Exercise, disability and physical functioning in older Chinese adults during their last six years of life: a cohort study

Meng-Lei Chen
Zhejiang University
Cong Huang
Zhejiang University
Yu-Min Huang
Zhejiang University
Chun-Chun Wu
Zhejiang University
Sen Xue
Zhejiang University
Yu-xin Yang
Zhejiang University
Xu Wen (wenxu@zju.edu.cn)
Zhejiang University https://orcid.org/0000-0003-3658-6368

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Abstract

Background

Little is known about the potential effects of exercise behaviour on disability and physical functioning (PF) in late-life. This study aimed to investigate whether exercise behaviour with four different long term exercise status influences disability and PF in older Chinese adults during their last six years of life.

Methods

Secondary data analyses were performed using participants (≥ 65 years) from the Chinese Longitudinal Healthy Longevity Study. Exercise behaviour was collected every three years during their last six years of life. 4265 participants were enrolled and divided into four groups, including long-term non-exercising (NN), non-exercising to exercise (NY), exercise to non-exercising (YN), and long-term exercising (YY). Disability was measured based on the Katz Index of Activities of Daily Living scale and divided into three disability levels. PF was included as chair-rise, pick-up book and turn-around. Risks burden in disability and PF among four groups were compared using logistic regression analyses.

Results

Compared with NN, the risk of developing severe disability was attenuated in YY (OR 0.11, 95%CI 0.06 to 0.21) and attenuated in NY (OR 0.27, 95%CI 0.17 to 0.44) and increased in YN (OR 1.36, 95%CI 1.08 to 1.72). Moderate disability risk was increased in YN (OR 1.85, 95%CI 1.26 to 2.71) only. The risk of developing physical dysfunction (chair-rise, pick-up book, and turning around 360°) was decreased in YY and NY, and did not have significant difference in YN.

Conclusions

EP were associated with disability and PF in older Chinese adults during their late-life. Late-life exercise behaviour is still beneficial. Our findings suggest that it is meaning to encourage older people doing EP at late-life in China.

Background

With longer life expectancy, population aging is becoming one of the most important challenges of the future. The average life expectancy in China is 75.3 years old in 2015 and is predicted to be 80 years old by 2050, but older population's health-related quality of life is not increasing proportionally[1]. It has been researched that more than 40 million of the Chinese older population live with physical dysfunction or disability[2]. Maintaining or improving physical functioning (PF) of older population is becoming meaningful and necessary[3].

PF was measured by physical performance tests. Disability was defined as limitation with activities of daily living. Researches reported that negative health consequences of physical dysfunction may include disability and shortened life expectancy[4, 5]. The annual prevalence of physical dysfunction and disability among the older people have been studied[3], but the existed researches was not focused on the specific life periods' prevalence, especially end-of-life period's. Consequently, investigation on these aspects should be made on this special population group.

It's been proved that exercise practice (EP) has a positive effect on improved older populations' muscle strength [6], mobility disability[7] and survival in patients with cardiac disease[8]. Studies found that more the exercise performed preceding the less end-of-life inpatient care[9], the cardiac surgery less the ICU stay and a better disability recovery[10]. Nevertheless, little is known about the time-dependent effect of exercise behaviour on the late-life PF and disability. Additionally, most studies[11–13] particularly indicated age-, sex-, or diseases-related differences among older people who experienced disability at their late-life. But studies[14, 15] focused on exercise-related effects in older adults who had short life expectancy are still inadequate.

Studying of exercise cessation (EC) in old population is equally significant. Because of age-related chronic disease or hospital care, older adults are more likely to cease their exercise behaviour. Effects of EC on PF were well established in younger elderly[16, 17] and mixed results have been reported, with some finding a decline in functioning fitness[18, 19] and others finding a better physical performance than the pre-training value[17, 20]. Moreover, less is currently known about these effects in the older adults who had short life expectancy.

In this study, we aimed to investigate the potential effect of exercise behaviour and EC on the development of disability and physical dysfunction in older Chinese adults during their last six years of life.

Methods

Participants

The participants came from the Chinese Longitudinal Healthy Longevity Study (CLHLS). The CLHLS is a nationwide investigations that aimed to investigate factors affecting the health of Chinese older people (≥65 years)[21]. This investigation started in 1998, continued in 2000, 2002, 2005, 2008, 2011, 2014 and 2018. It randomly selected half of the counties, cities, and autonomous regions in 22 of 31 provinces, covering 85% (985 million) of the total population[22]. This representative survey has been recognized by the international and domestic academic circles and a large segment of studies have been conducted[1, 23].

The participants inclusion criteria in this study were as follows: (1) died between 2005 and 2014; (2) had two consecutive follow-up (three years apart) within the last six years of life; (3) did not become disabled at the earlier interview; (4) no missing data.

Exercise behaviour

At each investigation, the exercise behaviour of participants was measured with the question “Do you do exercises regularly at present? such as walking, playing balls, running, and qigong.”[24] And the regular exercise behaviour did not refer to all types of bodily movement but to purposeful fitness activities. Therefore, housework, garden work, and physical labor were not considered exercise behaviour. The participants were coached and were able to distinguish the difference between physical activity and exercise before they answered “Yes” or “No”. For each participants, their last 6 years to 4 years’ data were considered as baseline exercise status. The last 3 years to 1 year’s were measured as outcomes of exercise status. Two investigations’ exercise behaviour were combined and stratified into four groups:long-term non-exercising (NN), non-exercising to exercise (NY), exercise to non-exercising (YN), and long-term exercising (YY).

Disability

Disabilities in activities of daily living (ADL) were measured through the Katz Index of Activities of Daily Living scale (Cronbach’s α = 0.87)[25] according to self-reported responses to questions that involved six daily activities of eating, dressing, transferring, using the toilet, bathing, and continence. ADL had been proved as a good scale for measuring participants’ functional performance[26, 27]. Participants answered on a three-point scale, with “1” for “able to perform independently”, “2” for “receives assistance only for one part of process” and “3” for “receives more assistance”. The total score ranged from 6 to 18. The classification of disability adopted in other studies was followed in this study[23, 28]. “Good” was defined as needing assistance for none or only one of the six items. “Moderately disabled” was defined as needing assistance for two of the six items. When the person requires assistance for three or more, he is considered as “severely disabled.”

Physical functioning

Three objective PF performance tests were used to measure participants’ PF and tested in the participants’ homes by trained interviewers from the local center for disease prevention[23]. Since self-reported measures of disability are subjective, they are recommended as a complementary measures and have been used in Chinese older population[29]. For each investigation (three years apart), the participants were asked to □) stand up from a chair (1=can without using arms, 2=can using arms, and 3=cannot); □) pick up a book from floor (1=can while standing, 2=can while sitting, and 3=cannot). “1,” “2,” and “3” three codes represented normal, moderate impairment, and severe impairment, respectively; and □) turn around 360° (1=yes and 2= no)[23, 30]. As mentioned previously, the baseline data were collected from the last 6 years to 4 years, and the outcome data were collected from the last 3 years to 1 year.

Covariables

Relevant control variables were adjusted in bivariate and unordered multiclassification logistic regression analyses. Age at death was reported by family members. Body weight was measured by objective examination. The number of chronic diseases and arthritis-suffering situations (yes/no) were diagnosed by hospital. Chronic diseases included hypertension, diabetes, heart disease, stroke, cerebrovascular disease, bronchitis, emphysema, asthma, pneumonia, and pulmonary tuberculosis. Education level (0, 1–6, 7–9, 10–12, or >12 years), place of residence (city, town, or rural), living companions (with household member(s), alone, or in an institution), financial support (enough/not enough), current marital status (married and living with spouse/else), medical service status (enough/not), main occupation characteristics before 60 years (physical work/else), and the current intake status of smoke and alcohol were collected through face-to-face interview. The smoke and alcohol intake status were defined based on the baseline investigation phase. In addition, the time duration between the first follow-up and death were calculated. The objective PF were determined from the last 6 years to 4 years investigation.

Statistical analysis

Differences in demographic characteristics were examined using the Kruskal-Wallis H test or the chi-square test, as appropriate. Data were presented as mean and standard deviation (SD) for continuous variables and as number and percentage for categorical variables.

Bivariate and unordered multi-classification logistic regression analyses were used to compare disability level and three PF performance among four-set groups controlling for various confounding factors. Crude and adjusted odds ratio (ORs) with 95% confidence intervals (CIs) were calculated. Data analyses were conducted using the SPSS 20.0 statistical software (SPSS Inc). Statistical significance was considered at $P<0.05$.

Results

Baseline characteristics

Of the 4589 participants with two constructive follow-up, 74 were missing information on exercise behaviour, disability, or covariates of interest and 250 were disabled at the initial investigation . We documented a total of 4265 decedent participants in the current study with 25.81% octogenarians, 41.06% nonagenarians, and 21.76% centenarians. As shown in Table 1, a slightly higher proportion of participants were men, with the proportion of men increasing as exercise behaviour was practiced. At baseline, the educated participants were more likely to practice exercise consistently ($P < 0.05$). Overall, all of the participants were not disabled (not requiring assistance with six of activities of daily living), and more than 78% participants were able to complete three objective PF performance tests.

Main findings

The prevalence of disability and three objective PF performance are reported in Figure 1. In YY group, 2.7% of participants had moderate disability, 1.75% had severe disability, increasing to 3.14%, 12.86%, respectively, in NN group. In YN group, increased to 5.5% of participants had moderate disability and 15.38% had severe disability. Similar proportional growth trend were obtained in three objective PF performance.

The highlight of this study is to investigate exercise effects on the burden of disability and physical dysfunction. Therefore, we took NN as the reference group and focused on the adjusted findings.

After adjustment for all included covariates and compared with NN group, the participants who practised exercise during their last 3 to 1 years had a lower burden of severe disability ($P<0.001$); YY had the lowest burden of severe disability (OR 0.11, 95% CI 0.06 to 0.21); The highest burden of moderate disability (OR 1.85, 95%CI 1.26 to 2.71) and severe disability (OR 1.36, 95%CI 1.08 to 1.72) were experienced by YN (Table 2).

Compared with NN group's chair-rise performance, the risks in later cohorts were almost all lower and statistically significant for YY (OR 0.59, 95%CI 0.47 to 0.75) and NY groups (OR 0.77, 95%CI 0.62 to 0.97) in moderate impairment dysfunction, and for YY (OR 0.10, 95%CI 0.05 to 0.23) and NY groups (OR 0.18, 95%CI 0.09 to 0.34) in severe standing dysfunction.

Compared with NN group's pick-up book performance, YY (OR 0.48, 95%CI 0.38 to 0.61) and NY (OR 0.65, 95%CI 0.52 to 0.82) had a significant less risks using hand option and for YY (OR 0.17, 95%CI 0.11 to 0.28) and NY groups (OR 0.22, 95%CI 0.14 to 0.36) in severe standing dysfunction.

Compared with NN group's "turning around 360°" performance, YY (OR 0.36, 95%CI 0.28 to 0.46) and NY (OR 0.41, 95%CI 0.31 to 0.52) had a significant less risk in not being able to turning around, respectively, and YN had no significant difference (Table 2).

Discussion

In this nationwide cohort study from China, it focused on the potential effects of EP in older adults who had short life expectancy. This study suggested that exercise effects in PF and disability are linked to time duration, and late-life exercise is still beneficial[9]. Although people's early living conditions, such as residence or job had long-term effects on physical fitness, exercise behaviour effects on PF and disability remained after further adjustment for relevant factors.

Participants who consistently practice exercise for three years had the lowest risk of developing disability and physical dysfunction. Exercise would be beneficial to physical fitness in several ways. At the physiological level, EP can improve bone mass, strength, aerobic fitness, flexibility, and balance functioning[27, 31]. From the perspective of chronic diseases prevention, exercise can be a protective factor[27, 32] by preventing coronary heart disease, osteoporosis, and type 2 diabetes, etc. The above-mentioned benefits reduced the risk of developing physical dysfunction and disability. Moreover, on the psychological level, exercise can induce a healthy mentality and enhance participants' social integration[33]. For older adults who exercise consistently, these benefits can be accumulated and reduce the risk of physical dysfunction and disability.

Short-term EP can favorably impact physiological systems as well. The participants who newly uptake of EP in the later period had a lower risk of developing disability and physical dysfunction than their counterparts who never did exercise. These findings may be accredited to the physiological and psychological benefits as well. Studies focusing among older adults have reported that 12 weeks or over of moderate-intensity exercise can evoke cardiovascular adaptations[27] and 24 weeks traditional training practices can increase muscle power[34].

In relation to the effects of EC, those who stopped exercise had an increased risk of developing moderate and severe disabilities compared with long-term nonexercise peers. But no meaningful risk difference were noted in three objective PF performance. These findings are consistent with some studies focusing on older adults aged over 70 years that their PF and mobility level declined to pretraining level after 1 year of detraining[35], their dynamic muscle strength declined near the pretraining level, and muscle endurance declined even worse than before after three years of detraining[36]. It's hard for older people to continue to reap exercise benefits after stopping exercise. The influence of age on the short-lived benefits after EC is complex. Age-related absolute improvements in functional performance tend to be less in older versus younger individuals[37]. On the other hand, the available evidence on cessation of exercise in older people showed that the benefits of muscle training and aerobic training declined and lost quickly upon cessation of exercise, even in regular exercise older individuals[38].

The small absolute differentiation in the risk of developing physical dysfunction and disability between consistently practicing exercise and long-term non-exercising was probably due to the age and exercise modality. The CLHLS only investigated the oldest population (aged over 80 years) in 1998 and 2000, and enrolled 65 years over adults in later investigations. Many Chinese people do live into their 80 s, 90 s, or even 100 s, free of chronic diseases and able to live independently. But they are tend to be frailty, loose independent living ability and have similar degree of physical fitness. Aging causes the degeneration of physiological fitness, such as the rarefaction of bone and metabolic fitness[37], and plays an important role in preventing the reaping of the benefits of exercise[39, 40]. In fact, Health Behaviors of Adults: United States, 2008–2010 reported that most of older adults who practices exercise focuses merely on aerobic exercise, i.e. the number of populations (aged over 75 years) in Asia with regular aerobic exercise behaviour are fourfold the number of regular muscle training peers[41]. Although older adults reap relatively little exercise benefits[42], our results found that late-life EP is still beneficial.

Some limitations should be noted and acknowledged. A weakness is the method used to classify exercise behaviour. The self-report measures of exercise behaviour did not include some detail about the modality and amount of exercise performed and the frequency as this is possible to vary substantially among participants. Since we did not investigate the reasons for EC, limited discussion exists on the influence of EC. The strengths of this study are the relevance of the target and the large sample studied over years with the inclusion of subjective and objective measured PF and disability. The results of this study may provide evidence for the government and clinicians to provide exercise prescription to older people even if they are at an old age with limited life expectancy.

Conclusion

The results of this study demonstrate late-life exercise behaviour is still beneficial. Consistent EP and newly uptake of EP have a lower risk of developing disability and physical dysfunction. Consistent EP was associated with a greater reduction in developing both risks. However, both risks may rise again after the cessation of exercise. Our findings suggest that it is meaning to encourage older people doing EP at late-life in China.

Abbreviations

EP: Exercise practice; EC: Exercise cessation; PF: Physical functioning; NN: Long-term non-exercising; NY: Non-exercising to exercise; YN: Exercise to non-exercising; YY: Long-term exercising; CLHLS: Chinese Longitudinal Healthy Longevity Study; ADL: Activities of daily living; ORs: Odds ratio; CIs: Confidence intervals; SD: Standard deviation;

Declarations

Ethics approval and consent to participate

The data from CLHLS obtained the ethical approval by the Research Ethics Committees of Peking University and Duke University (IRB00001052-13074). Informed consent was obtained from all individual participants included in the CLHLS. All data sources (except those protected by data agreement) are available from the Center for Healthy Aging and Development Studies of Peking University Open Research Data and the authors got a permission for use, upon regular application. And the data used in this study was anonymized before its use.

Consent for publication

Not applicable.

Availability of data and materials

The data that support the findings of this study are available from the Center for Healthy Aging and Development Studies of Peking University Open Research Data but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of the Center for Healthy Aging and Development Studies of Peking University Open Research Data.

Competing interests

The authors declare that they have no conflict of interest.

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Authors' contributions

X.W. conceived the study, oversaw the data analyses and edited the manuscript. M.C. designed the study, cleansed the data, and wrote the paper. C.H. played a role in the construction of the theoretical framework and revised the manuscript. Y.M. and C.W helped results interpretation. S.X. helped statistical analyses and modified the manuscript. Y.Y participated in data cleansing provided critical comments. All authors read and approved the final manuscript.

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Tables

Table 1 Baseline Characteristics by the exercise behaviour[a]

Factor	Overall	NN	NY	YN	YY	P value
N	4265	2100	553	982	630	
Age at death, mean (SD)	92.07(9.39)	92.92(9.45)	90.64(9.29)	92.28(9.07)	90.17(9.35)	<0.0001
Time duration between the first follow-up and death	4.85(0.76)	4.84(0.77)	4.83(0.74)	4.87(0.76)	4.87(0.75)	0.617
Sex (male),%	50.69	44.57	51.53	54.48	64.44	<0.0001
Residence (City),%	39.76	32.19	33.82	45.93	60.63	<0.0001
Current married,%	31.37	27.14	34.72	32.89	40.16	<0.0001
Education level,%						<0.0001
Not educated	58.57	66.67	58.23	53.05	40.48	
Primary level	31.84	27.57	35.62	35.95	36.35	
Junior level	4.81	3.29	2.71	5.09	11.27	
Senior level	2.98	1.67	2.53	3.36	7.14	
University level	1.81	0.81	0.90	2.55	4.76	
Main occupation characteristics before age 60 (Physical work),%	77.9	82.00	80.11	75.66	65.87	<0.0001
Living companions,%						<0.0001
Household member(s)	80.07	80.05	78.66	81.67	78.89	
Alone	16.20	17.43	17.18	14.77	13.49	
In an institution	3.73	2.52	4.16	3.56	7.62	
Medical service status (Enough),%	89.85	87.57	91.50	91.55	93.33	<0.0001
Financial support (Enough),%	79.06	76.10	78.30	81.47	85.87	<0.0001

Smoking status (Yes),[b] %	21.99	21.24	23.87	23.42	20.63	0.298
Alcohol intake (Yes),[c] %	24.31	22.10	23.51	28.62	25.71	0.01
Body weight, mean (SD)	49.93(10.65)	48.12(9.70)	49.96(9.55)	51.16(11.57)	54.05(11.69)	<0.0001
Number of chronic diseases, mean (SD)[d]	0.40(0.71)	0.36(0.66)	0.44(0.75)	0.41(0.72)	0.50(0.78)	<0.0001
Suffering from arthritis,%	10.76	9.71	12.12	12.22	10.79	<0.131
Degree of disability (good),%	100.00	100.00	100.00	100.00	100.00	
Standing up from a chair,%						<0.0001
can without using arms	78.36	73.24	81.74	81.26	87.94	
Can using hands	18.55	23.05	15.55	16.29	9.68	
Cannot	3.09	3.71	2.71	2.44	2.38	
Picking up a book from floor,%						<0.0001
Can while standing	78.90	73.33	81.37	82.48	89.68	
Can while sitting	18.52	23.10	15.91	16.40	8.89	
Cannot	2.58	3.57	2.71	1.12	1.43	
Turning around 360° (Yes),%	86.00	82.24	87.34	87.68	94.76	<0.0001

[a] "Y" and "N" refer to exercising and non-exercising behaviour, respectively. The earlier and later exercise behaviours from constructive follow-up were combined (last 6 to 4 years of life and last 3 to 1 year of life). Hence, "YY" means consistent practice exercise; "YN" means stopped EP; "NY" means newly uptake EP; "NN" means did not do any EP.

[b c] The smoke and alcohol intake status were defined based on the baseline investigation status.

[d] Chronic diseases were diagnosed by hospital, including hypertension, diabetes, heart disease, stroke, cerebrovascular dsease, bronchitis, emphysema, asthma, pneumonia, and pulmonary tuberculosis.

Table 2 Disability and PF among four exercise groups

		NN	NY	P-value	YN	P-value	YY	P-value
Degree of disability	Good	1(Ref)	1(Ref)		1(Ref)		1(Ref)	
	Morderate disability	1(Ref)	0.66(0.35-1.25)	0.203	1.85(1.26-2.71)	0.002	0.69(0.39-1.23)	0.207
	Severe disability	1(Ref)	0.27(0.17-0.44)	<0.0001	1.36(1.08-1.72)	0.009	0.11(0.06-0.21)	<0.0001
Standing up from chair	Yes, without using hands	1(Ref)	1(Ref)		1(Ref)		1(Ref)	
	Yes, using hands	1(Ref)	0.77(0.62-0.97)	0.023	1.02(0.86-1.23)	0.801	0.59(0.47-0.75)	<0.0001
	No	1(Ref)	0.18(0.09-0.34)	<0.0001	1.30(1.00-1.70)	0.05	0.10(0.05-0.23)	<0.0001
Picking up a book from floor	Yes, standing	1(Ref)	1(Ref)		1(Ref)		1(Ref)	
	Yes, sitting	1(Ref)	0.65(0.52-0.82)	<0.0001	1.02(0.85-1.22)	0.846	0.48(0.38-0.61)	<0.0001
	No	1(Ref)	0.22(0.14-0.36)	<0.0001	1.16(0.92-1.47)	0.212	0.17(0.11-0.28)	<0.0001
Turning around 360°	Yes	1(Ref)	1(Ref)		1(Ref)		1(Ref)	
	No	1(Ref)	0.41(0.31-0.52)	<0.0001	0.96(0.81-1.14)	0.618	0.36(0.28-0.46)	<0.0001

Bivariate and unordered multi-classification logistic regression analyses were used to compare disability and three objective PF performance among four-set groups, adjusted for age at death, sex, body weight, education level (0, 1–6, 7–9, 10–12, or >12 years), place of residence (city, town, or rural), living companions (with household member(s), alone, or in an institution), number of chronic diseases, arthritis-suffering situation (yes/no), financial support (enough/not enough), current marital status (married and living with spouse/else), medical service status (enough/not), current smoking status (yes/no), current alcohol intake status (yes/no), main occupation characteristics before 60 years (physical work/else), the time duration between the first follow-up and death, and their baseline disability and PF data. Chronic diseases included hypertension, diabetes, heart disease, stroke, cerebrovascular disease, bronchitis, emphysema, asthma, pneumonia, and pulmonary tuberculosis.

Figures

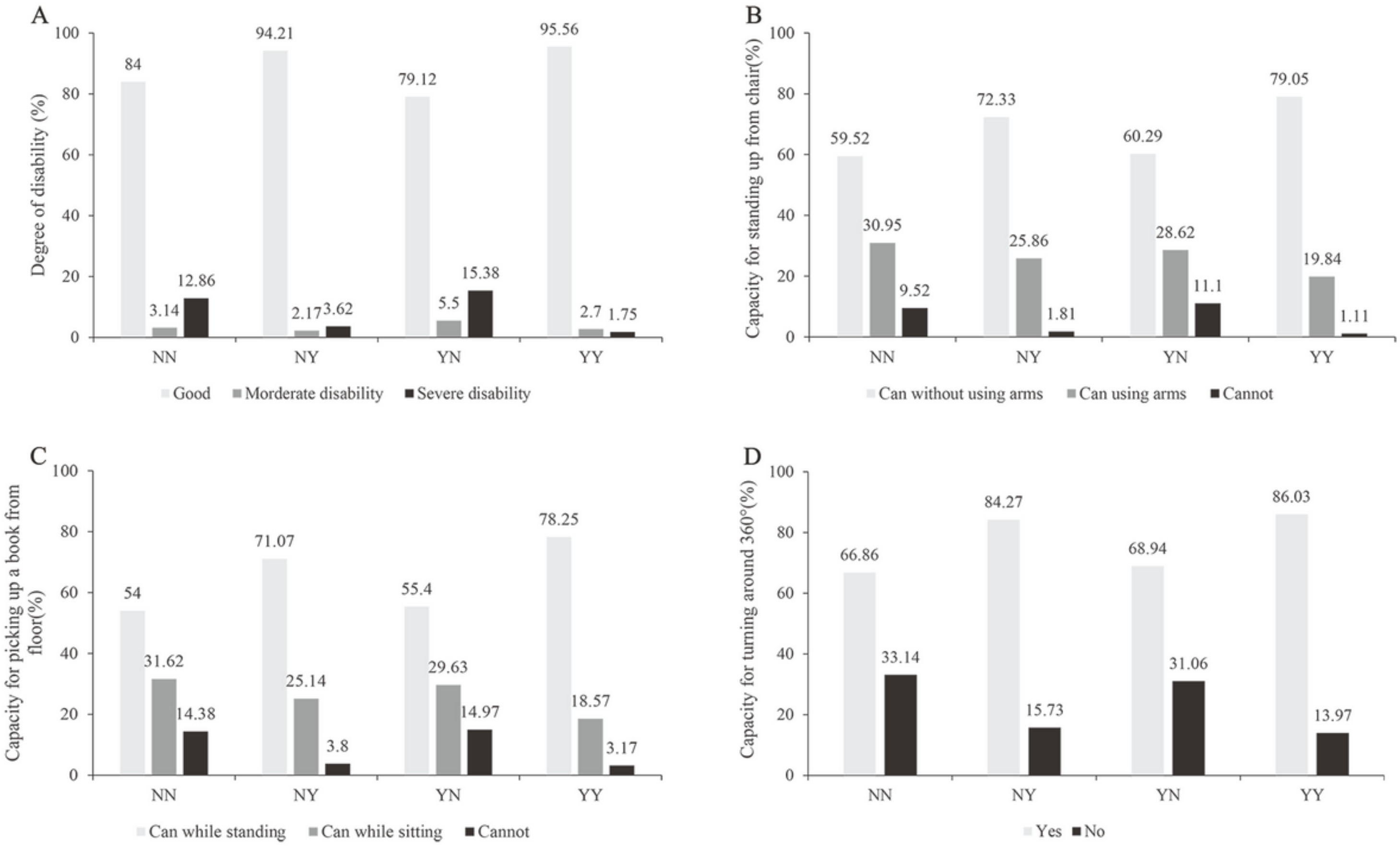

Figure 1

Prevalence of disability and PF performance during the last 3 to 1 years of life