Journal of Physical Activity and Health, (Ahead of Print)
https://doi.org/10.1123/jpah.2024-0415
First Published Online: Nov. 8, 2024

Human Kinetics
ORIGINAL RESEARCH

Changes in Municipal-Level Social Capital and Socioeconomic Inequalities in Sports Group Participation and Walking Time Among Older Adults

Taishi Tsuji,[1] Meiko Yokoyama,[2,3] Satoru Kanamori,[4,5] Takahiro Tabuchi,[6,7] and Katsunori Kondo[2,3,8]

[1]Institute of Health and Sport Sciences, University of Tsukuba, Bunkyo, Tokyo, Japan; [2]Center for Preventive Medical Sciences, Chiba University, Chiba, Chiba, Japan; [3]Japan Agency for Gerontological Evaluation Study (JAGES Agency), Kashiwa, Chiba, Japan; [4]Teikyo University Graduate School of Public Health, Itabashi, Tokyo, Japan; [5]Department of Preventive Medicine and Public Health, Tokyo Medical University, Shinjuku, Tokyo, Japan; [6]Cancer Control Center, Osaka International Cancer Institute, Osaka, Osaka, Japan; [7]Division of Epidemiology, School of Public Health, Tohoku University Graduate School of Medicine, Sendai, Miyagi, Japan; [8]Research Department, Institute for Health Economics and Policy, Minato, Tokyo, Japan

Background: This study aimed to examine trends in socioeconomic inequalities in sports group participation and daily walking time among older adults in Japan from 2016 to 2019, and to elucidate the association of municipal-level social capital in these trends. ***Methods:*** Using data from the Japan Gerontological Evaluation Study across 2 waves (2016 and 2019), this repeated cross-sectional ecological study included 50 municipalities with 102,575 and 94,022 participants, respectively. We investigated inequalities in sports group participation, and daily walking time by income and education, using the slope index of inequality and relative index of inequality with municipal-level social capital variables, such as civic participation, reciprocity, social cohesion, and social network. ***Results:*** From 2016 to 2019, all slope index of inequalities showed a decreasing trend (–4.2 to – 0.5), whereas relative index of inequalities maintained or decreased (–0.10 to 0.00). Increases in municipal-level social capital particularly civic participation and social networks with friends were associated with reduced inequalities in both sports group participation and walking time. For example, increased civic participation scores were associated with reduced relative index of inequalities, which assessed inequalities in sports group participation by income ($B = –0.13$, 95% CI, –0.24 to – 0.03) and in walking time by education ($B = –0.06$, 95% CI, –0.11 to – 0.01). ***Conclusions:*** Enhancements in municipal social capital can reduce socioeconomic inequalities in sports group participation and daily walking among older adults, highlighting the importance of fostering civic participation, social networks, and cohesion in public health strategies aimed at reducing inequalities in sports and walking.

Keywords: aging, epidemiology, community-based research, public health

Key Points

- Our study demonstrates that from 2016 to 2019, socioeconomic inequalities in sports group participation and daily walking time among older adults in Japan showed a decreasing trend.
- Increased municipal social capital, particularly in civic participation and social networks, was found to play a significant role in reducing these inequalities in physical activity among older adults.

Yokoyama https://orcid.org/0000-0002-5788-2732
Kanamori https://orcid.org/0000-0002-8707-471X
Tabuchi https://orcid.org/0000-0002-1050-3125
Kondo https://orcid.org/0000-0003-0076-816X
Tsuji (tsuji.taishi.gn@u.tsukuba.ac.jp) is corresponding author, https://orcid.org/0000-0002-8408-6619

Physical activity, a modifiable behavior, can prevent or improve various health problems in older adults.[1–3] Walking time, a major part of the physical activity in daily life, is also an adequate predictor of decline in independent functioning and mortality among older adults.[4,5] Furthermore, older adults engaging in sports and exercises as part of a group have several advantages, including a reduced risk of functional disability,[6] depressive symptoms,[7] and falls,[8] compared with those participating in individual sports and exercises. Therefore, the widespread promotion of these activities among older adults is important from a public health perspective.

Those with less favorable status, such as lower educational attainment and income, and lower levels of physical activity, including sports activity, experience socioeconomic inequalities.[9–11] Higher educational levels promote sports participation through several individual and social factors, such as self-efficacy, financial resources, social networks, and environmental conditions, such as

neighborhood safety.[12] These inequalities may partially explain social inequalities in health outcomes.[13] Thus, reducing socioeconomic inequalities in physical activity, including daily walking time and sports group participation, can potentially reduce inequalities in health outcomes. However, most reports on socioeconomic inequalities in physical activity and sports participation among older adults have focused on socioeconomic inequalities at a single time point, with limited data on how these inequalities have changed over time or how inequalities can be reduced.

A systematic review showed that the level of social capital at the area level partially determines health inequalities among its citizens.[14] For a comprehensive theoretical overview of social capital, see the primary literatures,[15–17] which describes it as "features of social organizations, such as networks, norms, and trust that facilitate action and cooperation for mutual benefit,"[18] or "resources that are accessed by individuals as a result of their membership of a network or a group."[17] Particularly, area-level social capital can potentially have contextual effects on the entire population in the area through mechanisms, such as social contagion, informal social control, and collective efficacy.[17] Although this contextual social capital was expected to reduce health inequalities, the opposite was also a concern.[14] Inequality will be reduced when socially disadvantaged individuals have higher health benefits of area-level rich structural (eg, civic participation) and cognitive (eg, community trust and social support) social capital. Conversely, inequality could widen when those are higher for advantaged individuals. We would expect that area-level social capital might play a role in mitigating socioeconomic inequalities in sports group participation and daily walking in the community; however, little is known about this.

This study aimed to describe trends in socioeconomic inequalities in sports group participation and daily walking time among older adults in Japan from 2016 to 2019 at the municipal level and identify the changes in municipal-level social capital in relation to these trends. We hypothesized that inequalities in sports group participation and daily walking time will be reduced in municipalities where social capital is fostered at the municipal level. This provides useful evidence for developing local public health strategies to reduce socioeconomic inequalities in sports group participation and physical activity among older people.

Material and Methods

Study Design and Participants

In this repeated cross-sectional ecological study, data were derived from the Japan Gerontological Evaluation Study (JAGES), which is an ongoing investigation focusing on examining social, behavioral, and environmental factors associated with functional decline or cognitive impairment in individuals aged ≥65 years, which can lead to a loss of independence.[19,20] Our data were collected from 2 waves of the JAGES in 2016 and 2019. Self-reported questionnaires were mailed to independent residents not eligible to receive public long-term care insurance benefits. The questionnaires were mailed to 39 municipalities in the 2016 wave and 64 municipalities in the 2019 wave. The questionnaires were collected from 180,021 and 260,310 participants, with response rates of 64.4% and 69.1%, respectively. Data from 28 municipalities were obtained at both time points, in 2016 (n = 131,394) and 2019 (n = 148,550). Random sampling and complete enumeration survey methods were used in 19 and 9 municipalities, respectively. Because ordinance cities in Japan have wards with functions similar to municipalities, we divided the 4 ordinance-designated cities into 49 wards. Subsequently, we excluded missing information on sex, age, or basic activity of daily living; individuals whose basic activity of daily living was not independent (2016: n = 16,824, 2019: n = 44,492); and respondents living in municipal units with <500 valid responses (to obtain stable aggregates by municipal unit). Due to slight changes in sampling methodology, in 2019, more municipalities included older adults with slightly more advanced functional decline in their samples, which consequently increased the number of individuals excluded due to nonindependence in basic activity of daily living. Finally, we used data from 50 municipal units (2016: n = 102,575 [minimum: 704, maximum: 7529]; 2019: n = 94,022 [minimum: 594, maximum: 5698]). In subsequent calculations and analyses, missing values were handled using pairwise elimination.

This study was conducted following the principles of the Declaration of Helsinki and approved by the Ethics Committee, Chiba University, Japan (approval number: 2493), the National Center for Geriatrics and Gerontology, Japan (approval number: 992-3), and the University of Tsukuba, Japan (approval number: tai022-32). All participants were informed that their participation was voluntary, and they provided their consent by completing and returning the questionnaire via mail.

Socioeconomic Inequalities in Exercise Group Participation and Walking Time

We assessed inequalities in sports group participation and walking time across equivalent income and years of education for each region and each wave.

Participants were evaluated based on their frequency of sports group participation, with the following response options: ≥4 days per week, 2 to 3 days per week, 1 day per week, 1 to 3 days per month, a few times per year, and zero. Consistent with previous studies, participation was defined as engaging in a sports group activity at least 1 day per month.[21,22] The participants were asked about their average daily walking time (<30, 30–59, 60–89, ≥90 min/d) and were categorized into 2 groups: <30 and ≥30 minutes per day. We adopted this criterion because a meta-analysis examining the association between walking time and all-cause mortality showed that walking for 170 minutes weekly (approximately 24 min daily), independent of other physical activities, was associated with an 11% lower risk of all-cause mortality.[23]

We assessed equivalent income and years of education which are representative indicators of socioeconomic status (SES) and robustly associated with health in older adults. The participants were asked their pretax household income for the previous year, including pension. We calculated an equivalized household income by dividing the household income by the square root of the equivalent household members. Income was categorized into 5 groups: <0.99, 1 to 1.99, 2 to 2.99, 3 to 3.99, and ≥4 million yen/year. They were also asked about their educational attainment and were then categorized into 3 groups: ≤9, 10 to 12, and ≥13 years.

We calculated the slope index of inequality (SII) and the relative index of inequality (RII) using the above variables.[24] The benefits of these indexes include accounting for changes in the population distribution of social groups over time and using information across social groups. The SII represents the linear regression coefficient that shows the relationship between the frequency of health behaviors (ie, sports group participation and adequate daily walking time) in each socioeconomic category and the hierarchical ranking of each socioeconomic category. Thus, an SII of 0 indicates no inequality between each socioeconomic category, whereas a larger positive

value indicates higher inequality (less frequent health behaviors in disadvantaged socioeconomic categories). The SII can be interpreted as the estimated absolute difference in health status across the entire distribution of social groups. This index is sensitive to the mean level of health behaviors in the population and may be limited in comparisons between populations. By contrast, the RII is a relative measure calculated by dividing by the mean frequency of health behaviors in the population, which may be appropriate for comparisons between populations with different levels of health behaviors. We used the PHE (Public Health England) Inequalities Calculation Tool.

Municipal-Level Social Capital and Characteristics

Following earlier research,[22] we assessed the 4 components of municipal-level social capital in both waves: civic participation, social cohesion, reciprocity, and social network. Civic participation and social networks reflect the structural aspects of social capital, whereas social cohesion and reciprocity reflect the cognitive aspects. Following the categorization definitions of earlier research,[22] we aggregated individual-level data to calculate municipal-level social capital.

We assessed civic participation by the percentage of individual participation (≥ 1 per month) in a sports group, hobby activity, volunteer group, study or cultural group, and skills teaching in each municipality. Each of the 5 items was assigned between 0% and 100%. Subsequently, these 5 percentage scores were added to obtain the civic participation score (0–500 points).

We assessed reciprocity by the percentage of "yes" answers to 3 items: emotional support received ("Do you have someone who listens to your concerns and complaints?"), emotional support provision ("Do you listen to the concerns and complaints of other(s)?"), and instrumental support received ("Do you have someone who looks after you when you are sick and confined to bed?"). Each of the 3 items was assigned between 0% and 100%. Subsequently, the 3 percentage scores were added to calculate the reciprocity score (0–300 points).

We assessed social cohesion by the percentage of "very" or "moderately" answers to 3 items: general trust ("In general, do you think that people living in your area can be trusted?"), perception of others' intention to help ("Do you think people living in your area try to help others in most situations?"), and attachment to the residential area ("How attached are you to the area where you live?"). Each of the 3 items was scored between 0% and 100%. Subsequently, the 3 percentage scores were added to obtain the social cohesion score (0–300 points).

We assessed social networks by the percentage of responses "once a month or more" to the frequency of contact with friends and acquaintances ("How often do you see your friends/acquaintances?"), and "10 or more" to the number of friends and acquaintances ("How many friends/acquaintances have you seen over the past month?"). Each of the 2 items was scored between 0% and 100%. However, these 2 indicators were evaluated separately, which was consistent with previous studies.

As characteristics at the municipality level, we calculated the percentage of people aged ≥75 years, the percentage of women, and the percentage reporting good self-rated health (very good or good) among the analyzed participants.

Statistical Analyses

For each variable, we calculated the value of each wave and the amount of change between waves for each municipality. Pearson product-moment correlation coefficients (r) were calculated to test the relationship between changes in inequality indexes and municipal-level social capital and characteristics. In addition, multiple linear regression analysis was used to estimate the amount of change in inequality indexes associated with changes in social capital at the municipal level. The amount of change in each inequality index was used as the outcome, and the amount of change in the civic participation, reciprocity, and social cohesion scores, percentage of those who contact friends once a month or more, and percentage of those with ≥10 friends were entered separately as explanatory variables. Furthermore, the change in the percentage of participants in sports groups was introduced as an explanatory variable in the model with the inequality index of sports group participation as the outcome. The change in the percentage of participants with walking time ≥30 minutes per day was introduced as an explanatory variable in the model with the inequality index of walking time as the outcome. To prevent differences in age structure from influencing the results, we adjusted for the change in the percentage of people aged ≥75 years among those included in the count. Unstandardized partial regression coefficients (B) and 95% CIs were calculated per 10 points for each independent variable. Statistical analyses were performed using STATA/MP (version 17.0, Stata Corp).

Results

Supplementary Figures S1 and S2 (available online) show the percentage of each SES group in the total target population and the corresponding percentage of sports group participation (≥1 d/mo) and daily walking time (≥30 min) in each group to visually understand the inequality situation. Compared with the low SES group, the high SES group was 5 to 15 percentage points more likely to participate in a sports group and walk ≥30 minutes daily. Table 1 and Supplementary Table S1 (available online) show the descriptive statistics for each municipal-level variable. From 2016 to 2019, all SIIs showed a decreasing trend (–4.2 to – 0.5), whereas RIIs maintained or decreased (–0.10 to 0.00). Civic participation, including participation in sports groups, and the percentage of participants walking ≥30 minutes daily showed a decreasing trend.

Supplementary Table S2 (available online) presents Pearson product-moment correlation coefficients between changes in SII and RII from 2016 to 2019 and changes over the same period in the social capital variables and the percentage of participants walking ≥30 minutes daily. In municipalities where civic participation and sports group participation increased, the RII for sports group participation with equivalent income decreased ($r = -.357$ and $r = -.315$, respectively), and the SII ($r = -.317$ and $r = -.301$, respectively) and RII ($r = -.334$ and $r = -.316$, respectively) for walking time with education years decreased, which confirmed a negative correlation. SII and RII decreased for sports group participation with equivalent income in municipalities where the frequency and number of people who contact friends increased ($r = -.329$ to $-.419$). In municipalities with developed norms of reciprocity and community attachment, SII and RII decreased for walking time with education years ($r = -.283$ to $-.295$).

Table 2 shows the results of a multiple linear regression analysis using the inequality indexes with equivalent income as the outcome. After adjusting for age (ie, the change in the percentage of people aged ≥ 75 y), the analysis revealed decreased RII for sports group participation with equivalent income in municipalities with increased sports group ($B = -0.33$; 95% CI, –0.61 to – 0.06) and civic participation ($B = -0.13$; 95% CI, –0.24 to – 0.03).

Table 1 Descriptive Statistics for Each Wave and Change for the 50 Municipalities

	2016				2019				Δ (2016 → 2019)			
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
Percentage of respondents aged ≥75 y, %	41.5	4.2	32.2	48.2	46.4	5.5	37.0	55.3	4.9	3.4	−1.8	11.0
SII of sports group participation with equivalent income	14.1	6.6	−3.9	31.5	10.1	5.5	−3.7	21.6	−4.0	5.8	−14.3	14.1
RII of sports group participation with equivalent income	0.44	0.20	−0.13	0.98	0.34	0.19	−0.15	0.75	−0.10	0.20	−0.48	0.52
SII of daily walking time with equivalent income	10.9	4.8	1.6	23.2	10.4	5.2	−1.0	20.7	−0.5	6.1	−15.2	10.9
RII of daily walking time with equivalent income	0.15	0.06	0.02	0.30	0.14	0.08	−0.01	0.31	0.00	0.08	−0.19	0.18
SII of sports group participation with education years	15.6	6.7	2.4	29.3	11.4	4.8	0.4	23.7	−4.2	6.2	−17.9	8.8
RII of sports group participation with education years	0.49	0.21	0.08	0.94	0.40	0.19	0.01	1.02	−0.10	0.20	−0.52	0.30
SII of daily walking time with education years	7.4	4.9	−4.5	19.7	6.4	5.0	−7.8	14.6	−1.0	6.8	−12.8	17.3
RII of daily walking time with education years	0.10	0.07	−0.06	0.28	0.09	0.07	−0.11	0.20	−0.01	0.09	−0.18	0.25
Civic participation (≥1 per mo), point	106.3	14.3	69.5	138.3	97.4	13.3	66.1	126.1	−8.9	5.3	−23.6	0.7
Sports group, %	31.7	4.9	19.7	43.3	29.7	4.2	20.2	39.5	−2.0	2.0	−7.5	3.2
Hobby activity, %	39.8	5.0	27.6	50.9	35.5	4.7	25.1	45.8	−4.2	2.1	−11.0	0.0
Volunteer group, %	16.0	2.1	11.0	20.6	15.0	2.4	9.8	20.9	−1.1	1.6	−4.5	1.8
Study or cultural group, %	10.8	2.4	5.9	16.1	10.3	2.2	5.7	14.6	−0.5	1.0	−3.3	1.7
Skills teaching, %	7.9	1.5	5.2	12.2	6.8	1.2	4.3	10.6	−1.1	0.9	−3.7	0.9
Reciprocity, point	284.1	3.4	274.8	290.9	284.0	3.2	275.8	290.0	−0.1	2.2	−5.7	4.7
Receive emotional support, %	95.0	1.1	92.4	97.2	95.0	1.0	91.7	97.0	0.0	0.9	−2.9	2.1
Provide emotional support, %	94.1	1.1	91.2	96.6	94.3	1.0	91.5	96.0	0.2	1.1	−2.1	2.8
Receive instrumental support, %	95.0	1.6	90.0	97.5	94.7	1.7	89.7	97.0	−0.3	0.8	−3.4	2.3
Social cohesion, point	202.7	11.8	174.1	226.5	205.3	12.1	174.3	232.0	2.5	4.9	−8.0	13.4
Community trust, %	69.7	4.4	56.3	78.3	71.1	4.5	60.0	79.3	1.4	2.1	−2.6	6.3
Norms of reciprocity, %	53.8	5.2	43.3	67.8	54.4	5.3	42.9	69.0	0.6	1.8	−3.3	4.2
Community attachment, %	79.3	3.1	70.4	84.5	79.8	3.2	71.4	86.3	0.5	1.7	−3.6	3.2
Frequency of contact with friends (≥once a month), %	72.2	3.6	65.7	80.6	71.2	3.4	65.6	81.8	−1.0	1.8	−6.9	1.4
Number of friends (≥10), %	35.4	2.9	29.0	43.5	33.3	3.4	26.0	42.6	−2.1	2.2	−6.1	2.6
Daily walking time (≥30 min), %	74.5	3.2	68.7	82.0	73.1	3.3	65.7	81.0	−1.5	2.1	−7.3	2.6

Abbreviations: RII, relative index of inequality; SII, slope index of inequality. Note: The units in the delta column are percentage points for variables whose units are percentage.

Negative associations with changes in the SII and RII were also found for the frequency and number of people who contact friends, similar to the correlation analysis. Regarding inequality in daily walking time, RII by equivalent income decreased with increase in people walking ≥30 minutes per day ($B = -0.13$; 95% CI, −0.24 to −0.01). In contrast, a positive association was observed in municipalities where reciprocity was observed, where the SII ($B = 10.3$; 95% CI, 2.6 to 17.9) and RII ($B = 0.14$; 95% CI, 0.03 to 0.24) increased.

Table 3 shows the multiple linear regression analysis results using the inequality indexes with education years as the outcome. The RII for sports group participation decreased in municipalities with an increased percentage of sports group participants ($B = -0.30$; 95% CI, −0.56 to −0.04). Regarding inequality of daily walking time, SII and RII with education years decreased in municipalities where civic participation and social cohesion were fostered.

Discussion

The key findings of this study were as follows: (1) the inequalities in sports group participation and daily walking time among older

Table 2 Results of Linear Regression Analysis With Changes in Inequality Indexes by Equivalent Income as Outcome

	SII with equivalent income				RII with equivalent income			
	B	95% CI		*P*	*B*	95% CI		*P*
Outcome: inequality of sports group participation								
Sports group	−5.8	−14.1	2.5	.168	−0.33	−0.61	−0.06	.019
Civic participation	−2.8	−5.9	0.3	.072	−0.13	−0.24	−0.03	.011
Reciprocity	−3.2	−10.9	4.5	.406	−0.17	−0.43	0.10	.210
Social cohesion	−0.9	−4.3	2.5	.598	−0.05	−0.17	0.06	.372
Frequency of contact with friends	−10.1	−19.2	−1.0	.030	−0.41	−0.72	−0.11	.009
Number of friends	−10.6	−17.5	−3.8	.003	−0.37	−0.61	−0.14	.003
Outcome: inequality of daily walking time								
Daily walking time	−7.5	−15.9	0.8	.076	−0.13	−0.24	−0.01	.028
Civic participation	−1.3	−4.7	2.0	.429	−0.02	−0.07	0.02	.364
Reciprocity	10.3	2.6	17.9	.010	0.14	0.03	0.24	.012
Social cohesion	−1.2	−4.9	2.4	.494	−0.02	−0.07	0.03	.449
Frequency of contact with friends	−7.1	−17.1	2.8	.156	−0.11	−0.24	0.02	.105
Number of friends	0.8	−7.2	8.8	.839	0.00	−0.11	0.11	.951

Abbreviations: RII, relative index of inequality; SII, slope index of inequality. Note: n = 50 municipalities. All unstandardized partial regression coefficients (*B*) were calculated per 10 points after adjusting for the percentage of individuals aged ≥75 years.

Table 3 Results of Linear Regression Analysis With Changes in Inequality Indexes by Education Years as Outcome

	SII with education years				RII with education years			
	B	95% CI		*P*	*B*	95% CI		*P*
Outcome: inequality of sports group participation								
Sports group	−3.7	−11.9	4.5	.371	−0.30	−0.56	−0.04	.026
Civic participation	0.4	−2.7	3.4	.820	−0.05	−0.15	0.05	.345
Reciprocity	0.6	−6.9	8.1	.869	−0.04	−0.29	0.20	.722
Social cohesion	−1.7	−5.0	1.6	.314	−0.08	−0.19	0.03	.133
Frequency of contact with friends	5.3	−3.8	14.5	.245	0.06	−0.25	0.37	.695
Number of friends	4.7	−2.5	11.9	.193	0.08	−0.16	0.32	.494
Outcome: inequality of daily walking time								
Daily walking time	−7.2	−16.5	2.2	.131	−0.11	−0.24	0.02	.088
Civic participation	−4.1	−7.7	−0.6	.024	−0.06	−0.11	−0.01	.017
Reciprocity	1.7	−7.5	10.8	.714	0.02	−0.11	0.14	.784
Social cohesion	−4.2	−8.1	−0.4	.032	−0.06	−0.11	−0.01	.026
Frequency of contact with friends	−8.1	−19.1	3.0	.150	−0.12	−0.28	0.03	.103
Number of friends	−0.4	−9.3	8.5	.931	−0.01	−0.14	0.11	.827

Abbreviations: RII, relative index of inequality; SII, slope index of inequality. Note: n = 50 municipalities. All unstandardized partial regression coefficients (*B*) were calculated per 10 points after adjusting for the percentage of individuals aged ≥75 years.

adults tended to decrease or remain constant in the 50 municipalities; (2) the inequalities were reduced in municipalities with more older adults participating in social activities, including sports groups, and who had enough time to walk; and (3) fostering network with friends and social cohesion were also negatively associated with some indicators of inequality.

To the best of our knowledge, this is the first study to describe trends in socioeconomic inequalities in sports group participation and walking time among older adults in Japan, which has the world's oldest population.[25] Studies using secondary national survey data and tracked trends in socioeconomic inequalities in health behaviors among Japanese adults for more than a decade have reported widening inequalities in smoking behavior.[26,27] However, no widening trend was observed for inequalities in physical activity.[26] Our study focused on sports group participation and walking time among older adults and found that the trend was constant or decreased, partially supporting the report. This trend may be because of the community-based population strategy for long-term care prevention measures initiated by the Japanese government in 2015.[28] The strategy focuses on community-based care and social determinants of health. Specifically, it promotes salon activities in locations within walking distance of community residents' homes, managed by community volunteers, and with a low participation fee. These salons often include activities, such as health exercises and simple sports, which fall under sports group participation. In addition, walking to and from the gathering place will contribute to extending walking time. In 2017, 86.5% (1506/1741) of municipalities in Japan implemented salons,[28] which could potentially encourage participation in sports groups and walking by people from disadvantaged socioeconomic backgrounds.

Furthermore, the promotion of salon activities aims to promote social capital in the community; encourage civic participation; and foster social networks, support, and cohesion.[28,29] Because several indicators of inequality decreased in municipalities with higher civic participation, including sports group participation, social networks, and cohesion, the community-based strategy can be beneficial in reducing inequality. A nonrandomized cluster-controlled trial of salon activities called "Kayoinoba" managed by community volunteers was conducted in a large city (Kobe City) in Japan.[30] School districts in the city with large proportions of older people with socioeconomic and health problems were selected as intervention regions, and salon activities were actively promoted over 6 years in the regions. Thus, the percentage of participation in sports and hobby groups, the number of friends they met, and the provision of emotional support increased significantly more than in the nonintervention regions. This led to a reduction in the inequality in these social capital indicators between regions.[30] We believe that the more successful these community-based strategies are in municipalities, the more socioeconomic inequalities in sports group participation and walking time could be reduced. Although only 6.7% of municipal salons participated among the population aged ≥65 years in 2019,[31] the broader impact may include increased participation in other sports and hobby groups, with current percentages of participation ranging from approximately 20% to 45% as shown in Table 1. However, this alone does not fully explain the reduction in inequality indexes. Further investigation into additional factors and their interplay is required to understand the underlying mechanisms more comprehensively.

The associations with each exposure were not all consistent between income and education. For example, fostering social networks with friends may reduce income inequalities for sports group participation but not for educational inequalities. Education is exposed earlier, and its effects accumulate over time, whereas income is more likely to reflect current socioeconomic conditions. The mechanisms linking low education and poor health may include a lack of knowledge about disease prevention and poor social networks in addition to low income.[32] The cumulative negative effects of such long-term exposure may have made it difficult for the effects to reach less educated individuals, even if social networks have been fostered in recent years.

Income inequality in walking time increased in municipalities with improved reciprocity, which was the opposite of the hypothesis. Observational studies conducted in China reported that the health benefits associated with adequate social support were higher for older adults with higher SES.[33] The availability of financial resources may allow for the effective use of social support to efficiently link health behaviors and health outcomes, which may widen the inequalities. In fostering reciprocity, consideration will be required to reach the disadvantaged in socioeconomic circumstances.

Although a tendency for more significant associations was found with changes in social capital for RIIs than for SIIs, we found that the association with changes in social capital was broadly similar across SIIs and RIIs. Because absolute and relative indicators of inequality may show conflicting changes, such as when populations have the same proportional risk reduction, both absolute and relative indicators should be used.[34] It is worth emphasizing that we followed this recommendation and used both indicators, and obtained the robustness of the results, which are not contradictory.

The strength of this study is that the linkage of data on SES, sports group participation, and walking time among older adults at the individual level made it possible to calculate the inequality index, which could capture changes over time for multiple municipalities. Thus, we could quantify the characteristics of the municipalities with reduced socioeconomic inequality in these health behaviors.

However, our study has several limitations. First, the included municipalities do not cover entire Japan and were not a nationally representative sample. The municipalities that participated may have been more aware of health policies, and the individual older adults who responded may have been biased toward those with better health. This may have contributed to underestimating socioeconomic inequalities. Second, a validated physical activity questionnaire was not used, and only sports group participation and walking were assessed. Future research is needed to comprehensively assess physical activity and identify and address socioeconomic inequalities in intensity, by domain, and in sedentary behavior. Third, while adjustments were made for age composition, which showed a significant correlation with inequality indexes, this does not eliminate the possibility of residual confounding factors by other unmeasured factors. Fourth, we excluded data from the COVID-19 pandemic period. Several reports indicate that socioeconomic inequalities in health increased during this period.[35,36] The application of our study results in this period warrants careful discussion.

Conclusions

This study's analysis of 50 municipalities from 2016 to 2019 revealed important insights into the socioeconomic inequalities in sports group participation and daily walking time among older adults. Although the findings should be cautiously interpreted due to differences in sample characteristics between time points, our results showed a trend toward reducing or maintaining these inequalities over the study period. Specifically, inequalities were

decreased in municipalities with increased participation in social activities, including sports groups among older adults, and those where older adults had sufficient time for walking. Additionally, fostering social networks with friends and enhancing social cohesion within the municipalities have been associated with reducing various indicators of inequality. These findings highlight the importance of fostering municipal-level social capital in public health strategies aimed at reducing inequalities in sports group participation and walking among older adults.

Acknowledgments

This study used data from JAGES (the Japan Gerontological Evaluation Study). **Funding Source**: This work was supported by Grant-in-Aid for Scientific Research (20H00557, 20K10540, 20K19534, 21H00848, 21H03153, 21H03196, 21K11108, 21K17302, 21KK0168, 22H00934, 22H03299, 22K04450, 22K13558, 22K17409, 23H00060, 23H00449, 23H03117) from JSPS (Japan Society for the Promotion of Science), Health Labor Sciences Research Grants (19FA1012, 19FA2001, 21FA1012, 22FA2001, 22FA1010, 22FG2001) from Ministry of Health, Labor and Welfare, Research Institute of Science and Technology for Society (JPMJRS22B1) from the Japan Science and Technology, a grant from Japan Health Promotion & Fitness Foundation, Tokyo Medical and Dental University (TMDU) priority research areas grant, and National Research Institute for Earth Science and Disaster Resilience. The views and opinions expressed in this article are those of the authors and do not necessarily reflect the official policy or position of the respective funding organizations. **Authors' Contributions**: *Conceived and designed the study, analyzed, interpreted the data, and wrote the article:* Tsuji. *Collection of data:* Tsuji, Yokoyama, Kondo. *Critically revised the article:* Yokoyama, Kanamori, Tabuchi, Kondo. *Principal investigator for the JAGES:* Kondo. *Read and approved the final version of the manuscript and agreed with the order of presentation of the authors*: All authors. **Data Statement**: The data underlying this study are from JAGES and contain sensitive information. Data for research purposes are available upon request. Requests for JAGES data can be sent to dataadmin.ml@jages.net.

References

1. Nelson ME, Rejeski WJ, Blair SN, et al. Physical activity and public health in older adults: recommendation from the American College of Sports Medicine and the American Heart Association. *Med Sci Sports Exerc*. 2007;39(8):1435–1445. doi:10.1249/mss.0b013e3180616aa2
2. McPhee JS, French DP, Jackson D, Nazroo J, Pendleton N, Degens H. Physical activity in older age: perspectives for healthy ageing and frailty. *Biogerontology*. 2016;17(3):567–580. doi:10.1007/s10522-016-9641-0
3. Dipietro L, Campbell WW, Buchner DM, et al. Physical activity, injurious falls, and physical function in aging: an umbrella review. *Med Sci Sports Exerc*. 2019;51(6):1303–1313. doi:10.1249/MSS.0000000000001942
4. Aoyagi Y, Shephard RJ. Sex differences in relationships between habitual physical activity and health in the elderly: practical implications for epidemiologists based on pedometer/accelerometer data from the Nakanojo study. *Arch Gerontol Geriatr*. 2013;56(2):327–338. doi:10.1016/j.archger.2012.11.006
5. Lee IM, Shiroma EJ, Kamada M, Bassett DR, Matthews CE, Buring JE. Association of step volume and intensity with all-cause mortality in older women. *JAMA Intern Med*. 2019;179(8):1105–1112. doi:10.1001/jamainternmed.2019.0899
6. Kanamori S, Kai Y, Kondo K, et al. Participation in sports organizations and the prevention of functional disability in older Japanese: The AGES cohort study. *PLoS One*. 2012;7(11):e51061. doi:10.1371/journal.pone.0051061
7. Kanamori S, Takamiya T, Inoue S, Kai Y, Tsuji T, Kondo K. Frequency and pattern of exercise and depression after two years in older Japanese adults: The JAGES longitudinal study. *Sci Rep*. 2018;8(1):11224. doi:10.1038/s41598-018-29053-x
8. Hayashi T, Kondo K, Kanamori S, et al. Differences in falls between older adult participants in group exercise and those who exercise alone: a cross-sectional study using Japan Gerontological Evaluation Study (JAGES) data. *Int J Environ Res Public Health*. 2018;15(7):1413. doi:10.3390/ijerph15071413
9. Yamakita M, Kanamori S, Kondo N, Kondo K. Correlates of regular participation in sports groups among Japanese older adults: JAGES cross-sectional study. *PLoS One*. 2015;10:e0141638. doi:10.1371/journal.pone.0141638
10. Scholes S, Bann D. Education-related disparities in reported physical activity during leisure-time, active transportation, and work among US adults: repeated cross-sectional analysis from the National Health and Nutrition Examination Surveys, 2007 to 2016. *BMC Public Health*. 2018;18(1):926. doi:10.1186/s12889-018-5857-z
11. Zapata-Lamana R, Poblete-Valderrama F, Cigarroa I, Parra-Rizo MA. The practice of vigorous physical activity is related to a higher educational level and income in older women. *Int J Environ Res Public Health*. 2021;18:10815. doi:10.3390/ijerph182010815
12. Kamphuis CB, Van Lenthe FJ, Giskes K, Huisman M, Brug J, Mackenbach JP. Socioeconomic status, environmental and individual factors, and sports participation. *Med Sci Sports Exerc*. 2008;40(1):71–81. doi:10.1249/mss.0b013e318158e467
13. Laaksonen M, Talala K, Martelin T, et al. Health behaviours as explanations for educational level differences in cardiovascular and all-cause mortality: a follow-up of 60 000 men and women over 23 years. *Eur J Public Health*. 2008;18(1):38–43. doi:10.1093/eurpub/ckm051
14. Uphoff EP, Pickett KE, Cabieses B, Small N, Wright J. A systematic review of the relationships between social capital and socioeconomic inequalities in health: a contribution to understanding the psychosocial pathway of health inequalities. *Int J Equity Health*. 2013;12(1):54. doi:10.1186/1475-9276-12-54
15. Coleman JS. *Foundations of Social Theory*. Belknap Press of Harvard University Press; 1990.
16. Putnam RD. *Bowling Alone: The Collapse and Revival of American Community*. Simon & Schuster; 2000.
17. Kawachi I, Berkman LF. Social capital, social cohesion, and health. In: Berkman LF, Kawachi I, Glymour MM, eds. *Social Epidemiology*. 2nd ed. Oxford University Press; 2014:290–319.
18. Putnam RD. *Making Democracy Work: Civic Traditions in Modern Italy*. Princeton University Press; 1993.
19. Kondo K. Progress in aging epidemiology in Japan: The JAGES project. *J Epidemiol*. 2016;26(7):331–336. doi:10.2188/jea.JE20160093
20. Kondo K, Rosenberg M, World Health Organization. *Advancing Universal Health Coverage Through Knowledge Translation for Healthy Ageing: Lessons Learnt from the Japan Gerontological Evaluation Study*. 2018.
21. Tsuji T, Kanamori S, Miyaguni Y, Hanazato M, Kondo K. Community-level sports group participation and the risk of cognitive impairment. *Med Sci Sports Exerc*. 2019;51(11):2217–2223. doi:10.1249/MSS.0000000000002050
22. Saito M, Kondo N, Aida J, et al. Development of an instrument for community-level health related social capital among Japanese older people: The JAGES Project. *J Epidemiol*. 2017;27(5):221–227. doi:10.1016/j.je.2016.06.005

23. Kelly P, Kahlmeier S, Gotschi T, et al. Systematic review and meta-analysis of reduction in all-cause mortality from walking and cycling and shape of dose response relationship. *Int J Behav Nutr Phys Act*. 2014;11(1):132. doi:10.1186/s12966-014-0132-x
24. Mackenbach JP, Kunst AE. Measuring the magnitude of socio-economic inequalities in health: an overview of available measures illustrated with two examples from Europe. *Soc Sci Med*. 1997;44(6):757–771. doi:10.1016/S0277-9536(96)00073-1
25. World Health Organization. *World Health Statistics 2023: Monitoring Health for the SDGs, Sustainable Development Goals*. 2023.
26. Hanibuchi T, Nakaya T, Honjo K. Trends in socioeconomic inequalities in self-rated health, smoking, and physical activity of Japanese adults from 2000 to 2010. *SSM Popul Health*. 2016;2:662–673. doi:10.1016/j.ssmph.2016.09.002
27. Tanaka H, Mackenbach JP, Kobayashi Y. Widening socioeconomic inequalities in smoking in Japan, 2001–2016. *J Epidemiol*. 2021;31(6):369–377. doi:10.2188/jea.JE20200025
28. Saito J, Haseda M, Amemiya A, Takagi D, Kondo K, Kondo N. Community-based care for healthy ageing: lessons from Japan. *Bull World Health Organ*. 2019;97(8):570–574. doi:10.2471/BLT.18.223057
29. Ide K, Nakagomi A, Tsuji T, et al. Participation in community gathering places and subsequent health and well-being: an outcome-wide analysis. *Innov Aging*. 2023;7:igad084. doi:10.1093/geroni/igad084
30. Tsuji T, Takagi D, Kondo N, et al. Promoting community gathering places "Kayoinoba" for healthy aging reduce health inequalities among communities: an eight-year ecological study. *Nihon Koshu Eisei Zasshi*. 2022;69:383–393. doi:10.11236/jph.21-120
31. Ministry of Health, Labour and Welfare. Survey Results on the Implementation Status of the Comprehensive Project for Preventive Care and Daily Life Support (Community Support Projects) for FY 2019. 2019. https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/0000141576_00007.html. Accessed August 1, 2024.
32. Glymour MM, Avendano M, Kawachi I. Socioeconomic status and health. In: Berkman LF, Kawachi I, Glymour MM, eds. *Social Epidemiology*. 2nd ed. Oxford University Press; 2014:17–62.
33. Shi L, Tao L, Chen N, Liang H. Relationship between socioeconomic status and cognitive ability among Chinese older adults: the moderating role of social support. *Int J Equity Health*. 2023;22(1):70. doi:10.1186/s12939-023-01887-6
34. Harper S, Lynch J, Meersman SC, Breen N, Davis WW, Reichman ME. An overview of methods for monitoring social disparities in cancer with an example using trends in lung cancer incidence by area-socioeconomic position and race-ethnicity, 1992–2004. *Am J Epidemiol*. 2008;167(8):889–899. doi:10.1093/aje/kwn016
35. Khanijahani A, Iezadi S, Gholipour K, Azami-Aghdash S, Naghibi D. A systematic review of racial/ethnic and socioeconomic disparities in COVID-19. *Int J Equity Health*. 2021;20(1):248. doi:10.1186/s12939-021-01582-4
36. Yang K, Qi H. Research on health disparities related to the COVID-19 pandemic: a bibliometric analysis. *Int J Environ Res Public Health*. 2022;19(3):1220. doi:10.3390/ijerph19031220