mentioned by participants as main advantages of peer coach physical activity groups.[11] Linking the community-based exercise groups to formal care might be a promising way for delivering physical exercise on a wider scale. Primary care physicians and practice nurses are in frequent contact with the 50+ population and have the position and expertise to determine who is eligible for physical activity interventions. Health professionals are generally regarded as a credible source for health advice and are therefore likely to be able to influence the (un)healthy behaviour of their patients.[15]

Therefore, referring patients to a peer coach physical activity intervention could be a promising addition to this successful novel method.[16] We studied the integration a referral scheme for primary care patients to an existing peer coach physical activity intervention. We evaluated the number of referred patients by primary care professionals, adoption of referred patients and retention of referred patients in the peer coach physical activity intervention during the study period. Considering the number of people that do not meet physical activity recommendations, these efforts contribute to establishing a highly needed population wide delivery of effective, low-cost and durable strategies for increasing physical activity.

METHODS

This study evaluated the effect of an exercise referral scheme in a real-world primary care setting to a peer coach physical activity intervention. From July 2018 to April 2020 general practices actively referred patients to the peer coach groups with all practices at least referring for one year. In the peer coach groups in this study, people of 50 years and older engage in an hour of peer led exercises in a public park or space in their neighbourhood on weekdays. The general and accessible fitness exercises focus on strength, flexibility, coordination and stamina.[11] The groups are self-organizing and there is no monitoring from the research team. An extensive description of the format of the peer coach physical activity intervention can be found elsewhere.[11,12] The study was registered and approved by the medical research ethics committee of Leiden University Medical Centre. All participants provided informed consent verbally.

We invited primary care practices in the vicinity of the existing peer coach physical activity groups to refer patients to the exercise groups. In the Netherlands, every citizen is enlisted with a primary care physician and more than 75% of the 50+ population sees their GP at least once a year.[17] The primary care physician acts as a gate-keeper for the access to specialized hospital care and is responsible for several primary prevention programs for chronic diseases such as cardiovascular disease and diabetes. Practice nurses, who help primary care physicians with numerous (para)medical tasks, play an important role in the delivery of these prevention programs.

The physicians and practice nurses were asked to refer patients who would potentially benefit from participating in the peer coach physical activity group. To establish a real-world setting, no further specific inclusion and exclusion criteria were imposed, as this would require more effort. The physicians and practice nurses in the participating primary care practices were asked to inform these patients on the nature of the peer coach physical activity groups and on the details of the study. They were instructed to mention the following aspects of this physical activity intervention: peer coaching, no professional, specifically for older adults, outside, in the neighbourhood, no registration and a small fee of €1 a week. The referral was not monitored. Finally, the name and date of birth of the referred patient and referral date was written down on a referral form and was given to the patient. The form contained all key aspects of the intervention; Peer coached, exercising in a group, outside, specifically for older adults, accessible for every level and participation at your own risk. Practical information consisted of exercise location and time, participation fee

and that there was no need to register in advance. A carbon copy of the referral form was saved at the general practice and used to identify study participants. No other personal or medical information was retrieved as this would require a longer and more thorough informed consent conversation which would affect the referral numbers and would not be represent a realistic real-world referral.

The general practices were visited every four months to collect the forms and inform about the study progress. A referral was defined when a patient received a referral form. The participation of the referred person was recorded by daily attendance lists that were kept at the peer coach groups. Participation was defined if a person was on the attendance list. If a referred person did not show up, no further data was available. Since people are not formally enrolled in the peer coach groups, drop-out was defined as a person who did not participate for at least 3 months. A successful referral was defined as a referred person who participated once and did not dropout during the study period. Number needed to refer was calculated dividing 1 by the proportion of successful referrals. We used a Wilson score interval of the proportion successful referrals to calculate a 95% confidence interval of the number needed to refer.[18] Statistical analyses are performed with IBM SPSS Statistics for Macintosh, Version 25.0, Armonk, NY: IBM Corp.

Table 5.1 Characteristics of exercise referral scheme for peer coached exercise groups, per participating primary care practice

Participating primary care practices
Total referred patients, *n*
Referral by physicians, *n (%)*
Referral by practice nurses, *n (%)*
Patients that showed up at exercise group, *n (%)*
Patients that remained participating during follow up, *n (%)*

RESULTS

We studied the application of an exercise referral scheme for the peer coach physical activity groups in a real-world primary care setting. A summary of the inclusion of study participants and primary care practices can be seen in figure 5.1. Thirteen primary care practices located in the neighbourhood of one of the three peer coach groups were invited to participate in our study with an estimated total of 3500 inactive older adults. 8 practices responded positively with an estimated 2500 inactive older adults, 1 primary practice did not want to participate and 4 did not react. A total of 26 older adults were referred by 9 physicians and 80 older adults were referred by 8 practice nurses, which was only 5% of the total estimated inactive older adults. 6 (6%) of the referred older adults participated in the peer coach physical activity group of which 4 (4%) continued to participate during the study period. The number needed to refer to engage one older adult in long term physical activity was 26.5 (95% CI 11-100). The median time between referral and first participation was 12 (range 1-225) days. The mean frequency of participation of the referred participants was 1.2 times a week.

Table 5.1 shows the number of participating physicians and practice nurses and referred patients per primary care practices in the study. 75% of referrals was done by practice nurses, whereas physicians referred 25% of the patients. More than half of all referrals were done by only one practice. Some of the participating practices referred none or only a small number of patients.

1	2	3	4	5	6	7	8	Total
58	11	12	0	6	5	4	10	106
15 (26%)	0 (0%)	4 (33%)	0 (0%)	6 (100%)	0 (0%)	1 (25%)	0 (0%)	26 (25%)
43 (74%)	11 (100%)	8 (67%)	0 (0%)	0 (0%)	5 (100%)	3 (75%)	10 (100%)	80 (75%)
4 (7%)	2 (18%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	6 (6%)
2 (3%)	2 (18%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	4 (4%)

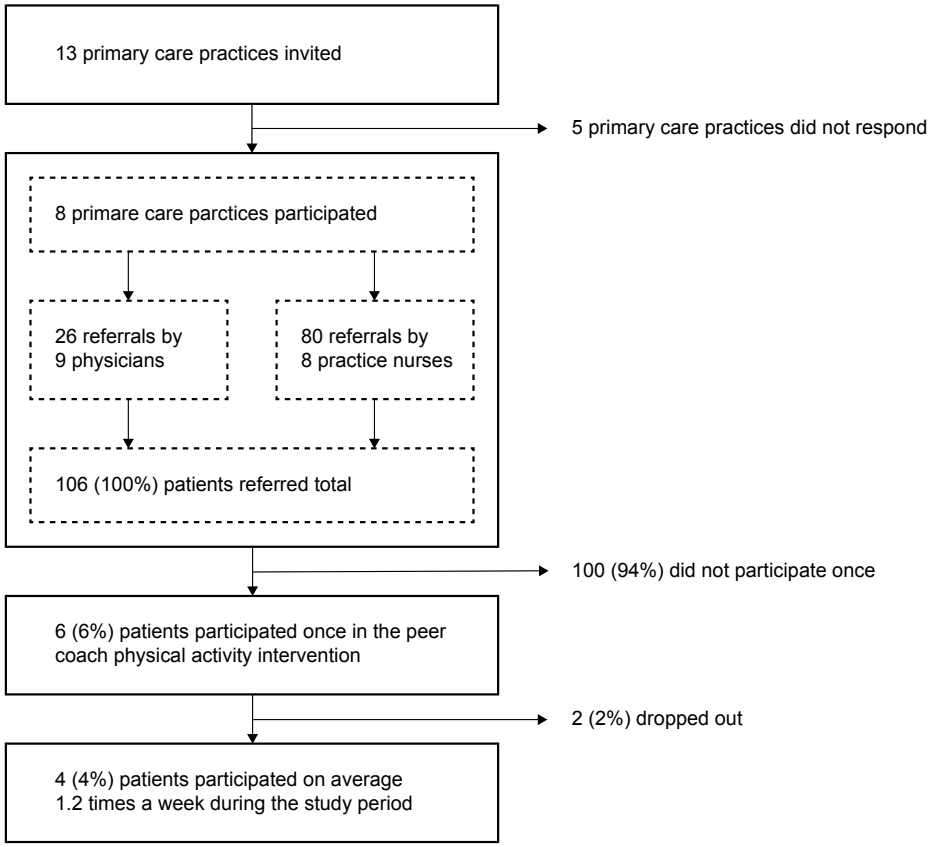

Figure 5.1 Flowchart of process evaluation of exercise referral scheme. This flowchart shows the inclusion of primary care practices and referral of patients. Per participating primary care practice both the practice nurse as the physician was allowed to refer patients to the physical activity intervention.

DISCUSSION

We studied the role of primary care in referring 50+ patients to an existing peer coach physical activity intervention. Notwithstanding the promising characteristics of peer coach activity groups as an accessible intervention for primary care patients, the success rate of the referral scheme was only 4% of the referred patients. Reviews have shown mixed evidence on the effectiveness of ERS, possibly due to the heterogeneity of ERS interventions, and the complex settings in which they take place.[19-21] Therefore, this study was performed in a real-world setting and provides a good outlook on the effect of establishing this exercise referral scheme in a Dutch primary care system.

There are several limitations and strengths to this study. The strength of this study is in the approximation of a real-world setting. No study can really imitate the real-world. However, this study approached the real-world by having no formal inclusion criteria for referring patients, having a very short informed consent procedure and no recurring contact of the physician or research team with the study participant. As a result, extensive medical and motivational information from study participants is missing. A limitation is the lack of qualitative data from professionals and patients to determine facilitators and barriers in the referral process. There is extensive research on facilitators and barriers in referral scheme.[22-26] However, these studies mostly include referral schemes within the (para)medical sector.[27] Future research should examine facilitators and barriers for referral schemes to peer coach physical activity interventions.

Peer coach physical activity groups have proven to be an effective and innovative solution for increasing physical activity in a community-based setting. Previously, we have shown in a two-year follow up study that 118 people joined the exercise groups on their own initiative, and these groups continue to grow until this date.[12] There are now more than 17 peer coach physical activity groups that we know of, with more than 500 participating older adults in The Netherlands. These groups have proven to be sustainable and have a retention rate of 86% in a period of two years.[12] However, its use as part of an exercise referral scheme appears to be limited. The referred primary care patients might have been less inclined to engage in physical activity. Whereas in a community-based setting the participants have made the conscious effort themselves to join the peer coach physical activity groups, patients that were considered eligible for exercise referral have not been able or willing to find a suitable exercise opportunity.

According to the health belief model, there are various factors that are needed for health behaviour change.[28-30] First, the perceived severity and susceptibility of future health problems influence to what extent a patient is inclined to engage in the ERS. Second the perceived benefits and barriers of the intervention itself play an important role. Third, a sense of self-efficacy and a cue to action are needed to make patients go to the intervention. Addressing the perceived severity and susceptibility are standard procedures in primary care, the referral serves as a cue to action. Until now the perceived barriers of costs, location (an intimidating gym atmosphere) and an inconvenient timing of sessions were most often reported as barriers for participation in exercise programs based on exercise referral schemes in formal care.[14] The major advantage of peer coaching physical activity groups is to take away these barriers. However, we hypothesize that a key characteristic of peer coaching, the fact that the sessions are not led by a health professional could have a negative effect on the perceived benefit of the intervention.

Most referrals were from one primary care practice. There are several hypotheses why the primary care professionals from this practice referred more than the others. Firstly, this was the only practice that had direct view on the exercising older adults. This visual feedback of the referrals could be a strong motivator. Secondly, the director of the primary care practice was a physician who was parttime active at the research department of the nearby academic hospital. Therefore, he had more affinity with research and this resulted in easier implementation of new programs in his practice. When interpreting these results for the real world, it is important to note that the other primary care practices more closely represent the general population of primary care practices.

Another explanation for the limited effectivity of the ERS lies at the level of the health professional. Most referrals were done by practice nurses, who generally have more time to address healthy lifestyle options than primary care physicians. In a recent review, it was suggested that primary care nurses provide equal care compared to primary care doctors and that nurses achieve higher patient satisfaction levels.[31] However, it is not clear if physical activity advice from a practice nurse has the same effectivity as an advice from the primary physician. A study on the perspectives of primary care physicians on ERS emphasizes that physicians are trained to deliver pharmaceutical interventions and do not regard written exercise referrals as a priority. Physicians rather referred to other health professionals for prescribing exercise schemes.[32] Overall, physicians seem to have the least positive attitude towards preventive health interventions, compared to other health professionals.[33,34] Most physicians rather focus on the high risk patients in their

population, instead of taking a population approach to lifestyle advice.[35] However, attitudes and communication abilities of physicians remain important for achieving patient compliance in lifestyle changes. A qualitative study into the perceptions of older adults on the role of physicians in promoting physical activity showed that patients expected physical activity counselling, but that physicians did not meet these expectations.[36] Furthermore, a study into rehabilitation participation in older cardiac patients showed that the strength of physicians' advice was the most powerful predictor for rehabilitation entry.[37]

CONCLUSION

A success rate of 4% per referred patient is comparable with other lifestyle interventions in primary care.[38] The minimal intervention strategies for smoking cessation also require 33-100 referrals for one person to quit smoking.[39] And although these numbers might seem high, the large health benefits outweighs the minimal effort. Also in this study, the cost and effort of the referral scheme are low and proportional to the time and costs of referral. Moreover, referral effectiveness can improve over time with increasing awareness of healthy lifestyle and adaptation of better referral skills by the GP's.[40] Finally, future research on this type of minimal effort referrals must collaborate with disciplines like marketing, communication or consumer behaviour. These disciplines are more experienced in recruitment and their insights can increase effectiveness of these minimal effort referrals.[41,42] Lifestyle prevention in primary care is important and a referral scheme to an effective, durable and low-cost peer coach physical activity intervention could be a promising solution to the increasing disease burden in the worldwide ageing population.

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REFERENCES

1. Cunningham C, O'Sullivan R, Caserotti P, Tully MA. Consequences of physical inactivity in older adults: A systematic review of reviews and meta-analyses. *Scandinavian journal of medicine & science in sports.* 2020;30:816-827.
2. Kohl 3rd HW, Craig CL, Lambert EV, et al. The pandemic of physical inactivity: global action for public health. *The lancet.* 2012;380:294-305.
3. Conn VS, Hafdahl AR, Mehr DR. Interventions to increase physical activity among healthy adults: meta-analysis of outcomes. *American journal of public health.* 2011;101:751-758.
4. Hall KS, Sloane R, Pieper CF, et al. Long-term changes in physical activity following a one-year home-based physical activity counseling program in older adults with multiple morbidities. *J Aging Res.* 2010;2011:308407.
5. van der Bij AK, Laurant MG, Wensing M. Effectiveness of physical activity interventions for older adults: a review. *Am J Prev Med.* 2002;22:120-133.
6. Muller-Riemenschneider F, Reinhold T, Nocon M, Willich SN. Long-term effectiveness of interventions promoting physical activity: a systematic review. *Prev Med.* 2008;47:354-368.
7. Guthold R, Ono T, Strong KL, Chatterji S, Morabia A. Worldwide variability in physical inactivity: a 51-country survey. *American journal of preventive medicine.* 2008;34:486-494.
8. Buman MP, Giacobbi PR, Jr., Dzierzewski JM, et al. Peer Volunteers Improve Long-Term Maintenance of Physical Activity With Older Adults: A Randomized Controlled Trial. *J Phys Act Health.* 2011;8:S257-S266.
9. Dorgo S, Robinson KM, Bader J. The effectiveness of a peer-mentored older adult fitness program on perceived physical, mental, and social function. *J Am Acad Nurse Pract.* 2009;21:116-122.
10. Ginis KA, Nigg CR, Smith AL. Peer-delivered physical activity interventions: an overlooked opportunity for physical activity promotion. *Transl Behav Med.* 2013;3:434-443.
11. Van de Vijver P, Wielens H, Slaets JPJ, Van Bodegom D. Vitality club: a proof-of-principle of peer coaching for daily physical activity by older adults. *Translational behavioral medicine.* 2018;8:204-211.
12. Van de Vijver P, Schalkwijk F, Numans ME, Slaets JP, Van Bodegom D. Self-organizing peer coach groups to increase daily physical activity in community dwelling older adults. *Preventive Medicine Reports.* 2020:101181.
13. Burton E, Farrier K, Hill KD, Codde J, Airey P, Hill A-M. Effectiveness of peers in delivering programs or motivating older people to increase their participation in physical activity: Systematic review and meta-analysis. *Journal of Sports Sciences.* 2018;36:666-678.
14. Morgan F, Battersby A, Weightman AL, et al. Adherence to exercise referral schemes by participants - what do providers and commissioners need to know? A systematic review of barriers and facilitators. *BMC Public Health.* 2016;16:227.
15. Graham RC, Dugdill L, Cable NT. Health professionals' perspectives in exercise referral: implications for the referral process. *Ergonomics.* 2005;48:1411-1422.
16. Dugdill L, Graham RC, McNair F. Exercise referral: the public health panacea for physical activity promotion? A critical perspective of exercise referral schemes; their development and evaluation. *Ergonomics.* 2005;48:1390-1410.
17. Hupkens C, Swinkels H. Around three-quarters of population see GP and dentist once a year. Statistics Netherlands (CBS). Published 2013. Accessed 23 september, 2019.

18. Agresti A, Coull BA. Approximate is better than "exact" for interval estimation of binomial proportions. *The American Statistician.* 1998;52:119-126.
19. Arsenijevic J, Groot W. Physical activity on prescription schemes (PARS): do programme characteristics influence effectiveness? Results of a systematic review and meta-analyses. *BMJ open.* 2017;7:e012156.
20. Pavey TG, Taylor AH, Fox KR, et al. Effect of exercise referral schemes in primary care on physical activity and improving health outcomes: systematic review and meta-analysis. *BMJ.* 2011;343:d6462.
21. Campbell F, Holmes M, Everson-Hock E, et al. A systematic review and economic evaluation of exercise referral schemes in primary care: a short report. *Health Technol Assess.* 2015;19:1-110.
22. Graham R, Dugdill L, Cable N. Health professionals' perspectives in exercise referral: implications for the referral process. *Ergonomics.* 2005;48:1411-1422.
23. Leijon ME, Bendtsen P, Nilsen P, Ekberg K, Ståhle A. Physical activity referrals in Swedish primary health care–prescriber and patient characteristics, reasons for prescriptions, and prescribed activities. *BMC health services research.* 2008;8:1-9.
24. James DV, Johnston LH, Crone D, et al. Factors associated with physical activity referral uptake and participation. *Journal of sports sciences.* 2008;26:217-224.
25. Almeida FA, Smith-Ray RL, Van Den Berg R, et al. Utilizing a simple stimulus control strategy to increase physician referrals for physical activity promotion. *Journal of Sport and Exercise Psychology.* 2005;27:505-514.
26. Morgan F, Battersby A, Weightman AL, et al. Adherence to exercise referral schemes by participants–what do providers and commissioners need to know? A systematic review of barriers and facilitators. *BMC public health.* 2016;16:1-11.
27. Leenaars K, Smit E, Wagemakers A, Molleman G, Koelen M. Facilitators and barriers in the collaboration between the primary care and the sport sector in order to promote physical activity: a systematic literature review. *Preventive Medicine.* 2015;81:460-478.
28. Rosenstock IM. Historical Origins of the Health Belief Model. *Health Education Monographs.* 1974;2:328-335.
29. Rosenstock IM. The Health Belief Model and Preventive Health Behavior. *Health Education Monographs.* 1974;2:354-386.
30. Becker MH. *The Health belief model and personal health behavior.* Thorofare, N.J.: Slack; 1974.
31. Laurant M, van der Biezen M, Wijers N, Watananirun K, Kontopantelis E, van Vught AJ. Nurses as substitutes for doctors in primary care. *Cochrane Database Syst Rev.* 2018;7:CD001271.
32. Persson G, Brorsson A, Ekvall Hansson E, Troein M, Strandberg EL. Physical activity on prescription (PAP) from the general practitioner's perspective - a qualitative study. *BMC family practice.* 2013;14:128.
33. Johansson H, Stenlund H, Lundstrom L, Weinehall L. Reorientation to more health promotion in health services - a study of barriers and possibilities from the perspective of health professionals. *J Multidiscip Healthc.* 2010;3:213-224.
34. Zolnierek KB, Dimatteo MR. Physician communication and patient adherence to treatment: a meta-analysis. *Med Care.* 2009;47:826-834.
35. Lawlor DA, Keen S, Neal RD. Can general practitioners influence the nation's health through a population approach to provision of lifestyle advice? *The British journal of general practice : the journal of the Royal College of General Practitioners.* 2000;50:455-459.
36. Costello E, Leone JE, Ellzy M, Miller TA. Older adult perceptions of the physicians' role in promoting physical activity. *Disabil Rehabil.* 2013;35:1191-1198.

37. Ades PA, Waldmann ML, McCann WJ, Weaver SO. Predictors of cardiac rehabilitation participation in older coronary patients. *Arch Intern Med.* 1992;152:1033-1035.
38. Wiggers LC, Smets EM, Oort FJ, et al. The effect of a minimal intervention strategy in addition to nicotine replacement therapy to support smoking cessation in cardiovascular outpatients: a randomized clinical trial. *European Journal of Cardiovascular Prevention & Rehabilitation.* 2006;13:931-937.
39. Stead LF, Buitrago D, Preciado N, Sanchez G, Hartmann-Boyce J, Lancaster T. Physician advice for smoking cessation. *Cochrane database of systematic reviews.* 2013.
40. Finger JD, Busch MA, Heidemann C, Lange C, Mensink GB, Schienkiewitz A. Time trends in healthy lifestyle among adults in Germany: Results from three national health interview and examination surveys between 1990 and 2011. *PloS one.* 2019;14:e0222218.
41. Reingen PH, Kernan JB. Analysis of referral networks in marketing: Methods and illustration. *Journal of marketing research.* 1986;23:370-378.
42. Berman B. Referral marketing: Harnessing the power of your customers. *Business Horizons.* 2016;59:19-28.

CHAPTER 6

Círculos de Abuelos: Cuba's population wide physical activity intervention for older adults

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ABSTRACT

Most countries worldwide face an increasing prevalence of age-related diseases. Physical activity is effective in delaying and preventing these diseases. Current interventions to improve physical activity are effective, but do not reach large numbers of older adults for longer periods. Cuba, however, does have a long-standing population-wide program, Círculos de Abuelos, that has not been described in the English literature yet. Círculos de Abuelos are local peer groups of 10 to 30 older adults that exercise three days a week under the guidance of a professional sport coach and that engage in self-organized social activities. The Cuban Ministry of Public Health founded Círculos de Abuelos in 1987 and during the last count in 2018, the program promoted physical activity in 908,412 participants, 39.7% of Cuba's older population. Appointed by the National Institute for Sports, Physical Education and Recreation, the professional sports coach initiates new Círculos de Abuelos in cooperation with the family doctor and forms a lasting link between the Círculos de Abuelos and the local community. Because of its success, Círculos de Abuelos is implemented in other countries including Venezuela, Panama and Colombia. Círculos de Abuelos is a proof-of-principle of a longstanding population-wide program to promote physical activity in older adults. Therefore, it could serve as an example for physical activity programs to decrease the burden of age-related diseases worldwide.

INTRODUCTION

The number of older adults is increasing worldwide, resulting in rising healthcare costs, shortage of healthcare professionals, and many healthcare systems are not prepared for the multimorbidity of older adults.[1] With many countries facing the same challenge, it offers an opportunity to identify best practices. Here we describe such a best practice from Cuba.

Many of the age-related diseases are influenced by healthy lifestyle of which physical activity has most broad beneficial effects.[2] Although physical activity is beneficial, many older adults do not reach the recommended level.[3] Many current interventions are proven to be effective during the intervention period, but when most interventions stop the majority of older adults return to their inactive behaviour.[4] Also, interventions rarely reach practice and large numbers of older adults.[5,6] In Cuba we identified an intervention that increased physical activity in large numbers of older adults for a longer period of time.[7,8]

THE CÍRCULOS DE ABUELOS PROGRAM

Cuba focuses on prevention instead of curation and is internationally praised for its public health policy that results in high life expectancy with low economic resources.[9] It has been running a successful population-wide program promoting physical activity in older adults. Founded in 1987, the so-called *Círculos de Abuelos*, increases physical activity and social interaction in 908,412 participants, 39.7% of Cuban's older adults in 2018.[10,11] The program is also implemented in other Spanish speaking countries, including Venezuela, Panama and Colombia. However, it has not been discussed in the English literature.

Círculos de Abuelos are social groups of older adults that focus on physical activity to increase health and well-being The groups are self-organizing and activities are organized within the possibilities of the participants and area where they are situated. Some *Círculos de Abuelos* engage in various social, physical and educational activities. Universities or high schools regularly organize *conversaciones* (talks), theme nights during which personal concerns are shared and advice and support is given. Participants are invited with family and friends. Other social activities are initiated and paid for by the participants themselves. Some *Círculos de Abuelos* organize social activities and excursions. Groups also organize dance nights or read poetry and literature together. Furthermore, they share food and medicine, which can be in short supply in Cuba, and visit each other when they are ill.

Regarding the physical aspect, *Círculos de Abuelos* organize exercise sessions one to three times a week in public spaces in neighbourhoods throughout Cuba. The exercise sessions are led by a professional sport coach called *profesor de deporte* and consists of three parts: the warming-up, core-exercises and the cooling down, all accompanied by music. After the cooling down, the group plays a memory game and sings their group specific song. According to the last publicly available official count in 2018, 15,663 groups of *Círculos de Abuelos* were active.[12] This number has probably diminished since the US embargo has strengthened over the last years, which affected the available funds for the program. A group of *Círculos de Abuelos* consists of 10 to 30 participants. Since *Círculos de Abuelos* are open to all older adults, the participants vary in their level of physical and mental fitness.

Organizational structure

The *Círculos de Abuelos* program was founded in 1987 by the Ministry of Public Health (MINSAP).[11] Dr Cosme Ordóñez (Plaza Polyclinic) was the first who implemented the program, followed by Dr Fernández Sacasas (Alamar Polyclinic) and Dr Benito Pérez

Maza (Playa Polyclinic), encouraged and supported by Dr Raúl Mazorra, from the National Institute for Sports, Physical Education and Recreation (INDER).[13,14] INDER collaborated by recommending sport specialists fitting to serve as *profesores de deportes* (sports coaches).

MINSAP and INDER formulated an implementation program with an executive responsibility for the *profesor de deporte*. The format describes the objectives of the *Círculos de Abuelos*, the outline of the exercise sessions, several exercise examples and special exercises for people with diseases such as type 2 diabetes, obesity and hypertension. The *profesor de deporte* is instructed to create new groups, guide the exercise sessions and link the local community and the family doctor (FD). All FD's in Cuba focus on prevention and health promotion.[15] The family nurse identifies people who would be interested in or who benefit from physical exercise and provides the addresses of these potential participants to the *profesor de deporte*. The *profesor de deporte* actively reaches out to the potential participants and invites them personally for the program.

The cooperation between INDER and the healthcare system is also visible when a participant experiences discomfort during the physical exercise, when a participant is ill, or is recovering from a disease. In this case, the *profesor de deporte* accompanies the participant to the FD and cooperates with the FD in reintegrating the participant in the exercise sessions.

Monitoring & Evaluation

INDER continuously evaluates the effect of the program. Data for monitoring and evaluation is collected by the FD and the *profesor de deporte*—showing again a close cooperation among them. Every FD provides information on the percentage of older adults in their population that participate in *Círculos de Abuelos*, the medical history and self-reported functional independence. The *profesor de deporte* conducts a physical performance test of the participants every six months. This includes an examination of heart, lungs, muscles, bones and joints, and the central nervous system. Data from the FD and the *profesor de deporte* is collected at municipal, provincial and national level and information is returned to the participants, the *profesor de deporte* and INDER's policymakers. This data was not publicly available, but several Cuban studies show improvements on many aspects, including hypertension, chronic obstructive pulmonary disease, anxiety and sleeping disorders and reduction in the use of medication and cigarettes, intake of alcohol and quality of life.[16-19]

COVID-19 Pandemic

Since the outbreak of the Sars-CoV-2 virus many of the activities of the *Circulos de Abuelos* have been cancelled. Most groups are connected via phone or through WhatsApp if this was available to the participant. The lockdown has had several negative effects on the physical and mental health of older adults in Cuba.[20]

ANALYSIS

Although *Círculos de Abuelos* reaches large numbers of older adults for a long period, no data is available on health or social effects in the English scientific literature. However, since extensive evidence demonstrates that daily physical activity and social interaction is effective in the prevention of age-related diseases and improvement of quality of life, we assume that *Círculos de Abuelos* positively influences physical and mental health.[21]

To explain the success of the longstanding, population wide *Círculos de Abuelos*, we identified four key factors for success. The first key factor is the combination of physical exercise and social activities. This is also supported by a growing body of evidence showing that peers have a large influence on lifestyle.[22-24] The second key factor for success is the easy accessibility of *Círculos de Abuelos*, a free program that forms an integrated part of the Cuban society and does not require a certain level of fitness. Third, the cooperation of the sports coaches with the Cuban healthcare system and their door-to-door approach of inviting new participants to *Círculos de Abuelos* lead to the inclusion of large numbers of people, including those that are not intrinsically motivated to exercise. The last key factor for success is the *Círculos de Abuelos*' structure of three exercise sessions a week. In this regular structure, physical activity may more easily become a routine than in exercise sessions that occur only once a week.

Several aspects must be considered concerning the generalization of *Círculos de Abuelos* for possible use in other countries. First, the success of *Círculos de Abuelos* could be explained by Cuba's socialist political structure. Cuba's political structure operates in a top-down approach that has facilitated the dissemination of the program everywhere in Cuba. In countries with a different political structure, it could be more difficult to spread out, evaluate and adjust a national program like *Círculos de Abuelos*. Second, the success of *Círculos de Abuelos* can also be the result of the cultural environment in Cuba. In contrast to western cultures, characterized as individualist, the Cuban culture is described as collectivist.[25] This difference in experiencing the self and the relationship with others influence cognition, emotion and motivation and may thus affect the motivation to engage in physical activity.[26] Third, Cuba's climate enables the participants to exercise outside at every possible location, whereas a colder or wetter climate could demotivate older adults to exercise outdoors and could challenge a similar program to find appropriate locations. Fourth, since INDER and all *profesores de deporte* are paid by the government, we assume that costs would be high if implemented in countries

with a different political structure. However, when looked at the health care costs and the effect on population health, the health care costs of the USA, $8863 per capita corrected for purchasing power parity (PPP), are four times higher than the Cuban health care costs, $2235 GDP per capita corrected for PPP.[27] Despite the difference in costs, both countries have the same health outcome, an average life-expectancy of 79 years and a healthy life-expectancy of 69 years.[27] Although there are many reasons for this difference, it is a general fact that prevention is more cost-effective than the treatment of care for chronic diseases.

The *Circulos de Abuelos* is an example that increases physical activity in large number of older adults in a sustainable way. Thirty years after the founding, it has reached 908,412 older adults to exercise up to three times a week. The program is effective by using paid professionals and peer coaches, in which older adults themselves are trained to serve as exercising guides. To reach these large numbers of older adults there is close collaboration with local representatives and FD's. To make it sustainable, the group also indulges in social activities that bind participants to the group and the program is financially secured by a governmental organization. It should be recognized that it cannot be implemented in other countries without adaptation. We should for example acknowledge Cuba's socialist political top-down structure that has facilitated the dissemination of the program in Cuba. Policy makers could also argue that a financial contribution from the government isn't sustainable, but Cuba's health care costs per capita are much lower than in the USA with a similar life expectancy.[28] The scarcity of professionals and long-term financial security could be a barrier to implement this in other countries. However, in the Netherlands we have studied the use of peer coaches to sustainably increase physical activity with low costs with success.[29]

CONCLUSION

Círculos de Abuelos is unique worldwide due to its scale and duration. *Círculos de Abuelos* provides an opportunity to learn how to sustainably increase daily physical activity on a population level.

REFERENCES

1. Prince MJ, Wu F, Guo Y, et al. The burden of disease in older people and implications for health policy and practice. *The Lancet.* 2015;385:549-562.
2. Vogel T, Brechat PH, Leprêtre PM, Kaltenbach G, Berthel M, Lonsdorfer J. Health benefits of physical activity in older patients: a review. *International journal of clinical practice.* 2009;63:303-320.
3. Hallal PC, Andersen LB, Bull FC, et al. Global physical activity levels: surveillance progress, pitfalls, and prospects. *The lancet.* 2012;380:247-257.
4. Hall KS, Sloane R, Pieper CF, et al. Long-term changes in physical activity following a one-year home-based physical activity counseling program in older adults with multiple morbidities. *Journal of aging research.* 2011.
5. Martinson BC, Crain AL, Sherwood NE, Hayes MG, Pronk NP, O'Connor PJ. Population reach and recruitment bias in a maintenance RCT in physically active older adults. *Journal of Physical Activity and Health.* 2010;7:127-135.
6. Durlak JA, DuPre EP. Implementation matters: A review of research on the influence of implementation on program outcomes and the factors affecting implementation. *American journal of community psychology.* 2008;41:327-350.
7. Benítez Pérez ME. Envejecer en Cuba: mucho más que un indicador demográfico. *Revista Novedades en Población.* 2015;11:10-19.
8. Rodríguez-Loeches E, Suárez A. Desarrollo regional y envejecimiento poblacional en Cuba. http://repositorio.geotech.cu/jspui/bitstream/1234/1905/1/Desarrollo%20regional%20y%20envejecimiento%20poblacional%20en%20Cuba.pdf. Published 2005. Accessed2020.
9. De Vos P, De Ceukelaire W, Bonet M, Van der Stuyft P. Cuba's health system: challenges ahead. *Health policy and planning.* 2008;23:288-290.
10. National Health Statistics and Medical Records Division (CU). Anuario Estadístico de Salud 2018 [Internet]. https://files.sld.cu/bvscuba/files/2019/04/Anuario-Electrónico-Español-2018-ed-2019-compressed.pdf. Published 2018. Accessed2020.
11. Panadero RM, Matos J. Círculos de Abuelos cumplieron 30 años de fundados. http://www.jit.cu/NewsDetails.aspx?idnoticia=40140. Published 2017. Accessed2020.
12. National Health Statistics and Medical Records Division (CU). Indicadores seleccionados del Adulto Mayor, 2018. *Havana: Ministry of Public Health (CU).* 2019.
13. Coutin G, MD MSc, Director, Puentes Grandes Polyclinic (1983-1991) and Vice-Director, Municipal Health Assistance Division (1992-1994). In. Havana, Cuba (Personal communication, May 2020).
14. Mazorra R. Personal information. https://www.ecured.cu/Raúl_Mazorra. Published 2020. Accessed.
15. Gorry C. Cuba's Family Doctor-and-Nurse Teams: A Day in the Life. *MEDICC review.* 2017;19:6-9.
16. Hernandez AR. Circulo de abuelos -La luz de la esperanza-. https://www.monografias.com/trabajos93/circulo-abuelos-luz-esperanza/circulo-abuelos-luz-esperanza.shtml. Published 2011. Accessed2019.
17. Barreto Ramos J, Morfi Samper R, Reyes Figueroa M, Cabrera Leal G. Diagnóstico del programa de ejercicios físicos realizados en el Círculo de abuelos "Abel Santamaría". *Rev Cubana Enfermer.* 2007;23:1-11.

18. Bravo Hernández N, Noa Garbey M, Gómez LLoga T, Soto Martínez J. Repercusión del envejecimiento en la calidad de vida de los adultos mayores. *Revista Información Científica.* 2018;97:596-605.
19. Barrios Duarte R, Borges Mojaiber R, Cardoso Pérez LdC. Beneficios percibidos por adultos mayores incorporados al ejercicio. *Revista Cubana de Medicina General Integral.* 2003;19:0-0.
20. Jesús E. Not Infected but Physically and Mentally Affected: Older Cubans and COVID-19. *MEDICC review.* 2020;22:83-84.
21. Hupin D, Roche F, Gremeaux V, et al. Even a low-dose of moderate-to-vigorous physical activity reduces mortality by 22% in adults aged≥ 60 years: a systematic review and meta-analysis. *British journal of sports medicine.* 2015;49:1262-1267.
22. Buman MP, Giacobbi Jr PR, Dzierzewski JM, et al. Peer volunteers improve long-term maintenance of physical activity with older adults: a randomized controlled trial. *Journal of Physical Activity and Health.* 2011;8:S257-S266.
23. Christakis NA, Fowler JH. The spread of obesity in a large social network over 32 years. *New England journal of medicine.* 2007;357:370-379.
24. McAuley E, Blissmer B, Marquez DX, Jerome GJ, Kramer AF, Katula J. Social relations, physical activity, and well-being in older adults. *Preventive medicine.* 2000;31:608-617.
25. Sotgiu I, Galati D, Manzano M, Rognoni E. Happiness components and their attainment in old age: A cross-cultural comparison between Italy and Cuba. *Journal of Happiness Studies.* 2011;12:353-371.
26. Markus HR, Kitayama S. Culture and the self: Implications for cognition, emotion, and motivation. *Psychological review.* 1991;98:224.
27. United Nations Statistics Division. UNDATA. https://data.un.org/. Published 2014. Accessed2020.
28. Drain PK, Barry M. Fifty Years of US Embargo: Cuba's health Outcomes and lessons. *Science.* 2010;328:572-573.
29. Van de Vijver PL, Wielens H, Slaets JPJ, Van Bodegom D. Vitality club: a proof-of-principle of peer coaching for daily physical activity by older adults. *Translational behavioral medicine.* 2018;8:204-211.

CHAPTER 7

General discussion

Paul van de Vijver

Based on:
Van de Vijver PL, Van Bodegom D
Van gezonde individuen naar gezonde populaties.
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GENERAL DISCUSSION

In this thesis, we explore a new approach to increase health at the population level. We tested the hypothesis that physical activity interventions can be successful to increase physical activity in a sustainable way by using peer coaches without professional interference. In several consecutive studies we explore the timing of physical fitness, a proof-of-principle of peer coaching, the replicability of peer coaching and its integration in formal care and the Cuban case as an example of a nationwide physical activity intervention.

Chapter one lays the foundation for our studies. Many age-related diseases like cardiovascular disease and diabetes are largely influenced by lifestyle. Physical activity is a lifestyle factor that prevents and delays many of the common age-related diseases worldwide. However, our physical activity frequency has diminished over the past 150 years due to a changing environment. Industrialization, change in labour and household machinery changed physical activity from an unconscious part of everyday life to a conscious action. Some people need continuous external support to reach the recommended level of physical activity for healthy ageing. Therefore, interventions aiming to increase physical activity need to be able to exert their effects for a sustainable time by durably changing someone's health behaviour for a longer period of time or the intervention itself needs to exist for a long period.

In **chapter two** we study the effect of physical exercise during the life course on ageing. More specifically, we study how the timing and magnitude of peak physical performance relates to life expectancy in Olympic athletes. A higher age at peak physical performance is associated with a higher age at death. This is in line with life history theory. There is growing evidence between life history trade-offs between species. A longer period of development, measured as time from birth to sexual maturation, is associated with a higher lifespan. Within humans, this association has been found in females where age at menarche was negatively associated with risk of all-cause mortality. However, this only shows the relation of germline development with longevity in human females. We studied if there was such a sign of a life-history trade-off in both sexes using the development of the whole soma by using a unique historical cohort of 1055 Olympic track and field athletes from 41 different nationalities from the Olympic Games from 1896 through 1936. Professional athletes push their physical performance to the maximum and keep accurate track of these achievements. Consequently, their personal record is an accurate representation of the age of their peak performance. Under the assumption that professional athletes train

at maximum intensity, this peak performance is an accurate read-out of the maximal physiological capacity of the individual. Comparing the performance with contemporaries in the same discipline we also get an estimate of the magnitude of this performance as z-scores. Here, we show a life history trade-off between early and above average physical performance and longevity in male Olympic athletes. Athletes who peaked at an earlier age showed 17-percent increased mortality rates (95% CI 8-26% per SD, $p<0.001$) and athletes who ranked higher showed 11-percent increased mortality rates (95% CI 1-22% per SD, $p=0.025$). Male athletes who had both an early and extraordinary peak performance suffered a 4.7-year longevity cost. (95% CI 2.1-7.5 years, $p=0.001$). This is the first time a life history trade-off between physical performance and longevity has been found in humans. This study, sometimes misinterpreted as proof that being a young Olympian is unhealthy, shows that a biological life history trade-off is not only seen between species, but also within a species. Moderate and longer period of maturation comes with a longevity gain.

Early high physical peaks were not beneficial for longevity. We propose here that moderate and long-term physical activity during life is essential for healthy ageing. In line with this, the recommended level of physical activity for older adults is not to exercise like an Olympic athlete but only 150 minutes of moderate intense exercises per week. Moderate intense exercises are safe and without the use of professionals maybe possible to achieve over a longer period of time.

Chapter three shows the description and proof-of-principle of a peer coached physical activity intervention for community dwelling adults spawned in the community by older adults themselves. This first peer coached physical activity group was set up by an older adult himself and his peers. The group used the local soccer and track and field association for the exercises and storage of sport attributes. The group grew by word-of-mouth and was completely self-sustainable thanks to a small fee participants paid to participate. At the time of writing, this group exists for over 10 years and reports over 200 weekly participants. The peer coach group gathered every weekday to exercise coached by an older adult. Members attend on average 2.5 days per week and retention rate is 77.5% after 6 years. The members perceived improvements in several health measures. In line with this, the six-minute walk test results of members of this peer coach physical activity group improved with 21.7 meters per year, compared with the decline of 2-7 meters per year in the general population. Because of the self-sustainable and self-organizing character of the intervention, peer coaching has the potential to be scaled up at low cost and increase physical activity in the increasing number of older adults.

In **chapter four** we answer the succeeding question whether this self-sustainable and self-organizing peer coach intervention is replicable. The group described in the previous chapter was created by community dwelling older adults themselves, but as far as we know there was only one. To use this successful group as an intervention it needs to be replicable in different locations by professionals. Therefore, we created three new groups in Leiden, the Netherlands. Facilitators were a motivated initiator and a non-professional atmosphere for participants to take ownership. Barriers were the absence of motivated participants to take ownership and insufficient participants to ensure the presence of participants at every exercise session. The groups were similar to the previous described group and were self-organizing after 114, 216 and 263 days. The initial investments were low. The groups reached 118 members and a retention of 86.4% in two years. The groups are still active at the time of writing. During the study quality of life increased with 0.4 points on a ten-point scale (95% CI 0.1-0.7, p=0.02) and six-minute walk test results improved with 33 meters (95% CI 18-48, p<0.01) annually. This study showed that the proof-of-principle of a peer coached physical activity intervention is replicable. The groups can be set up by professionals to later transfer the execution and organization to the participants themselves.

Chapter five explores the role of formal care to aid these self-sustainable and self-organizing interventions by identifying specific high-risk individuals who could benefit the most from daily physical activity. In an exercise referral scheme study we tested if an exercise referral scheme to an unsupervised peer coached intervention was effective in primary care. Results show that a total of 106 patients were referred to the peer coach exercise groups. 5.7% of patients showed up at the peer coach exercise groups and 66.7% remained participating during follow up. The success of the exercise referral scheme was limited. There were two moments of attrition identified. First, general practitioners and nurses rarely referred a patient to the peer coached intervention, or any specific physical activity intervention. Second, not many of the referred patients actually went to the intervention. The current healthcare system in the Netherlands does not promote preventive care sufficiently. However, this minimal effort referral scheme showed similar result as quit smoking programs in primary care.

In **Chapter six** we studied an example of the healthcare system in Cuba. In Cuba there is a successful population physical activity intervention for community dwelling older adults named the *Circulos de Abuelos* (Grandparent Circles). In these grandparent circles, older adults exercise together three days a week under the guidance of a professional sport coach and engage in self-organized social activities. The Cuban Ministry of Public Health (MINSAP) founded Círculos de Abuelos in 1985 and during

the last count in 2011, the program promoted physical activity in 908,412 participants, 39% of Cuba's older population. Appointed by National Institute for Sports, Physical Education and Recreation, the professional sports coach initiates new Círculos de Abuelos in cooperation with the general practitioner and forms a lasting link between the Círculos de Abuelos and the local community. The *Circulos de Abuelos* is a proof-of-principle of a longstanding population-wide program to promote physical activity in older adults. To explain the success, we identified four key factors. The intervention combines physical activity in a social group with other social activities, it charges no participation fee, has a direct link with their equivalent of general practitioners and exercises three times a week which give participants a weekly routine.

CONSIDERATIONS

The timing and magnitude of physical peak performance was measured by an athlete's personal record. This was used as a read out for biological peak and we assumed that the timing and magnitude was only influenced by genes and not environment. However, the timing of peak performance is not only influenced by genes, but also by type of sport, duration of sport event and start of sport career.[1] Moreover, it remains unclear if this relation is set from birth or causal in a sense that it can be influenced during life by delaying one's maturation. Future research should focus on the possibility to influence the biological predisposition of the timing of maturation and if changing this timing also influences longevity.

The difference in life expectancy between above average performers and below average performers is also influenced by their relative success in sports and no inferences should be made towards the benefits of different intensity levels of exercise. However, several studies show that moderate as well as vigorous intensity exercise is associated with lower mortality.[2-4] Some studies stress the difference between recreational versus professional, leisure-time versus non-leisure-time or exercise versus non-exercise physical activity.[4-6] In general, physical activity in all forms is healthy and we should not strive towards intense exercises or highly developed models to exercise.[7,8] The challenge is to increase all forms of daily physical activity in large numbers of older adults for a long period of time.

The mental well-being effects of the peer coach physical activity intervention are inferred by self-reported measures. These measures are subjective and could have been collected in a more objective way. However, self-reported well-being was just as valuable in our study and there is ample evidence that daily physical activity (with or without peer coaching) is beneficial for mental well-being in older adults.[9-13]

Similar consideration are in place for physical effects of the peer coach physical activity intervention. Even though the objective six-minute walk test was used to assess physical fitness, no mortality data was obtained. The goal of this thesis was not to study an effect between physical activity and health benefits, as this is well established in the scientific literature. Therefore, we measured attendance and inferred that attending a session meant engaging in moderate-intense physical activity. A better measure for physical activity would be energy expenditure or metabolic equivalent of task (METC) measured by an accelerometer. However,

lengthy observation for over a year showed that the participants did engage in physical activity at the intervention and there is reasonable agreement between self-reported physical activity and accelerometer data in older adults.[14] Additionally, the six-minute walk indicated that participants did engage in physical activity during participation.

In line with the past two paragraphs, effect of the peer coach physical activity intervention was not established in a Randomized Control Trial (RCT) with a control group. Inferences regarding the effect of the intervention should be made cautiously. Yet the real world setting of these studies add strength to this thesis' main message. Additionally, an RCT would not add much useful knowledge for the cost of the study. In a more practical sense, the results show us that in the Netherlands it is feasible to create self-organizing and self-supporting peer coach physical activity interventions.

Moreover, we suggested scalability on the grounds that no scarce resources are needed. Little financial investments are needed and public parks are widely available. Nevertheless, large scale implementation has not been formally tested in this thesis. Maybe even more important than large scale implementation, is to study the implementation in the harder to reach subgroups who benefit the most from daily physical activity. Not more of the same, but contextual diversity would give more insights in different implementation strategies.

Another consideration is that participants are in general younger and higher educated than the community dwelling older adults that would benefit most from daily physical activity. However, the group of participants in the peer groups that exist for a longer period shift more towards older and lower educated.

The sustainable nature of peer coaching is a strong characteristic of the intervention. There is therefore no rush to quickly recruit many participants. However, primary care could aid to reach older adults with comorbidities. The referral scheme we used had limited effect. There were two major moments of attrition. First, only a small portion of the patients were referred. Second, only a small portion of the patients responded to the referral. The implementation of the referral scheme in the primary care practice was done in a single interview with the general practitioner. More extensive implementation would probably benefit the first moment of attrition.[15] Also feedback from referred patients could increase adoption by primary care physician. Motivational interviewing and follow-up after referral could increase the responds to the referrals.[16] Future studies should focus under what circumstances this referral scheme works.

The current COVID-19 pandemic showed the resilience of the peer coach groups. In the Netherlands the regulation regarding the pandemic changed on a weekly basis. There are periods in which the peer coach groups could not gather and exercise together. The longest period in which the peer coach groups stopped was four weeks during the first lockdown. However, after this period all the peer coach groups regrouped and started exercising together again. At the time of writing, there is a second lockdown regarding sports and most peer coach groups have ceased activities. The groups stay in touch with each other which is a strong sign activities will resume when allowed by the Dutch government.

IMPLICATIONS

What are the implications of these results for peer coaching in physical activity promotion and peer coaching in general? Physical inactivity is almost omniprevalent. Especially in developed and developing countries where the burden of lifestyle diseases is high, physical activity promotion has priority. First, we discuss the implications of the intervention in this study. Second, we discuss possible applications of peer coaching in general.

Peer coaching for physical activity promotion

Several benefits of the use of peer coaching to promote physical activity have been mentioned in this thesis. The strength of peer-coaching lies in empathy and using the experiential knowledge of the peer coach, to understand the other peers wishes, motivations, possibilities and limitations. Having the same age and background and likely coming from the same neighbourhood increases the level of connectedness with the participants compared to a professional. This works two ways. Helping participants from his or her own neighbourhood also increases the involvement of the peer coach. This higher level of group cohesion increases the attendance and lowers attrition making peer coaching physical activity interventions successful in major challenges of promoting physical activity.[17-19] Additionally, the use of peer coaches is not inferior or unsafe compared to professionals.[9,20-22]

Peer coaches are participants from the target population that act as coach and motivator. Tasks normally performed in interventions by professionals. Professionals are scarce, there are less professionals than older adults, and are needed for more complicated tasks. Daily physical activity can be performed by older adults themselves safely. Removing the scarce professional in this intervention removes a barrier for implementing this intervention in large numbers for longer period of time.

In our study peer coaches were unpaid volunteers. This makes it more challenging to recruit peer coaches, but greatly diminishes structural costs. Without these structural costs the groups are self-sufficient and sustainable, two barriers faced by other physical activity interventions. In two groups, the funds collected by the groups were used to compensate the peer coaches for their efforts. Other groups gave an end-of-year present to thank their peer coaches. However, in principle the peer coaches coach the groups on a voluntary basis and do not receive any payment.

Finally, older adults prefer to exercise in groups when the group consists of similar aged individuals.[23] This makes peer coaching with its strong social component a suitable intervention. This could be the reason that eHealth interventions using apps or websites, where participants exercise alone at home, are more suitable for adolescents than older adults.

Peer coaching in interventions

All of the previous benefits of peer coaching also apply to non-physical activity interventions. There are already fields where peers are widely applied. In medical sciences peer support for mental health in patient groups is a known phenomenon. Peer support is used in patient groups for diabetes, several forms of cancer, cardiovascular disease, dementia, depression, addiction, pregnancy and early adulthood.[24-31] In some of these area's the beneficial effects of peer coaching on physical or mental health is still unclear.[25,26,30] However, for most areas there is a clear benefit to peer support.[24,27-29]

There are other areas where peer coaching could be applied. In primary care peer coaching could be used to monitor patient populations. The first check in the primary care practice could be done by peers. Neighbourhoods could create local peer networks for specific purposes, for example small domestic maintenance jobs, taxes or other chores. It is also possible to change the method of deploying peer volunteers. The self-organization is seen an attractive feature of peer support. The peer coach physical activity intervention in this study requires total self-organization from the peer coaches and participants. The organizational structure of the Alcoholics Anonymous has a high degree of decentralized organization of the A.A. Group with several regional and national boards to aid the local groups.[32] Thanks to the Alcoholics Anonymous, a total of 2 million people in over 150 countries receive health benefits without the use of professionals and healthcare budget.

RECOMMENDATIONS

There are several questions unanswered and recommendations for future research. In the following paragraphs we will discuss some of these. First, scalability will be discussed. Second, we will note the possibilities to further assess effectiveness. Third, we recommend a more peer centric explanatory framework in future studies. Finally, a semantic recommendation about definitions and uniformity will be discussed.

Scalability
To utilize the maximum potential of peer coach physical activity interventions the scalability should be studied. In line with previous studies a real-world study can conduct large scale implementation of different peer coach groups. There would be enough data to compare empirically internal factors of success and failure. If put in diverse contexts, external factors of success and failure can be studied extensively. Also, different forms of organizational structure can be tested. This would require collaboration of several different organizations in several countries.

Effectivity
First proof-of-principle has been given in this study. However, as mentioned before, ultimate effectivity measures like mortality or healthcare expenditure have not been tested yet. For reliable mortality data, a longer follow-up period is needed or more study participants. Both longer follow-up as well as more study participants are also needed for a health care expenditure measure. Healthcare expenditure and mortality are influenced by many determinants in a real world setting and experimental settings very badly reflect the real world. We therefore propose to not focus on mortality or healthcare expenditure.

Peer centric framework
The study in this thesis did not find how the effect of peer coaching is mediated. As Hulteen and colleagues rightly mention, this is still an understudied area of peer-led interventions.[33] There is lack of a peer centric framework that explains the mechanisms through which peer coaches influence the behaviour of participants. Such a theoretical framework would also help uniform future peer-led interventions.

Definition
There is a lack of uniformity across research regarding peer-led interventions.[31] Even though this is a frequent mentioned downside of research in this area, it could also be seen as a strength. A strong aspect of the peer coach physical activity intervention was its adaptability. However, there is still much progress to be made in this emerging

field of research. A clear definition of different matters would help communication. In the scientific literature the terms peer mentor, peer leader and peer coach are often interchangeable. The same goes for peer-led, peer-delivered and peer-coached. Terms like peer mentoring, peer support and peer coaching seemed interchangeable, but Matz-Costa and colleagues distinguished the nuances.[34] This is the single most important point for the future of peer support research. Although we did add a new word to the peer research lingo, we hope there will be a clear definition of all aspects in the near future.

CONCLUSION

Many of today's prevalent diseases with a high burden are at least partly caused by unhealthy lifestyle and improve with a healthy lifestyle. Physical activity is consistently identified as a strong factor to prevent, improve and treat many of these diseases. For some people, increasing daily physical activity requires an active and sustainable intervention with a strong social component. Peer coaching is an emerging method with inherit advantages that make it suitable for a sustainable and social intervention. Here we showed that peer coaching is proven effective in a real-world setting to increase physical activity in large numbers of older adults for a long period of time.

REFERENCES

1. Allen SV, Hopkins WG. Age of peak competitive performance of elite athletes: a systematic review. *Sports Medicine.* 2015;45:1431-1441.
2. Lee I-M, Paffenbarger Jr RS. Associations of light, moderate, and vigorous intensity physical activity with longevity: the Harvard Alumni Health Study. *American journal of epidemiology.* 2000;151:293-299.
3. Burtscher J, Burtscher M. Run for your life: tweaking the weekly physical activity volume for longevity. In: BMJ Publishing Group Ltd and British Association of Sport and Exercise Medicine; 2020.
4. Van Saase J, Noteboom W, Vandenbroucke JP. Longevity of men capable of prolonged vigorous physical exercise: a 32 year follow up of 2259 participants in the Dutch eleven cities ice skating tour. *British Medical Journal.* 1990;301:1409-1411.
5. Ekblom-Bak E, Ekblom B, Vikström M, de Faire U, Hellénius M-L. The importance of non-exercise physical activity for cardiovascular health and longevity. *British journal of sports medicine.* 2014;48:233-238.
6. Lin Y-P, Huang Y-H, Lu F-H, Wu J-S, Chang C-J, Yang Y-C. Non-leisure time physical activity is an independent predictor of longevity for a Taiwanese elderly population: an eight-year follow-up study. *BMC public health.* 2011;11:1-9.
7. Taylor D. Physical activity is medicine for older adults. *Postgraduate medical journal.* 2014;90:26-32.
8. Langhammer B, Bergland A, Rydwik E. The importance of physical activity exercise among older people. In: Hindawi; 2018.
9. Dorgo S, Robinson KM, Bader J. The effectiveness of a peer-mentored older adult fitness program on perceived physical, mental, and social function. *J Am Acad Nurse Pract.* 2009;21:116-122.
10. Sun F, Norman IJ, While AE. Physical activity in older people: a systematic review. *BMC public health.* 2013;13:449.
11. Acree LS, Longfors J, Fjeldstad AS, et al. Physical activity is related to quality of life in older adults. *Health and quality of life outcomes.* 2006;4:1-6.
12. Conn VS, Hafdahl AR, Brown LM. Meta-analysis of quality-of-life outcomes from physical activity interventions. *Nursing research.* 2009;58:175.
13. Halaweh H, Willen C, Grimby-Ekman A, Svantesson U. Physical activity and health-related quality of life among community dwelling elderly. *Journal of clinical medicine research.* 2015;7:845.
14. Slootmaker SM, Schuit AJ, Chinapaw MJ, Seidell JC, Van Mechelen W. Disagreement in physical activity assessed by accelerometer and self-report in subgroups of age, gender, education and weight status. *International Journal of Behavioral Nutrition and Physical Activity.* 2009;6:1-10.
15. Portacio FG, Corvalan D, Stoutenberg M. Implementation of a Referral Scheme to Text Messaging Programs for Physical Activity and Healthy Eating in Underserved Hispanics. *Translational Journal of the American College of Sports Medicine.* 2021;6:e000144.
16. Beidas RS, Paciotti B, Barg F, et al. A hybrid effectiveness-implementation trial of an evidence-based exercise intervention for breast cancer survivors. *Journal of the National Cancer Institute Monographs.* 2014;2014:338-345.

17. Estabrooks PA, Carron AV. Group cohesion in older adult exercisers: Prediction and intervention effects. *Journal of behavioral medicine.* 1999;22:575-588.
18. Christensen U, Schmidt L, Budtz-Jørgensen E, Avlund K. Group cohesion and social support in exercise classes: Results from a Danish intervention study. *Health education & behavior.* 2006;33:677-689.
19. Midtgaard J, Rorth M, Stelter R, Adamsen L. The group matters: an explorative study of group cohesion and quality of life in cancer patients participating in physical exercise intervention during treatment. *European journal of cancer care.* 2006;15:25-33.
20. Castro CM, Pruitt LA, Buman MP, King AC. Physical activity program delivery by professionals versus volunteers: the TEAM randomized trial. *Health Psychology.* 2011;30:285.
21. Ginis KAM, Nigg CR, Smith AL. Peer-delivered physical activity interventions: an overlooked opportunity for physical activity promotion. *Translational behavioral medicine.* 2013;3:434-443.
22. Dorgo S, King GA, Bader JO, Limon JS. Comparing the effectiveness of peer mentoring and student mentoring in a 35-week fitness program for older adults. *Archives of gerontology and geriatrics.* 2011;52:344-349.
23. Beauchamp MR, Carron AV, McCutcheon S, Harper O. Older adults' preferences for exercising alone versus in groups: considering contextual congruence. *Annals of Behavioral Medicine.* 2007;33:200-206.
24. Fisher EB, Boothroyd RI, Coufal MM, et al. Peer support for self-management of diabetes improved outcomes in international settings. *Health affairs.* 2012;31:130-139.
25. Hoey LM, Ieropoli SC, White VM, Jefford M. Systematic review of peer-support programs for people with cancer. *Patient education and counseling.* 2008;70:315-337.
26. Patil SJ, Ruppar T, Koopman RJ, et al. Effect of peer support interventions on cardiovascular disease risk factors in adults with diabetes: a systematic review and meta-analysis. *BMC public health.* 2018;18:1-10.
27. Colella TJ, King KM. Peer support. An under-recognized resource in cardiac recovery. *European Journal of Cardiovascular Nursing.* 2004;3:211-217.
28. Keyes SE, Clarke CL, Wilkinson H, et al. "We're all thrown in the same boat…": A qualitative analysis of peer support in dementia care. *Dementia.* 2016;15:560-577.
29. Pfeiffer PN, Heisler M, Piette JD, Rogers MA, Valenstein M. Efficacy of peer support interventions for depression: a meta-analysis. *General hospital psychiatry.* 2011;33:29-36.
30. Tracy K, Wallace SP. Benefits of peer support groups in the treatment of addiction. *Substance abuse and rehabilitation.* 2016;7:143.
31. McLeish J, Redshaw M. Peer support during pregnancy and early parenthood: a qualitative study of models and perceptions. *BMC Pregnancy and Childbirth.* 2015;15:1-14.
32. Wilson B. *Alcoholics Anonymous: Big Book.* AA World Services; 2015.
33. Hulteen RM, Waldhauser KJ, Beauchamp MR. Promoting health-enhancing physical activity: A state-of-the-art review of peer-delivered interventions. *Current obesity reports.* 2019;8:341-353.
34. Matz-Costa C, Howard EP, Castaneda-Sceppa C, Diaz-Valdes Iriarte A, Lachman ME. Peer-based strategies to support physical activity interventions for older adults: A typology, conceptual framework, and practice guidelines. *The Gerontologist.* 2019;59:1007-1016.

Chapter 8

Summary

PEER COACHING AS A POPULATION APPROACH TO INCREASE PHYSICAL ACTIVITY IN OLDER ADULTS

Introduction

The proportion of people older than 65 years increases worldwide. As a result, the prevalence of age-related diseases such as diabetes, cardiovascular disease, dementia and cancer increases steadily. Physical activity is effective in preventing and treating many of these age-related diseases. However, two thirds of Dutch older adults do not reach the recommended level of 150 minutes a week moderate intense physical activity. Current efforts to increase physical activity with professional led physical activity interventions are effective during the intervention period, but do not manage to have a sustainable effect. Scarcity and costs of professionals limit the reach and long-term implementation of these interventions.

Methods

In this thesis we studied the possibility of peer coaching to sustainably increase physical activity in older adults. Peer coaching is a promising method without the limitations of professionals-led interventions. Peer coaching is a face-to-face intervention to reach a common goal given by a non-professional, who has a common background with the recipient, either through a similar life experience or other shared characteristics.

Results

The first proof-of-principle of an effective peer coach physical activity intervention was created in 2010 by older adults themselves. This group of older adults exercised together every weekday one hour together under the guidance of one of their peers. The group was completely self-organizing and self-sustainable without external funding. At the time of writing, the group exists for 11 years and has almost 250 participants. Participants reported improvements in their well-being and the six-minute walk test showed yearly improvements in cardiovascular fitness. This peer coach physical activity intervention managed to engage older adults in daily physical activity for years at no structural costs to society.

The following question was if this success could be copied at another location which we tested in Leiden. Three similar peer coach physical activity interventions were set up by researchers in three neighbourhoods with different socioeconomic status. After the initial researcher led period, all three groups became completely self-organizing within 8 months. Investment per group was less than €170 and 187

hours. The three groups exist at the time of writing more than 3 years. During the study more than 15 similar peer coach physical activity interventions were set up in the Netherlands by older adults themselves, welfare organizations or private companies.

Consecutively we investigated if these self-organizing groups could be linked to formal care through an exercise referral scheme in primary care. Eight primary care practices referred only 106 older adults in one and a half year. Only 6 people responded to the referral of which 4 started exercising regularly for over a year in the peer coach group. The reach was small, but the potential benefits could be regarded proportional to the small effort needed to refer.

Finally, we ended this thesis with a vision for the future by describing a best practice example from Cuba. Cuba has implemented the Círculos de Abuelos (grandparent circles) in 1987, where currently 12,000 groups of 900,000 older adults exercise and enjoy life together. Cuba managed to implement a population approach that reaches 40% of its older population and has been effective for over 30 years.

Conclusion
Older adults can effectively and sustainably increase physical activity of older adults through peer coach physical activity interventions. After a small investment for implementation, a sustainable self-organising exercise intervention can be created which has existed for several years now. The reach of the groups can be increased through an exercise referral scheme in primary care, but the effectivity needs to be improved through research. Nationwide implementation of exercise groups for older adults is possible, but it requires effort from a large (governmental) party.

CHAPTER 9

Nederlandse samenvatting

PEER COACHING OM OP GROTE SCHAAL MEER BEWEGING TE STIMULEREN BIJ SENIOREN

Introductie

Het aandeel mensen ouder dan 65 jaar neemt wereldwijd toe. Als gevolg hiervan neemt de prevalentie van leeftijd gerelateerde ziekten zoals diabetes, hart- en vaatziekten, dementie en kanker gestaag toe. Dagelijkse beweging is effectief bij het voorkomen en behandelen van veel van deze ouderdomsziekten. Twee derde van de Nederlandse ouderen bereikt echter niet de beweegrichtlijn van 150 minuten per week matig intensieve beweging. De huidige inspanningen om dagelijkse beweging te verhogen met door professionals begeleide beweeginterventie zijn effectief tijdens de interventieperiode, maar slagen er niet in om een duurzaam effect te hebben. Schaarste en kosten van professionals beperken het bereik en de lange termijn borging van deze interventies.

Methode

In dit proefschrift bestudeerden we de mogelijkheid van peer coaching om de dagelijkse beweging van ouderen duurzaam te verhogen. Peer coaching is een veelbelovende methode zonder de beperkingen van interventies die door professionals worden begeleid. Peer coaching is een interventie om een gezamenlijk doel te behalen, die gegeven wordt door een amateur die een gemeenschappelijke achtergrond heeft met de ontvanger, hetzij door een vergelijkbare levenservaring of door andere gedeelde kenmerken.

Resultaten

Het eerste proof-of-principle van een effectieve interventie voor dagelijkse beweging door peer coaching werd gecreëerd in 2010 door ouderen zelf. Deze groep ouderen trainde elke weekdag samen een uur onder begeleiding van een van hun leeftijdsgenoten. De groep was volledig zelforganiserend en zelfvoorzienend zonder externe financiering. Op het moment van schrijven bestaat de groep al 11 jaar en heeft het bijna 250 deelnemers. De deelnemers rapporteerden verbeteringen in hun welzijn en de zes minuten looptest toonde jaarlijkse verbeteringen in conditie. Deze peer coach interventie slaagde erin om ouderen jarenlang te betrekken bij dagelijkse fysieke activiteit zonder structurele kosten voor de maatschappij.

De volgende vraag was of dit succes gekopieerd kon worden naar een andere locatie. Dit hebben we in Leiden getest. Onderzoekers hebben drie vergelijkbare peer coach beweeginterventies opgezet in drie buurten met een verschillende sociaaleconomische status. Na de initiële periode waren alle drie de groepen binnen

8 maanden volledig zelforganiserend. De investering per groep was minder dan €170 en 187 uur. De drie groepen bestaan op het moment van schrijven meer dan 3 jaar. Tijdens het onderzoek zijn in Nederland meer dan 15 vergelijkbare peer coach beweeginterventies opgezet door ouderen zelf, welzijnsorganisaties of particuliere bedrijven.

Achtereenvolgens onderzochten we of deze zelforganiserende groepen gekoppeld konden worden aan formele zorg door middel van een verwijzing bij de huisarts. Acht huisartspraktijken verwezen in anderhalf jaar slechts 106 ouderen. Slechts 6 mensen reageerden op de verwijzing, waarvan er 4 gedurende meer dan een jaar regelmatig sportten in de peer coach groep. Het bereik was klein, maar de potentiële voordelen waren in verhouding met de kleine inspanning die nodig was om door te verwijzen.

Ten slotte sloten we dit proefschrift af met een toekomstvisie door een best practice voorbeeld uit Cuba te beschrijven. Cuba heeft in 1987 de Círculos de Abuelos (grootoudercirkels) opgezet, waar nu 12.000 groepen van 900.000 ouderen sporten en samen van het leven genieten. Cuba is erin geslaagd een bevolkingsaanpak te implementeren die 40% van de oudere bevolking bereikt en al meer dan 30 jaar effectief is.

Conclusie
Ouderen kunnen ouderen effectief en duurzaam aanzetten tot bewegen in een peer coach beweeginterventie. Na een kleine investering voor de implementatie kan een duurzame zelf-organiserende interventie worden opgezet die in elk geval meerdere jaren blijft bestaan. Het bereik van de groepen kan worden vergroot door middel van een beweegverwijzingsregeling in de eerste lijn, maar de effectiviteit moet door onderzoek worden verbeterd. Landelijke implementatie van beweeggroepen voor ouderen is mogelijk, maar vergt inzet van een grote (overheids)instantie.

Chapter 10

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Chapter 11

List of publications

PUBLICATIONS

Van de Vijver PL, Van Bodegom D, Westendorp RGJ
Early and extraordinary peaks in physical performance come with a longevity cost.
Aging (Albany NY) 2016;8:1822-1828

Van de Vijver PL, & Van Bodegom D
De rol van de sociale omgeving bij veroudering.
Geron 2016;18:37-40.

Van de Vijver PL, Schalkwijk FH, Van Bodegom D
Peer coaching om ouderen gezond te houden.
Huisarts en wetenschap 2017;60:444-446.

Van de Vijver PL, Wielens H, Slaets JPJ, Van Bodegom D
Vitality club: a proof-of-principle of peer coaching for daily physical activity by older adults.
Translational behavioral medicine 2018;8:204-211.

Van de Vijver PL, Schalkwijk FH, Numans ME, Slaets JPJ, Van Bodegom D
Self-organizing peer coach groups to increase daily physical activity in community dwelling older adults.
Preventive Medicine Reports 2020;20:101181.

Van de Vijver PL, Schalkwijk FH, Numans ME, Slaets JPJ, & Van Bodegom D
Linking a peer coach physical activity intervention for older adults to a primary care referral scheme.
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De Bruin J*, **Van de Vijver PL***, Jonas PPM, Blom J, Diaz-Padilla N, Slaets JPJ, Van Bodegom D
Círculos de Abuelos: Cuba's population wide physical activity intervention for older adults.
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Van de Vijver PL, Van Bodegom D
Van gezonde individuen naar gezonde populaties.
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Chapter 12

List of references

REFERENCES

Acree LS, Longfors J, Fjeldstad AS, et al. Physical activity is related to quality of life in older adults. *Health and quality of life outcomes.* 2006;4:1-6.

Ades PA, Waldmann ML, McCann WJ, Weaver SO. Predictors of cardiac rehabilitation participation in older coronary patients. *Arch Intern Med.* 1992;152:1033-1035.

Agresti A, Coull BA. Approximate is better than "exact" for interval estimation of binomial proportions. *The American Statistician.* 1998;52:119-126.

Al Tunaiji H, Davis JC, Mackey DC, Khan KM. Population attributable fraction of type 2 diabetes due to physical inactivity in adults: a systematic review. *BMC Public Health.* 2014;14:1-9.

Allen SV, Hopkins WG. Age of peak competitive performance of elite athletes: a systematic review. *Sports Medicine.* 2015;45:1431-1441.

Almeida FA, Smith-Ray RL, Van Den Berg R, et al. Utilizing a simple stimulus control strategy to increase physician referrals for physical activity promotion. *Journal of Sport and Exercise Psychology.* 2005;27:505-514.

Aluttis C, Bishaw T, Frank MW. The workforce for health in a globalized context–global shortages and international migration. *Global health action.* 2014;7:23611.

Arsenijevic J, Groot W. Physical activity on prescription schemes (PARS): do programme characteristics influence effectiveness? Results of a systematic review and meta-analyses. *BMJ open.* 2017;7:e012156.

Barbaresko J, Rienks J, Nöthlings U. Lifestyle indices and cardiovascular disease risk: a meta-analysis. *American journal of preventive medicine.* 2018;55:555-564.

Barreto Ramos J, Morfi Samper R, Reyes Figueroa M, Cabrera Leal G. Diagnóstico del programa de ejercicios físicos realizados en el Círculo de abuelos "Abel Santamaría". *Rev Cubana Enfermer.* 2007;23:1-11.

Barrios Duarte R, Borges Mojaiber R, Cardoso Pérez LdC. Beneficios percibidos por adultos mayores incorporados al ejercicio. *Revista Cubana de Medicina General Integral.* 2003;19:0-0.

Baudisch A. The pace and shape of ageing. *Methods in Ecology and Evolution.* 2011;2:375-382.

Bauman AE, Reis RS, Sallis JF, et al. Correlates of physical activity: why are some people physically active and others not? *The lancet.* 2012;380:258-271.

Beauchamp MR, Carron AV, McCutcheon S, Harper O. Older adults' preferences for exercising alone versus in groups: considering contextual congruence. *Annals of Behavioral Medicine.* 2007;33:200-206.

Becker MH. *The Health belief model and personal health behavior.* Thorofare, N.J.: Slack; 1974.

Beidas RS, Paciotti B, Barg F, et al. A hybrid effectiveness-implementation trial of an evidence-based exercise intervention for breast cancer survivors. *Journal of the National Cancer Institute Monographs.* 2014;2014:338-345.

Benítez Pérez ME. Envejecer en Cuba: mucho más que un indicador demográfico. *Revista Novedades en Población.* 2015;11:10-19.

Benítez Pérez ME. Envejecer en Cuba: mucho más que un indicador demográfico. *Revista Novedades en Población.* 2015;11:0-0.

Berman B. Referral marketing: Harnessing the power of your customers. *Business Horizons.* 2016;59:19-28.

Berryman DE, Christiansen JS, Johannsson G, Thorner MO, Kopchick JJ. Role of the GH/IGF-1 axis in lifespan and healthspan: lessons from animal models. *Growth Hormone & IGF Research.* 2008;18:455-471.

Bethancourt HJ, Rosenberg DE, Beatty T, Arterburn DE. Barriers to and facilitators of physical activity program use among older adults. *Clinical medicine & research.* 2014;12:10-20.

Blagosklonny MV. Why men age faster but reproduce longer than women: mTOR and evolutionary perspectives. *Aging.* 2010;2:265-273.

Blagosklonny MV. Big mice die young but large animals live longer. *Aging.* 2013;5:227-233.

Blagosklonny MV, Hall MN. Growth and aging: a common molecular mechanism. *Aging.* 2009;1:357-362.

Blair SN. Physical inactivity: the biggest public health problem of the 21st century. *British journal of sports medicine.* 2009;43:1-2.

Blake H, Mo P, Malik S, Thomas S. How effective are physical activity interventions for alleviating depressive symptoms in older people? A systematic review. *Clinical rehabilitation.* 2009;23:873-887.

Bloom DE, Canning D, Lubet A. Global population aging: Facts, challenges, solutions & perspectives. *Daedalus.* 2015;144:80-92.

Booth ML, Bauman A, Owen N, Gore CJ. Physical activity preferences, preferred sources of assistance, and perceived barriers to increased activity among physically inactive Australians. *Preventive medicine.* 1997;26:131-137.

Bravo Hernández N, Noa Garbey M, Gómez LLoga T, Soto Martínez J. Repercusión del envejecimiento en la calidad de vida de los adultos mayores. *Revista Información Científica.* 2018;97:596-605.

Britto RR, Probst VS, Andrade AF, et al. Reference equations for the six-minute walk distance based on a Brazilian multicenter study. *Brazilian journal of physical therapy.* 2013;17:556-563.

Buman MP, Giacobbi Jr PR, Dzierzewski JM, et al. Peer volunteers improve long-term maintenance of physical activity with older adults: a randomized controlled trial. *Journal of Physical Activity and Health.* 2011;8:S257-S266.

Buman MP, Giacobbi Jr PR, Dzierzewski JM, et al. Peer volunteers improve long-term maintenance of physical activity with older adults: a randomized controlled trial. *Journal of Physical Activity and Health.* 2011;8:S257-S266.

Buman MP, Giacobbi PR, Jr., Dzierzewski JM, et al. Peer Volunteers Improve Long-Term Maintenance of Physical Activity With Older Adults: A Randomized Controlled Trial. *J Phys Act Health.* 2011;8:S257-S266.

Burton E, Farrier K, Hill KD, Codde J, Airey P, Hill A-M. Effectiveness of peers in delivering programs or motivating older people to increase their participation in physical activity: Systematic review and meta-analysis. *Journal of Sports Sciences.* 2018;36:666-678.

Burton NW, Khan A, Brown WJ. How, where and with whom? Physical activity context preferences of three adult groups at risk of inactivity. *British Journal of Sports Medicine.* 2012;46:1125-1131.

Burtscher J, Burtscher M. Run for your life: tweaking the weekly physical activity volume for longevity. In: BMJ Publishing Group Ltd and British Association of Sport and Exercise Medicine; 2020.

Campbell F, Holmes M, Everson-Hock E, et al. A systematic review and economic evaluation of exercise referral schemes in primary care: a short report. *Health Technol Assess.* 2015;19:1-110.

Castro CM, Pruitt LA, Buman MP, King AC. Physical activity program delivery by professionals versus volunteers: the TEAM randomized trial. *Health Psychology.* 2011;30:285.

Chase J-AD, Phillips LJ, Brown M. Physical activity intervention effects on physical function among community-dwelling older adults: a systematic review and meta-analysis. *Journal of aging and physical activity.* 2017;25:149-170.

Christakis NA, Fowler JH. The spread of obesity in a large social network over 32 years. *New England journal of medicine.* 2007;357:370-379.

Christensen U, Schmidt L, Budtz-Jørgensen E, Avlund K. Group cohesion and social support in exercise classes: Results from a Danish intervention study. *Health education & behavior.* 2006;33:677-689.

Colella TJ, King KM. Peer support. An under-recognized resource in cardiac recovery. *European Journal of Cardiovascular Nursing.* 2004;3:211-217.

Conn VS, Hafdahl AR, Brown LM. Meta-analysis of quality-of-life outcomes from physical activity interventions. *Nursing research.* 2009;58:175.

Conn VS, Hafdahl AR, Mehr DR. Interventions to increase physical activity among healthy adults: meta-analysis of outcomes. *American journal of public health.* 2011;101:751-758.

Costello E, Leone JE, Ellzy M, Miller TA. Older adult perceptions of the physicians' role in promoting physical activity. *Disabil Rehabil.* 2013;35:1191-1198.

Coutin G, MD MSc, Director, Puentes Grandes Polyclinic (1983-1991) and Vice-Director, Municipal Health Assistance Division (1992-1994). In. Havana, Cuba (Personal communication, May 2020).

Cunningham C, O'Sullivan R, Caserotti P, Tully MA. Consequences of physical inactivity in older adults: A systematic review of reviews and meta-analyses. *Scandinavian journal of medicine & science in sports.* 2020;30:816-827.

De Ponte G, Mans L, Di Sisto M, Van de Pas R. Health workforce shortages and international mobility in the EU. *Health Workers for all and all for Health Workers.* 2014.

de Rezende LFM, Rabacow FM, Viscondi JYK, do Carmo Luiz O, Matsudo VKR, Lee I-M. Effect of physical inactivity on major noncommunicable diseases and life expectancy in Brazil. *Journal of Physical Activity and Health.* 2015;12:299-306.

De Vos P, De Ceukelaire W, Bonet M, Van der Stuyft P. Cuba's health system: challenges ahead. *Health policy and planning.* 2008;23:288-290.

Devi R, Powell J, Singh S. A web-based program improves physical activity outcomes in a primary care angina population: randomized controlled trial. *Journal of medical Internet research.* 2014;16:e186.

Donato AJ, Tench K, Glueck DH, Seals DR, Eskurza I, Tanaka H. Declines in physiological functional capacity with age: a longitudinal study in peak swimming performance. *Journal of Applied Physiology.* 2003;94:764-769.

Dorgo S, King GA, Bader JO, Limon JS. Comparing the effectiveness of peer mentoring and student mentoring in a 35-week fitness program for older adults. *Archives of gerontology and geriatrics.* 2011;52:344-349.

Dorgo S, King GA, Bader JO, Limon JS. Outcomes of a peer mentor implemented fitness program in older adults: A quasi-randomized controlled trial. *International journal of nursing studies.* 2013;50:1156-1165.

Dorgo S, Robinson KM, Bader J. The effectiveness of a peer-mentored older adult fitness program on perceived physical, mental, and social function. *J Am Acad Nurse Pract.* 2009;21:116-122.

Drain PK, Barry M. Fifty Years of US Embargo: Cuba's health Outcomes and lessons. *Science.* 2010;328:572-573.

Dugdill L, Graham RC, McNair F. Exercise referral: the public health panacea for physical activity promotion? A critical perspective of exercise referral schemes; their development and evaluation. *Ergonomics.* 2005;48:1390-1410.

Durlak JA, DuPre EP. Implementation matters: A review of research on the influence of implementation on program outcomes and the factors affecting implementation. *American journal of community psychology.* 2008;41:327-350.

Ekblom-Bak E, Ekblom B, Vikström M, de Faire U, Hellénius M-L. The importance of non-exercise physical activity for cardiovascular health and longevity. *British journal of sports medicine.* 2014;48:233-238.

Ericsson KA. Peak performance and age: an examination of peak performance in sports. In: Baltes PB, Baltes MM, eds. *Successful aging: Perspectives from the behavioral sciences.* Vol 4. Cambridge University Press; 1993:164-196.

Estabrooks PA, Carron AV. Group cohesion in older adult exercisers: Prediction and intervention effects. *Journal of behavioral medicine.* 1999;22:575-588.

Farzadfar F, Finucane MM, Danaei G, et al. National, regional, and global trends in serum total cholesterol since 1980: systematic analysis of health examination surveys and epidemiological studies with 321 country-years and 3· 0 million participants. *The Lancet.* 2011;377:578-586.

Fehlings MG, Tetreault L, Nater A, et al. The aging of the global population: the changing epidemiology of disease and spinal disorders. *Neurosurgery.* 2015;77:S1-S5.

Finch CE. *Longevity, senescence, and the genome.* University of Chicago Press; 1994.

Finger JD, Busch MA, Heidemann C, Lange C, Mensink GB, Schienkiewitz A. Time trends in healthy lifestyle among adults in Germany: Results from three national health interview and examination surveys between 1990 and 2011. *PloS one.* 2019;14:e0222218.

Fink B, Neave N, Seydel H. Male facial appearance signals physical strength to women. *American Journal of Human Biology.* 2007;19:82-87.

Fisher EB, Boothroyd RI, Coufal MM, et al. Peer support for self-management of diabetes improved outcomes in international settings. *Health affairs.* 2012;31:130-139.

French DP, Olander EK, Chisholm A, Mc Sharry J. Which behaviour change techniques are most effective at increasing older adults' self-efficacy and physical activity behaviour? A systematic review. *Annals of behavioral medicine.* 2014;48:225-234.

Gidlow C, Johnston LH, Crone D, James D. Attendance of exercise referral schemes in the UK: a systematic review. *Health Education Journal.* 2005;64:168-186.

Ginis KAM, Nigg CR, Smith AL. Peer-delivered physical activity interventions: an overlooked opportunity for physical activity promotion. *Translational behavioral medicine.* 2013;3:434-443.

Giustini D, Ali SM, Fraser M, Boulos MNK. Effective uses of social media in public health and medicine: a systematic review of systematic reviews. *Online journal of public health informatics.* 2018;10.

Gomes M, Figueiredo D, Teixeira L, et al. Physical inactivity among older adults across Europe based on the SHARE database. *Age and ageing.* 2017;46:71-77.

González Ramos RM, Madrazo Ordaz DE, Osorio Núñez M. Conocimientos sobre salud bucal en los círculos de abuelos. *Revista Cubana de Estomatología.* 2013;50:284-291.

Gorry C. Cuba's Family Doctor-and-Nurse Teams: A Day in the Life. *MEDICC review.* 2017;19:6-9.

Graham R, Dugdill L, Cable N. Health professionals' perspectives in exercise referral: implications for the referral process. *Ergonomics.* 2005;48:1411-1422.

Graham RC, Dugdill L, Cable NT. Health professionals' perspectives in exercise referral: implications for the referral process. *Ergonomics.* 2005;48:1411-1422.

Greer KA, Canterberry SC, Murphy KE. Statistical analysis regarding the effects of height and weight on life span of the domestic dog. *Research in veterinary science.* 2007;82:208-214.

Gremeaux V, Gayda M, Lepers R, Sosner P, Juneau M, Nigam A. Exercise and longevity. *Maturitas.* 2012;73:312-317.

Groessl EJ, Kaplan RM, Blair SN, et al. A cost analysis of a physical activity intervention for older adults. *Journal of Physical Activity and Health.* 2009;6:767-774.

Guthold R, Ono T, Strong KL, Chatterji S, Morabia A. Worldwide variability in physical inactivity: a 51-country survey. *American journal of preventive medicine.* 2008;34:486-494.

Halaweh H, Willen C, Grimby-Ekman A, Svantesson U. Physical activity and health-related quality of life among community dwelling elderly. *Journal of clinical medicine research.* 2015;7:845.

Hall KS, Sloane R, Pieper CF, et al. Long-term changes in physical activity following a one-year home-based physical activity counseling program in older adults with multiple morbidities. *Journal of aging research.* 2010;2011.

Hall KS, Sloane R, Pieper CF, et al. Long-term changes in physical activity following a one-year home-based physical activity counseling program in older adults with multiple morbidities. *J Aging Res.* 2010;2011:308407.

Hall KS, Sloane R, Pieper CF, et al. Long-term changes in physical activity following a one-year home-based physical activity counseling program in older adults with multiple morbidities. *Journal of aging research.* 2011.

Hallal PC, Andersen LB, Bull FC, et al. Global physical activity levels: surveillance progress, pitfalls, and prospects. *The lancet.* 2012;380:247-257.

Han M, Lee E. Effectiveness of mobile health application use to improve health behavior changes: a systematic review of randomized controlled trials. *Healthcare informatics research.* 2018;24:207.

Harding JL, Pavkov ME, Magliano DJ, Shaw JE, Gregg EW. Global trends in diabetes complications: a review of current evidence. *Diabetologia.* 2019;62:3-16.

Harland J, White M, Drinkwater C, Chinn D, Farr L, Howel D. The Newcastle exercise project: a randomised controlled trial of methods to promote physical activity in primary care. *Bmj.* 1999;319:828-832.

Harvey PH, Zammuto RM. Patterns of mortality and age at first reproduction in natural populations of mammals. *Nature.* 1985;315:319-320.

Hernandez AR. Circulo de abuelos -La luz de la esperanza-. https://www.monografias.com/trabajos93/circulo-abuelos-luz-esperanza/circulo-abuelos-luz-esperanza.shtml. Published 2011. Accessed2019.

Ho JY, Hendi AS. Recent trends in life expectancy across high income countries: retrospective observational study. *bmj.* 2018;362.

Hobbs N, Godfrey A, Lara J, et al. Are behavioral interventions effective in increasing physical activity at 12 to 36 months in adults aged 55 to 70 years? A systematic review and meta-analysis. *BMC medicine.* 2013;11:1-12.

Hoey LM, Ieropoli SC, White VM, Jefford M. Systematic review of peer-support programs for people with cancer. *Patient education and counseling.* 2008;70:315-337.

Holt RI, Erotokritou-Mulligan I, Sönksen PH. The history of doping and growth hormone abuse in sport. *Growth Hormone & IGF Research.* 2009;19:320-326.

Hulteen RM, Waldhauser KJ, Beauchamp MR. Promoting health-enhancing physical activity: A state-of-the-art review of peer-delivered interventions. *Current obesity reports.* 2019;8:341-353.

Humphreys K, Blodgett JC, Wagner TH. Estimating the efficacy of Alcoholics Anonymous without self-selection bias: An instrumental variables re-analysis of randomized clinical trials. *Alcoholism: Clinical and Experimental Research.* 2014;38:2688-2694.

Hupin D, Roche F, Gremeaux V, et al. Even a low-dose of moderate-to-vigorous physical activity reduces mortality by 22% in adults aged≥ 60 years: a systematic review and meta-analysis. *British journal of sports medicine.* 2015;49:1262-1267.

Hupkens C, Swinkels H. Around three-quarters of population see GP and dentist once a year. Statistics Netherlands (CBS). Published 2013. Accessed 23 september, 2019.

Ibrahim JG, Molenberghs G. Missing data methods in longitudinal studies: a review. *Test.* 2009;18:1-43.

Ingle L, Cleland JG, Clark AL. The long-term prognostic significance of 6-minute walk test distance in patients with chronic heart failure. *BioMed research international.* 2014.

Ingram DK, Reynolds MA, Les EP. The relationship of genotype, sex, body weight, and growth parameters to lifespan in inbred and hybrid mice. *Mechanisms of ageing and development.* 1982;20:253-266.

International Association of Athletics Federation. IAAF: Disciplines. http://www.iaaf.org/disciplines. Accessed April 2016.

Iwama AM, Andrade GNd, Shima P, Tanni SE, Godoy Id, Dourado VZ. The six-minute walk test and body weight-walk distance product in healthy Brazilian subjects. *Brazilian Journal of Medical and Biological Research.* 2009;42:1080-1085.

Jacobsen B, Oda K, Knutsen S, Fraser G. Age at menarche, total mortality and mortality from ischaemic heart disease and stroke: the Adventist Health Study, 1976–88. *International journal of epidemiology.* 2009;38:245-252.

Jacobsen BK, Heuch I, Kvåle G. Association of low age at menarche with increased all-cause mortality: a 37-year follow-up of 61,319 Norwegian women. *American journal of epidemiology.* 2007;166:1431-1437.

Jagannathan R, Patel SA, Ali MK, Narayan KV. Global updates on cardiovascular disease mortality trends and attribution of traditional risk factors. *Current diabetes reports.* 2019;19:1-12.

James DV, Johnston LH, Crone D, et al. Factors associated with physical activity referral uptake and participation. *Journal of sports sciences.* 2008;26:217-224.

Jesús E. Not Infected but Physically and Mentally Affected: Older Cubans and COVID-19. *MEDICC review.* 2020;22:83-84.

Johansson H, Stenlund H, Lundstrom L, Weinehall L. Reorientation to more health promotion in health services - a study of barriers and possibilities from the perspective of health professionals. *J Multidiscip Healthc.* 2010;3:213-224.

Joseph DH, Griffin M, Hall RF, Sullivan ED. Peer coaching: an intervention for individuals struggling with diabetes. *The Diabetes Educator.* 2001;27:703-710.

Kaskutas LA. Alcoholics Anonymous effectiveness: Faith meets science. *Journal of addictive diseases.* 2009;28:145-157.

Keyes SE, Clarke CL, Wilkinson H, et al. "We're all thrown in the same boat…": A qualitative analysis of peer support in dementia care. *Dementia.* 2016;15:560-577.

Kohl 3rd HW, Craig CL, Lambert EV, et al. The pandemic of physical inactivity: global action for public health. *The lancet.* 2012;380:294-305.

Kontis V, Bennett JE, Mathers CD, Li G, Foreman K, Ezzati M. Future life expectancy in 35 industrialised countries: projections with a Bayesian model ensemble. *The Lancet.* 2017;389:1323-1335.

Koorts H, Eakin E, Estabrooks P, Timperio A, Salmon J, Bauman A. Implementation and scale up of population physical activity interventions for clinical and community settings: the PRACTIS guide. *International Journal of Behavioral Nutrition and Physical Activity.* 2018;15:51.

Kraus C, Pavard S, Promislow DE. The size–life span trade-off decomposed: why large dogs die young. *The American Naturalist.* 2013;181:492-505.

Lakshman R, Forouhi NG, Sharp SJ, et al. Early age at menarche associated with cardiovascular disease and mortality. *Journal of Clinical Endocrinology & Metabolism.* 2009;94:4953-4960.

Langhammer B, Bergland A, Rydwik E. The importance of physical activity exercise among older people. In: Hindawi; 2018.

Laurant M, van der Biezen M, Wijers N, Watananirun K, Kontopantelis E, van Vught AJ. Nurses as substitutes for doctors in primary care. *Cochrane Database Syst Rev.* 2018;7:CD001271.

Lawlor DA, Keen S, Neal RD. Can general practitioners influence the nation's health through a population approach to provision of lifestyle advice? *The British journal of general practice : the journal of the Royal College of General Practitioners.* 2000;50:455-459.

Lee I-M, Paffenbarger Jr RS. Associations of light, moderate, and vigorous intensity physical activity with longevity: the Harvard Alumni Health Study. *American journal of epidemiology.* 2000;151:293-299.

Lee I-M, Shiroma EJ, Lobelo F, et al. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. *The lancet.* 2012;380:219-229.

Leenaars K, Smit E, Wagemakers A, Molleman G, Koelen M. Facilitators and barriers in the collaboration between the primary care and the sport sector in order to promote physical activity: a systematic literature review. *Preventive Medicine.* 2015;81:460-478.

Leijon ME, Bendtsen P, Nilsen P, Ekberg K, Ståhle A. Physical activity referrals in Swedish primary health care–prescriber and patient characteristics, reasons for prescriptions, and prescribed activities. *BMC health services research.* 2008;8:1-9.

Leontieva OV, Paszkiewicz GM, Blagosklonny MV. Mechanistic or mammalian target of rapamycin (mTOR) may determine robustness in young male mice at the cost of accelerated aging. *Aging.* 2012;4:899-916.

Lin Y-P, Huang Y-H, Lu F-H, Wu J-S, Chang C-J, Yang Y-C. Non-leisure time physical activity is an independent predictor of longevity for a Taiwanese elderly population: an eight-year follow-up study. *BMC public health.* 2011;11:1-9.

Lycett JE, Dunbar R, Voland E. Longevity and the costs of reproduction in a historical human population. *Proceedings of the Royal Society of London B: Biological Sciences.* 2000;267:31-35.

Maher CA, Lewis LK, Ferrar K, Marshall S, De Bourdeaudhuij I, Vandelanotte C. Are health behavior change interventions that use online social networks effective? A systematic review. *Journal of medical Internet research.* 2014;16:e40.

Markus HR, Kitayama S. Culture and the self: Implications for cognition, emotion, and motivation. *Psychological review.* 1991;98:224.

Martinson BC, Crain AL, Sherwood NE, Hayes MG, Pronk NP, O'Connor PJ. Population reach and recruitment bias in a maintenance RCT in physically active older adults. *Journal of Physical Activity and Health.* 2010;7:127-135.

Matz-Costa C, Howard EP, Castaneda-Sceppa C, Diaz-Valdes Iriarte A, Lachman ME. Peer-based strategies to support physical activity interventions for older adults: A typology, conceptual framework, and practice guidelines. *The Gerontologist.* 2019;59:1007-1016.

Mazorra R. Personal information. https://www.ecured.cu/Raúl_Mazorra. Published 2020. Accessed.

McAuley E, Blissmer B, Marquez DX, Jerome GJ, Kramer AF, Katula J. Social relations, physical activity, and well-being in older adults. *Preventive medicine.* 2000;31:608-617.

McAuley E, Jerome GJ, Elavsky S, Marquez DX, Ramsey SN. Predicting long-term maintenance of physical activity in older adults. *Prev Med.* 2003;37:110-118.

McAuley E, Morris KS, Motl RW, Hu L, Konopack JF, Elavsky S. Long-term follow-up of physical activity behavior in older adults. *Health Psychology.* 2007;26:375.

McKay HA, Sims-Gould J, Nettlefold L, Hoy CL, Bauman AE. Implementing and evaluating an older adult physical activity model at scale: framework for action. *Translational Journal of the American College of Sports Medicine.* 2017;2:10-19.

McLeish J, Redshaw M. Peer support during pregnancy and early parenthood: a qualitative study of models and perceptions. *BMC Pregnancy and Childbirth.* 2015;15:1-14.

McNeill LH, Kreuter MW, Subramanian S. Social environment and physical activity: a review of concepts and evidence. *Social science & medicine.* 2006;63:1011-1022.

Meeûs D. Human longevity at the cost of reproductive success: evidence from global data. *Journal of Evolutionary Biology.* 2000;13:409-414.

Midtgaard J, Rorth M, Stelter R, Adamsen L. The group matters: an explorative study of group cohesion and quality of life in cancer patients participating in physical exercise intervention during treatment. *European journal of cancer care.* 2006;15:25-33.

Milat AJ, Bauman AE, Redman S, Curac N. Public health research outputs from efficacy to dissemination: a bibliometric analysis. *BMC Public Health.* 2011;11:934.

Milat AJ, King L, Newson R, et al. Increasing the scale and adoption of population health interventions: experiences and perspectives of policy makers, practitioners, and researchers. *Health research policy and systems.* 2014;12:18.

Mills KT, Bundy JD, Kelly TN, et al. Global disparities of hypertension prevalence and control: a systematic analysis of population-based studies from 90 countries. *Circulation.* 2016;134:441-450.

Mitchell JH, Haskell W, Snell P, Van Camp SP. Task Force 8: classification of sports. *Journal of the American College of Cardiology.* 2005;45:1364-1367.

Morgan F, Battersby A, Weightman AL, et al. Adherence to exercise referral schemes by participants - what do providers and commissioners need to know? A systematic review of barriers and facilitators. *BMC Public Health.* 2016;16:227.

Morgan F, Battersby A, Weightman AL, et al. Adherence to exercise referral schemes by participants–what do providers and commissioners need to know? A systematic review of barriers and facilitators. *BMC public health.* 2016;16:1-11.

Morgen CS, Sørensen TI. Global trends in the prevalence of overweight and obesity. *Nature Reviews Endocrinology.* 2014;10:513-514.

Moschny A, Platen P, Klaaßen-Mielke R, Trampisch U, Hinrichs T. Barriers to physical activity in older adults in Germany: a cross-sectional study. *International Journal of Behavioral Nutrition and Physical Activity.* 2011;8:1-10.

Muehlenbein MP, Bribiescas RG. Testosterone-mediated immune functions and male life histories. *American journal of human biology : the official journal of the Human Biology Council.* 2005;17:527-558.

Muller AM, Khoo S. Non-face-to-face physical activity interventions in older adults: a systematic review. *Int J Behav Nutr Phys Act.* 2014;11:35.

Muller-Riemenschneider F, Reinhold T, Nocon M, Willich SN. Long-term effectiveness of interventions promoting physical activity: a systematic review. *Prev Med.* 2008;47:354-368.

National Health Statistics and Medical Records Division (CU). Anuario Estadístico de Salud 2018 [Internet]. https://files.sld.cu/bvscuba/files/2019/04/Anuario-Electrónico-Español-2018-ed-2019-compressed.pdf. Published 2018. Accessed2020.

National Health Statistics and Medical Records Division (CU). Indicadores seleccionados del Adulto Mayor, 2018. *Havana: Ministry of Public Health (CU).* 2019.

Norman GJ, Zabinski MF, Adams MA, Rosenberg DE, Yaroch AL, Atienza AA. A review of eHealth interventions for physical activity and dietary behavior change. *American journal of preventive medicine.* 2007;33:336-345. e316.

Oeppen J, Vaupel JW. Broken limits to life expectancy. *Science.* 2002;296:1029-1031.

Panadero RM, Matos J. Círculos de Abuelos cumplieron 30 años de fundados. http://www.jit.cu/NewsDetails.aspx?idnoticia=40140. Published 2017. Accessed2020.

Patil SJ, Ruppar T, Koopman RJ, et al. Effect of peer support interventions on cardiovascular disease risk factors in adults with diabetes: a systematic review and meta-analysis. *BMC public health.* 2018;18:1-10.

Pavey TG, Taylor AH, Fox KR, et al. Effect of exercise referral schemes in primary care on physical activity and improving health outcomes: systematic review and meta-analysis. *BMJ.* 2011;343:d6462.

Pérez-Escamilla R, Hromi-Fiedler A, Vega-López S, Bermúdez-Millán A, Segura-Pérez S. Impact of peer nutrition education on dietary behaviors and health outcomes among Latinos: a systematic literature review. *Journal of nutrition education and behavior.* 2008;40:208-225.

Persson G, Brorsson A, Ekvall Hansson E, Troein M, Strandberg EL. Physical activity on prescription (PAP) from the general practitioner's perspective - a qualitative study. *BMC family practice.* 2013;14:128.

Pfeiffer PN, Heisler M, Piette JD, Rogers MA, Valenstein M. Efficacy of peer support interventions for depression: a meta-analysis. *General hospital psychiatry.* 2011;33:29-36.

Portacio FG, Corvalan D, Stoutenberg M. Implementation of a Referral Scheme to Text Messaging Programs for Physical Activity and Healthy Eating in Underserved Hispanics. *Translational Journal of the American College of Sports Medicine.* 2021;6:e000144.

Pratt M, Varela AR, Salvo D, Kohl III HW, Ding D. Attacking the pandemic of physical inactivity: what is holding us back? In: BMJ Publishing Group Ltd and British Association of Sport and Exercise Medicine; 2020.

Prince MJ, Wu F, Guo Y, et al. The burden of disease in older people and implications for health policy and practice. *The Lancet.* 2015;385:549-562.

Promislow DE, Harvey PH. Living fast and dying young: A comparative analysis of life-history variation among mammals. *Journal of Zoology.* 1990;220:417-437.

Quiñones RG, de Armas MA. Envejecimiento, políticas sociales y sectoriales en Cuba. *Ponencia presentada en Seminario Internacional sobre Políticas gerontológicas, Buenos Aires, Argentina.* 2010.

Raja S, Teti M, Knauz R, et al. Implementing peer-based interventions in clinic-based settings: Lessons from a multi-site HIV prevention with positives initiative. *Journal of HIV/AIDS & Social Services.* 2008;7:7-26.

Ramchand R, Ahluwalia SC, Xenakis L, Apaydin E, Raaen L, Grimm G. A systematic review of peer-supported interventions for health promotion and disease prevention. *Prev Med.* 2017;101:156-170.

Reingen PH, Kernan JB. Analysis of referral networks in marketing: Methods and illustration. *Journal of marketing research.* 1986;23:370-378.

Richards J, Thorogood M, Hillsdon M, Foster C. Face-to-face versus remote and web 2.0 interventions for promoting physical activity. *Cochrane Database Syst Rev.* 2013;9:Cd010393.

Riley JC. *Rising life expectancy: a global history.* Cambridge University Press; 2001.

Rimmer A. Shortage of doctors across Europe may be caused by migration to UK. *BMJ careers.* 2014.

Rodríguez-Loeches E, Suárez A. Desarrollo regional y envejecimiento poblacional en Cuba. http://repositorio.geotech.cu/jspui/bitstream/1234/1905/1/Desarrollo%20regional%20y%20envejecimiento%20poblacional%20en%20Cuba.pdf. Published 2005. Accessed2020.

Rollo CD. Growth negatively impacts the life span of mammals. *Evolution & development.* 2002;4:55-61.

Rosenstock IM. Historical Origins of the Health Belief Model. *Health Education Monographs.* 1974;2:328-335.

Rosenstock IM. The Health Belief Model and Preventive Health Behavior. *Health Education Monographs.* 1974;2:354-386.

Rossman B. Breastfeeding peer counselors in the United States: helping to build a culture and tradition of breastfeeding. *Journal of midwifery & women's health.* 2007;52:631-637.

Roth GA, Mensah GA, Johnson CO, et al. Global burden of cardiovascular diseases and risk factors, 1990–2019: update from the GBD 2019 study. *Journal of the American College of Cardiology.* 2020;76:2982-3021.

Schutzer KA, Graves BS. Barriers and motivations to exercise in older adults. *Preventive medicine.* 2004;39:1056-1061.

Shaw BA, Spokane LS. Examining the association between education level and physical activity changes during early old age. *Journal of aging and health.* 2008.

Shek DT, Ma C. Longitudinal data analyses using linear mixed models in SPSS: concepts, procedures and illustrations. *The Scientific World Journal.* 2011;11:42-76.

Short CE, Vandelanotte C, Duncan MJ. Individual characteristics associated with physical activity intervention delivery mode preferences among adults. *Int J Behav Nutr Phys Act.* 2014;11:25.

Slootmaker SM, Schuit AJ, Chinapaw MJ, Seidell JC, Van Mechelen W. Disagreement in physical activity assessed by accelerometer and self-report in subgroups of age, gender, education and weight status. *International Journal of Behavioral Nutrition and Physical Activity.* 2009;6:1-10.

Smith GL, Banting L, Eime R, O'Sullivan G, Van Uffelen JG. The association between social support and physical activity in older adults: a systematic review. *International Journal of Behavioral Nutrition and Physical Activity.* 2017;14:56.

Sokol R, Fisher E. Peer support for the hardly reached: a systematic review. *American journal of public health.* 2016;106:e1-e8.

Solomon P. Peer support/peer provided services underlying processes, benefits, and critical ingredients. *Psychiatric rehabilitation journal.* 2004;27:392.

Sotgiu I, Galati D, Manzano M, Rognoni E. Happiness components and their attainment in old age: A cross-cultural comparison between Italy and Cuba. *Journal of Happiness Studies.* 2011;12:353-371.

Sports Reference LLC. Olympics at Sports-Reference.com - Olympic Statistics and History. http://www.sports-reference.com/. Accessed April 2014.

Stead LF, Buitrago D, Preciado N, Sanchez G, Hartmann-Boyce J, Lancaster T. Physician advice for smoking cessation. *Cochrane database of systematic reviews.* 2013.

Sugiura Y, Ju Y-S, Yasuoka J, Jimba M. Rapid increase in Japanese life expectancy after World War II. *Biosci Trends.* 2010;4:9-16.

Sun F, Norman IJ, While AE. Physical activity in older people: a systematic review. *BMC public health.* 2013;13:449.

Sutter NB, Bustamante CD, Chase K, et al. A single IGF1 allele is a major determinant of small size in dogs. *Science.* 2007;316:112-115.

Taylor A, Cable N, Faulkner G, Hillsdon M, Narici M, Van Der Bij A. Physical activity and older adults: a review of health benefits and the effectiveness of interventions. *Journal of sports sciences.* 2004;22:703-725.

Taylor D. Physical activity is medicine for older adults. *Postgraduate medical journal.* 2014;90:26-32.

Thom DH, Ghorob A, Hessler D, De Vore D, Chen E, Bodenheimer TA. Impact of peer health coaching on glycemic control in low-income patients with diabetes: a randomized controlled trial. *The Annals of Family Medicine.* 2013;11:137-144.

Tracy K, Wallace SP. Benefits of peer support groups in the treatment of addiction. *Substance abuse and rehabilitation.* 2016;7:143.

Troosters T, Gosselink R, Decramer M. Six minute walking distance in healthy elderly subjects. *The European respiratory journal.* 1999;14:270-274.

United Nations Statistics Division. UNDATA. https://data.un.org/. Published 2014. Accessed2020.

van de Vijver P, Schalkwijk F, Numans ME, Slaets JP, van Bodegom D. Self-organizing peer coach groups to increase daily physical activity in community dwelling older adults. *Preventive Medicine Reports.* 2020:101181.

Van de Vijver PL, Wielens H, Slaets JPJ, Van Bodegom D. Vitality club: a proof-of-principle of peer coaching for daily physical activity by older adults. *Translational behavioral medicine.* 2018;8:204-211.

van de Vijver PL, Wielens H, Slaets JPJ, van Bodegom D. Vitality club: a proof-of-principle of peer coaching for daily physical activity by older adults. *Translational behavioral medicine.* 2018;8:204-211.

van der Bij A, Laurant M, Wensing M. Effectiveness of physical activity interventions for older adults: a review. *American journal of preventive medicine.* 2002;22:120.

van der Bij AK, Laurant MG, Wensing M. Effectiveness of physical activity interventions for older adults: a review. *Am J Prev Med.* 2002;22:120-133.

Van Saase J, Noteboom W, Vandenbroucke JP. Longevity of men capable of prolonged vigorous physical exercise: a 32 year follow up of 2259 participants in the Dutch eleven cities ice skating tour. *British Medical Journal.* 1990;301:1409-1411.

Vogel T, Brechat PH, Leprêtre PM, Kaltenbach G, Berthel M, Lonsdorfer J. Health benefits of physical activity in older patients: a review. *International journal of clinical practice.* 2009;63:303-320.

Vogel T, Brechat PH, Leprêtre PM, Kaltenbach G, Berthel M, Lonsdorfer J. Health benefits of physical activity in older patients: a review. *International journal of clinical practice.* 2009;63:303-320.

Wallace J, Raglin J, Jastremski C. Twelve month adherence of adults who joined a fitness program with a spouse vs without a spouse. *The Journal of sports medicine and physical fitness.* 1995;35:206-213.

Wang X, Byars SG, Stearns SC. Genetic links between post-reproductive lifespan and family size in Framingham. *Evolution, medicine, and public health.* 2013;2013:241-253.

Watson KB, Carlson SA, Gunn JP, et al. Physical inactivity among adults aged 50 years and older—United States, 2014. *Morbidity and Mortality Weekly Report.* 2016;65:954-958.

Wensink MJ, van Heemst D, Rozing MP, Westendorp RG. The maintenance gap: a new theoretical perspective on the evolution of aging. *Biogerontology.* 2012;13:197-201.

Westendorp RG, Kirkwood TB. Human longevity at the cost of reproductive success. *Nature.* 1998;396:743-746.

Wiggers LC, Smets EM, Oort FJ, et al. The effect of a minimal intervention strategy in addition to nicotine replacement therapy to support smoking cessation in cardiovascular outpatients: a randomized clinical trial. *European Journal of Cardiovascular Prevention & Rehabilitation.* 2006;13:931-937.

Wilson B. *Alcoholics Anonymous: Big Book.* AA World Services; 2015.

Wolff JK, Warner LM, Ziegelmann JP, Wurm S. What do targeting positive views on ageing add to a physical activity intervention in older adults? Results from a randomised controlled trial. *Psychology & Health.* 2014;29:915-932.

Yazdanyar A, Aziz MM, Enright PL, et al. Association Between 6-Minute Walk Test and All-Cause Mortality, Coronary Heart Disease–Specific Mortality, and Incident Coronary Heart Disease. *Journal of aging and health.* 2014;26:583-599.

Yesalis CE, Bahrke MS. History of doping in sport. *Performance enhancing substances in sport and exercise Champaign: Human Kinetics.* 2002:1-20.

Zhang Y, Pan X-F, Chen J, et al. Combined lifestyle factors and risk of incident type 2 diabetes and prognosis among individuals with type 2 diabetes: a systematic review and meta-analysis of prospective cohort studies. *Diabetologia.* 2020;63:21-33.

Zolnierek KB, Dimatteo MR. Physician communication and patient adherence to treatment: a meta-analysis. *Med Care.* 2009;47:826-834.

Zwiers R, Zantvoord F, Engelaer F, Van Bodegom D, van der Ouderaa F, Westendorp R. Mortality in former Olympic athletes: retrospective cohort analysis. *BMJ.* 2012;345:e7456.

Chapter 13

Curriculum vitae

CURRICULUM VITAE

Paulus Luigi van de Vijver was born on the 13th of July 1992 in 's-Gravenhage, the Netherlands. In 2010 he completed gymnasium secondary school cum laude at Segbroek College in 's-Gravenhage, the Netherlands. He was also awarded the Diligentia Prize for outstanding performance in the bèta subjects. After this he moved to Leiden to study medicine. During his studies he went to Vietnam to do a clerkship ophthalmology. In 2017 he graduated and got his Master of Science.

His interest in science started during the elective course The Ageing Programme, which resulted in an internship at the Leyden Academy on Vitality in Ageing in 2014. After this internship he joined the Young Excellence Class to practice his scientific skills. This culminated in a scientific publication and a PhD position from 2017 to 2021. As a PhD-student he was engaged in the development and organisation of the Vitality Clubs: the peer coach physical activity intervention studied throughout this thesis. He was also engaged in the organisation of the minor programme Human Evolution of Leiden Institute of Biology, Leyden Academy on Vitality and Ageing, the Faculty of Archaeology of Leiden University and Leiden University Medical Center.