7. Yamada T, Demura S. The relationship of force output characteristics during a sit-to-stand movement with lower limb muscle mass and knee joint extension in the elderly. Arch Gerontol Geriatr. 2010;50:e46e 50.
8. Bean JF, Leveille SG, Kiely DK, et al. A comparison of leg power and leg strength within the InCHIANTI study: which influences mobility more? J Gerontol A Biol Sci Med Sci. 2003;58:728e 733.
9. Daubney ME, Culham EG. Lower-extremity muscle force and balance performance in adults aged 65 years and older. Phys Ther. 1999;79:1177e 1185.
10. Schenkman M, Berger RA, Riley PO, et al. Whole-body movements during rising to standing from sitting. Phys Ther. 1990;70:638e 648.
11. Lindemann U, Muche R, Stuber M, et al. Coordination of strength exertion during the chair-rise movement in very old people. J Gerontol A Biol Sci Med Sci. 2007;62:636e 640.
12. Fleming BE, Wilson DR, Pendergast DR. A portable, easily performed muscle power test and its association with falls by elderly persoms. Arch Phys Med Rehabil. 1991;72:886e 889.
13. Tsuji T, Mitsuishi Y, Tsunoda K, et al. The relationship between ground reaction force in a sit-to-stand movement and physical functioning, history of falls, fear of falling, and mobility limitations in community-dwelling older adults. Jpn J Phys Fitness Sports Med. 2011;60:387e 399 [in Japanese].
14. Guralnik JM, Simonsick EM, Ferrucci L, et al. A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission. J Gerontol. 1994;49:M85e 94.
15. Symons TB, Vandervoort AA, Rice CL, et al. Reliability of a single-session isokinetic and isometric strength measurement protocol in older men. J Gerontol A Biol Sci Med Sci. 2005;60:114e 119.
16. Lamoureux EL, Sparrow WA, Murphy A, et al. Differences in the neuromuscular capacity and lean muscle tissue in old and older community-dwelling adults. J Gerontol A Biol Sci Med Sci. 2001;56:M381e 385.
17. Pääsuke M, Ereline J, Gapeyeva H. Age-related differences in knee extension rate of isometric force development and vertical jumping performance in women. J Sports Med Phys Fitness. 2003;43:453e 458.
18. McGibbon CA, Goldvasser D, Krebs DE, et al. Instant of chair-rise lift-off can be predicted by foot-floor reaction forces. Hum Mov Sci. 2004;23:121e 132.
19. Lord SR, Murray SM, Chapman K, et al. Sit-to-stand performance depends on sensation, speed, balance, and psychological status in addition to strength in older people. J Gerontol A Biol Sci Med Sci. 2002;57:M539e 543.
20. Hughes MA, Schenkman ML. Chair rise strategy in the functionally impaired elderly. J Rehabil Res Dev. 1996;33:409e 412.
21. Janssen WG, Bussmann HB, Stam HJ. Determinants of the sit-to-stand movement: a review. Phys Ther. 2002;82:866e 879.
22. Duffell LD, Gulati V, Southgate DF, et al. Measuring body weight distribution during sit-to-stand in patients with early knee osteoarthritis. Gait Posture. 2013;38:745e 750.
23. Eitzen I, Fernandes L, Nordsletten L, et al. Weight-bearing asymmetries during Sit-To-Stand in patients with mild-to-moderate hip osteoarthritis. Gait Posture. 2014;39:683e 688.

Prospective Study of Physical Activity and Sleep in Middle-Aged and Older Adults

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Introduction: Few prospective cohort studies have examined the association between physical activity (PA) and insomnia prevention, and the effective PA intensity remains unclear. This prospective study explores how PA intensity prevents incident short sleep duration and subjective insufficient sleep in middle-aged and older adults.

Methods: A self-reported questionnaire gathered data on sleep and PA variables, including moderate low-intensity PA (MLPA); moderate high-intensity PA (MHPA); and vigorous-intensity PA (VPA), during health checkups conducted in Meiji Yasuda Shinjuku Medical Center in Tokyo. This study followed two cohorts from a 2008 baseline survey: (1) participants free of short sleep duration (n=7,061) and (2) participants free of insufficient sleep (n=7,385). They were divided into middle-aged (<60 years; 45.7 [8.8] years for sleep duration and 45.5 [8.8] years for sleep sufficiency) and older adults (both groups aged 65.3 [4.7] years) and followed for a mean 3.4 years until 2013. Data were analyzed in 2014.

Results: Engaging in MHPA (hazard ratio [HR]=0.81, 95% CI=0.67, 0.98) and VPA (HR=0.83, 95% CI=0.71, 0.97) had a significant preventive effect on incident subjective insufficient sleep among middle-aged adults. For older adults, only MLPA (HR=0.58, 95% CI=0.42, 0.81) had a significant preventive effect on incident insufficient sleep, and PA did not significantly affect incident short sleep duration.

Conclusions: Middle-aged adults engaging in MHPA and VPA and older adults engaging in MLPA can effectively maintain sleep sufficiency. When providing an effective PA program to prevent insomnia, the intensity of PA should correspond to the participant's age.
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Introduction

Some cohort studies have reported that approximately 20%–30% of Japanese people suffer from insomnia.[1,2] Insomnia is a known risk factor for obesity-related diseases,[3–5] depression,[6,7] and mortality[8,9]; it can also cause socioeconomic damage by decreasing daytime productivity.[10,11] A recent study estimated the economic damage caused by sleep problems to reach 3.5 trillion yen per year in Japan.[11] Preventing sleep problems is an important issue for the health of both individuals and the socioeconomy.

Intervention studies[12–16] have shown that physical activity (PA) can lead to better sleep by decreasing mental stress, increasing physical fatigue, downregulating body temperature, and regulating circadian rhythm.[17,18] An intervention study is the best method for examining causal relationships and mechanisms, but it is often limited by small sample sizes and difficulty in confirming its long-term effects. Epidemiologic findings based on large prospective cohort studies are also important for building sound evidence. However, most of the available information on PA and sleep patterns is based on cross-sectional studies, and the evidence that can be gathered in longitudinal studies remains wanting.[17,19]

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Evidence is lacking on the intensity levels of PA that effectively improve sleep. Intervention studies have reported significant improvement in sleep by using both lower[12,13] and higher intensities of PA,[14,16] but the most effective PA intensity is uncertain. Physical fitness typically decreases with age,[20,21] and the effective PA intensity for prevention of insomnia may differ by age. Additionally, the reason why adults suffer from sleep problems can change with age. Work may affect younger adults' sleep,[22,23] whereas the circadian phase shift is a major cause of insomnia in older adults.[24] Therefore, the association between PA intensity and sleep can change with age, and revealing these age differences would be helpful for developing strategies to prevent insomnia. The purpose of this study is to reveal effective levels of PA intensity that prevent short sleep duration and subjective insufficient sleep in both middle-aged and older adults.

Methods

Study Population

Data were gathered at health checkups conducted in Meiji Yasuda Shinjuku Medical Center in Shinjuku Ward, Tokyo, Japan. The majority of patients were employees and their spouses, with employers providing financial support for the annual health checkups. Figure 1 shows the flow of participants through the study. This study used health checkup data from 16,267 examinees in 2008 as baseline data. Of these examinees, 3,148 were excluded owing to incomplete data. Because mental disease is a strong risk factor for insomnia,[25] 263 individuals with a diagnosed history of mental disease including depression were excluded.

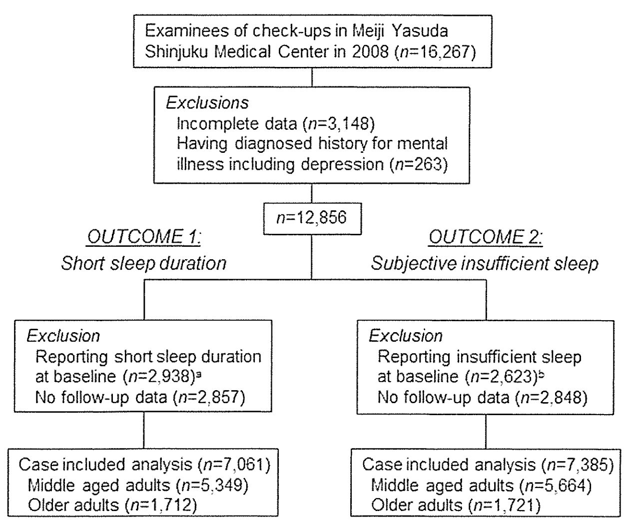

Figure 1. Flow of participants through the study.
[a]When looking at age stage, 2,691 of 10,397 middle-aged adults (25.9%) and 247 of 2,459 older adults (10.0%) reported short sleep duration at baseline.
[b]For sleep sufficiency, 2,376 of 10,397 middle-aged adults (22.9%) and 247 of 2,459 older adults (10.0%) reported insufficient sleep at baseline.

Because this study targeted two outcomes (short sleep duration and subjective insufficient sleep), we prepared two cohort models with participants that were free of the targeted outcome at baseline. In the cohort focused on short sleep duration, 2,938 individuals were excluded because of the prevalence of short sleep duration at baseline. Similarly, 2,623 individuals in the cohort looking at insufficient sleep were excluded owing to its prevalence at baseline. Furthermore, 2,857 individuals in the cohort for short sleep duration and 2,848 individuals in the cohort for insufficient sleep were excluded because they could not be followed for at least 1 year. Finally, there were 7,061 and 7,385 participants available for the short sleep duration and insufficient sleep cohorts, respectively. These participants were followed through their annual health checkups until they reported short sleep duration or insufficient sleep or until the end of 2013. When a participant did not attend an annual checkup, all available follow-up data were used. All participants provided informed consent. The Ethical Committee of Meiji Yasuda Life Foundation of Health and Welfare approved this study.

Measures

Quantitative and subjective assessments of sleep, sleep duration, and subjective sleep sufficiency were assessed via a self-administered questionnaire. For sleep duration, people reported their major patterns of sleep duration (hours per day) accurate to one decimal place. Sleep duration was considered short if it was less than 6.0 hours, and this sleep duration is a known risk factor of obesity-related diseases[5] and mortality.[8,9] Although long sleep duration, such as more than 9.0 hours, is also a known risk factor of heart disease[26] and mortality,[8,9] there were very few long-duration sleepers in the study at baseline (0.3% of middle-aged adults and 2.1% of older adults slept 9.0 hours or more). Therefore, this study focused only on short sleep duration.

To identify sleep sufficiency, a national standard question for Japanese health checkups was used.[27] Participants responded *yes* or *no* to the statement: *Do you sleep well and get a sufficient amount of rest?* For this study, a *no* response indicated insufficient sleep. Sleep sufficiency was validated through the 2013 survey data (Appendix Table 1). Four validation items (sleep latency, total time in bed, sleep duration, and sleep efficiency) were extracted from the Pittsburgh sleep quality index.[28] People who reported insufficient sleep were significantly more likely to have longer sleep latency (Cohen's d[29] in middle-aged adults, 0.34; d in older adults, 0.42); shorter total time in bed (d in middle-aged adults, 0.59; d in older adults, 0.67); shorter sleep duration (d in middle-aged adults, 0.81; d in older adults, 1.04); and lower sleep efficiency (d in middle-aged adults, 0.42; d in older adults, 0.61) than those reporting sufficient sleep.

A questionnaire assessed PA in daily life including leisure-time, household, and occupational PA by weekly frequency (never, less than once a week, once a week, twice a week, and three or more times a week); duration (<10 minutes/session, 10–19 minutes/session, 20–29 minutes/session, and ≥30 minutes/session); and intensity (moderate low-intensity PA [MLPA], moderate high-intensity PA [MHPA], and vigorous-intensity PA [VPA]). MLPA includes activities such as walking, gymnastics, golf, table tennis, house cleaning, and carrying light loads. MHPA includes baseball,

Table 1. Baseline Characteristics by Physical Activity Level in Analysis for Short Sleep Duration

	Middle-aged adults (n=5,349, mean age=45.7±8.8 years, male=51.2%)									Older adults (n=1,712, mean age=65.3±4.7 years, male=63.8%)								
	MLPA			MHPA			VPA			MLPA			MHPA			VPA		
Baseline variables	**<1-x/w**	**≥1-x/w**	***p*-value**	**<1-x/w**	**≥1-x/w**	***p*-value**	**<1-x/w**	**≥1-x/w**	***p*-value**	**<1-x/w**	**≥1-x/w**	***p*-value**	**<1-x/w**	**≥1-x/w**	***p*-value**	**<1-x/w**	**≥1-x/w**	***p*-value**
Number	2,972	2,377		4,800	549		4,541	808		645	1,067		1,477	235		1,424	288	
Mean (SD) age (years)	44.7 (8.9)	46.8 (8.5)	**<0.001**	45.6 (8.8)	46.4 (8.7)	**0.041**	45.7 (8.8)	45.6 (8.8)	0.934	64.7 (4.5)	65.7 (4.7)	**<0.001**	65.3 (4.7)	65.8 (4.8)	0.079	65.4 (4.7)	65.2 (4.4)	0.693
Male gender	56.2	45.1	**<0.001**	51.9	45.2	**0.003**	49.8	59.3	**<0.001**	60.6	65.8	**0.031**	64.0	62.6	0.658	63.2	67.0	0.219
Mean (SD) BMI (kg/m^2)	22.3 (3.2)	22.3 (3.3)	0.609	22.3 (3.2)	22.1 (2.9)	0.192	22.3 (3.3)	22.1 (2.7)	0.059	22.9 (2.9)	22.5 (2.6)	**0.013**	22.6 (2.7)	22.7 (2.6)	0.788	22.7 (2.8)	22.5 (2.3)	0.415
Smoking status			**<0.001**			**0.040**			**<0.001**			**<0.001**			0.143			0.220
Never	50.3	58.3		53.4	57.7		54.1	52.7		52.7	49.4		50.1	54.0		50.3	52.4	
Former	23.0	22.9		22.9	23.3		21.6	30.6		30.5	40.1		36.4	37.0		36.2	37.8	
Current	26.6	18.8		23.6	18.9		24.3	16.7		16.7	10.5		13.5	8.9		13.5	9.7	
Alcohol consumption (g/day)			**<0.001**			0.743			**<0.001**			0.271			**0.011**			0.198
Never	11.8	15.1		13.4	12.2		13.9	9.5		19.7	19.7		20.2	16.6		20.4	16.3	
<20	60.7	61.0		60.7	61.4		60.9	60.3		52.1	55.5		55.0	49.4		54.1	54.5	
≥20	27.6	23.9		25.9	26.4		25.2	30.2		28.2	24.8		24.8	34.0		25.5	29.2	
Milk products intake			**<0.001**			**<0.001**			**<0.001**			0.300			0.190			**0.003**
Never or seldom	38.8	28.9		35.2	27.3		35.6	27.7		28.2	24.8		26.7	22.6		27.7	18.4	
Once every 2 days	13.5	13.6		13.7	12.2		13.2	15.2		10.5	10.8		11.0	8.9		10.8	10.1	

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Table 1. Baseline Characteristics by Physical Activity Level in Analysis for Short Sleep Duration *(continued)*

	Middle-aged adults (n=5,349, mean age=45.7±8.8 years, male=51.2%)									Older adults (n=1,712, mean age=65.3±4.7 years, male=63.8%)								
	MLPA			MHPA			VPA			MLPA			MHPA			VPA		
Baseline variables	**<1-x/w**	**≥1-x/w**	***p*-value**	**<1-x/w**	**≥1-x/w**	***p*-value**	**<1-x/w**	**≥1-x/w**	***p*-value**	**<1-x/w**	**≥1-x/w**	***p*-value**	**<1-x/w**	**≥1-x/w**	***p*-value**	**<1-x/w**	**≥1-x/w**	***p*-value**
One or more times per day	47.7	57.4		51.1	60.5		51.2	57.1		61.2	64.4		62.4	68.5		61.5	71.5	
Coffee intake			0.917			0.555			0.133			0.171			0.538			0.464
Never or seldom	19.8	20.1		20.1	18.2		20.4	17.3		26.4	28.8		27.5	30.2		28.2	26.0	
Moderate	23.8	24.0		23.8	24.8		23.8	24.6		26.8	29.1		28.6	25.5		28.5	26.7	
Often or very often	56.4	55.9		56.1	57.0		55.8	58.0		46.8	42.2		43.9	44.3		43.3	47.2	
Days off a week			**<0.001**			**<0.001**			0.977			**<0.001**			**0.017**			0.080
≤1	7.9	7.2		7.8	6.0		7.5	7.8		7.9	4.0		5.1	8.1		5.7	4.5	
2	82.8	75.9		79.9	77.6		79.8	79.3		48.7	35.9		42.0	32.3		40.7	40.6	
3–6	3.4	6.9		4.6	8.6		4.9	5.3		14.0	19.4		16.7	21.7		16.6	20.8	
7	0.7	2.2		1.3	1.8		1.4	1.2		11.8	17.9		15.2	17.9		15.1	18.1	
Not reported	5.2	7.9		6.4	6.0		6.4	6.3		17.7	22.8		21.0	20.0		21.8	16.0	
Mean (SD) sleep duration (h/d)[a]	6.5 (0.6)	6.5 (0.6)	0.055	6.5 (0.6)	6.5 (0.6)	0.721	6.5 (0.6)	6.5 (0.6)	0.308	6.8 (0.8)	6.9 (0.7)	**<0.001**	6.9 (0.7)	7.0 (0.8)	**0.032**	6.9 (0.7)	6.9 (0.7)	0.637
Subjective insufficient sleep	16.6	14.0	**0.009**	15.9	11.1	**0.003**	16.3	10.5	**<0.001**	8.7	5.9	**0.029**	6.8	8.1	0.462	7.3	5.2	0.202

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Table 1. Baseline Characteristics by Physical Activity Level in Analysis for Short Sleep Duration *(continued)*

Baseline variables	Middle-aged adults (n=5,349, mean age=45.7±8.8 years, male=51.2%) MLPA <1-x/w	MLPA ≥1-x/w	MLPA *p*-value	MHPA <1-x/w	MHPA ≥1-x/w	MHPA *p*-value	VPA <1-x/w	VPA ≥1-x/w	VPA *p*-value	Older adults (n=1,712, mean age=65.3±4.7 years, male=63.8%) MLPA <1-x/w	MLPA ≥1-x/w	MLPA *p*-value	MHPA <1-x/w	MHPA ≥1-x/w	MHPA *p*-value	VPA <1-x/w	VPA ≥1-x/w	VPA *p*-value
MLPA (≥1x/w)	–	–	–	45.4	35.9	**<0.001**	46.8	31.4	**<0.001**	–	–	–	65.8	40.4	**<0.001**	66.0	44.1	**<0.001**
MHPA (≥1x/w)	11.8	8.3	**<0.001**	–	–	–	9.5	14.5	**<0.001**	21.7	8.9	**<0.001**	–	–	–	12.7	18.8	**0.007**
VPA (≥1x/w)	18.6	10.7	**<0.001**	14.4	21.3	**<0.001**	–	–	–	25.0	11.9	**<0.001**	15.8	23.0	**0.007**	–	–	–

Note: Boldface indicates statistical significance ($p<0.05$). Values are percentages unless stated otherwise.
[a]People who reported short sleep duration (≤5.9 hours/day) were excluded.
MLPA, moderate low-intensity physical activity; MHPA, moderate high-intensity physical activity; VPA, vigorous-intensity physical activity.

basketball, hiking, light carpentry work, light farming, and carrying moderate loads. VPA includes jogging, bicycling, tennis, swimming, mountaineering, carpentry work, farming, and carrying heavy loads. MLPA corresponds to approximately 3–5 METs, MHPA corresponds to 5–7 METs, and VPA corresponds to ≥7 METs.[30]

Because 10 minutes is considered the minimum duration for a single-event activity,[31] a single session of PA was determined to be ≥10 minutes. To obtain adequate statistical power, MLPA, MHPA, and VPA were, respectively, categorized into dichotomous variables of "less than once a week" and "once a week or more."

Demographic variables included age; gender; BMI; alcohol consumption (never, <20.0 grams/day, and ≥20.0 grams/day of alcohol); smoking status (never, former, and current); milk product consumption (never or seldom, once every two days, and one or more times per day); coffee intake (never or seldom, moderate, and often or very often); and days off from work per week (≤1 day/week, 2 days/week, 3–6 days/week, 7 days/week, and not reported). All demographic variables except BMI were assessed through a self-administered questionnaire. The question of days off was frequently left blank, especially in women and older adults, even when they answered every other question; these participants may not have been employed. To maintain a sample balance, when participants answered all the other questions except the one about days off, their days off were coded as "not reported."

Statistical Analysis

Participants were grouped into middle-aged adults (<60 years) and older adults (≥60 years), and all analyses were conducted with these groups. To compare baseline characteristics with engagement in PA, chi-square tests for categorical variables and Student's *t* test for continuous variables were used. Cox proportional-hazards analysis was performed to examine the preventive effect of PA on the development of short sleep duration and insufficient sleep. Two multivariable-adjusted models were set in this study: covariates of Model 1 included age, gender, BMI, alcohol consumption, smoking status, milk product consumption, coffee intake, and number of days off from work. Additionally, sleep duration in the outcome for insufficient sleep and sleep sufficiency in the outcome for short sleep duration, respectively, were adjusted. In Model 2, all three PA intensity variables were entered simultaneously into Model 1 to adjust for their effects on each other as covariates. The level of significance for all analyses was set at $p<0.05$. Statistical analyses were performed in 2014 using SPSS, version 21.0.

Results

Tables 1 and 2 show characteristics of participants in the two cohorts. In both middle-aged and older adults, participants who engaged in MLPA were less likely to engage in MHPA and VPA, whereas participants who engaged in MHPA were more likely to also engage in VPA.

During a mean follow-up period of 3.4 years, 1,245 of 5,349 (23.3%) middle-aged adults (17,968 person-years, 3.0 follow-up visits per person) newly reported short

Table 2. Baseline Characteristics by Physical Activity Level in Analysis for Subjective Insufficient Sleep

Baseline variables	Middle-aged adults (n=5,664, mean age=45.5±8.8 years, male=52.7%)									Older adults (n=1,721, mean age=65.3±4.7 years, male=63.5%)								
	MLPA			MHPA			VPA			MLPA			MHPA			VPA		
	<1-x/w	≥1-x/w	*p*-value	<1-x/w	≥1-x/w	*p*-value	<1-x/w	≥1-x/w	*p*-value	<1-x/w	≥1-x/w	*p*-value	<1-x/w	≥1-x/w	*p*-value	<1-x/w	≥1-x/w	*p*-value
Number	3,137	2,527		5,075	589		4,756	908		646	1,075		1,494	227		1,437	284	
Mean (SD) age (years)	44.6 (8.8)	46.6 (8.5)	**<0.001**	45.4 (8.8)	46.2 (8.6)	**0.032**	45.5 (8.8)	45.5 (8.7)	0.907	64.7 (4.6)	65.7 (4.7)	**<0.001**	65.3 (4.7)	65.9 (4.8)	**0.045**	65.4 (4.8)	65.3 (4.5)	0.848
Male Gender	57.3	47.0	**<0.001**	53.8	43.0	**<0.001**	51.4	59.4	**<0.001**	60.5	65.3	**0.046**	63.7	62.6	0.748	62.9	66.5	0.244
Mean (SD) BMI (kg/m²)	22.5 (3.3)	22.4 (3.3)	0.166	22.5 (3.4)	22.0 (2.8)	**0.002**	22.5 (3.4)	22.3 (2.8)	0.168	22.9 (2.9)	22.6 (2.7)	**0.033**	22.7 (2.8)	22.8 (2.6)	0.459	22.7 (2.8)	22.6 (2.4)	0.338
Smoking status			**<0.001**			**0.007**			**<0.001**			**<0.001**			0.111			0.278
Never	50.8	57.3		53.1	58.7		53.7	53.6		51.7	50.1		50.2	54.2		50.5	52.1	
Former	22.6	23.1		22.9	22.8		21.6	29.6		30.0	39.8		36.0	37.0		35.8	37.7	
Current	26.6	19.6		24.0	18.5		24.7	16.7		18.3	10.0		13.8	8.8		13.7	10.2	
Alcohol consumption (g/day)			**0.001**			0.962			**0.002**			0.303			**0.030**			0.097
Never	11.8	14.3		13.0	12.6		13.5	9.8		19.2	20.0		20.1	17.2		20.4	16.2	
<20	60.9	61.8		61.3	61.6		61.3	61.2		52.8	55.3		55.1	49.8		54.6	53.5	
≥20	27.3	23.9		25.8	25.8		25.1	29.0		28.0	24.7		24.8	33.0		25.1	30.3	
Milk products intake			**<0.001**			**<0.001**			**<0.001**			0.225			0.169			**0.001**
Never or seldom	38.4	29.1		35.1	27.3		35.6	27.1		28.0	24.8		26.6	22.0		27.6	18.3	
Once every two days	13.2	14.1		13.9	11.5		13.3	15.4		11.9	11.0		11.6	9.7		11.6	9.9	

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Table 2. Baseline Characteristics by Physical Activity Level in Analysis for Subjective Insufficient Sleep *(continued)*

Baseline variables	Middle-aged adults (n=5,664, mean age=45.5±8.8 years, male=52.7%)									Older adults (n=1,721, mean age=65.3±4.7 years, male=63.5%)								
	MLPA			MHPA			VPA			MLPA			MHPA			VPA		
	<1-x/w	≥1-x/w	*p*-value	<1-x/w	≥1-x/w	*p*-value	<1-x/w	≥1-x/w	*p*-value	<1-x/w	≥1-x/w	*p*-value	<1-x/w	≥1-x/w	*p*-value	<1-x/w	≥1-x/w	*p*-value
One or more times per day	48.4	56.7		51.1	61.1		51.1	57.5		60.1	64.2		61.8	68.3		60.8	71.8	
Coffee intake			0.452			0.497			0.054			0.093			0.392			0.532
Never or seldom	18.9	19.7		19.4	18.3		19.8	16.4		25.5	28.0		26.7	29.5		27.3	25.7	
Moderate	23.6	24.3		23.7	25.8		23.8	24.2		26.9	29.9		29.3	25.1		29.1	27.1	
Often or very often	57.6	55.9		56.9	55.9		56.3	59.4		47.5	42.1		44.0	45.4		43.6	47.2	
Days off a week			**<0.001**			**<0.001**			0.670			**<0.001**			**0.027**			0.179
≤1	8.0	6.9		7.7	5.8		7.4	8.0		9.0	4.2		5.8	7.0		6.1	5.6	
2	83.1	76.6		80.5	77.6		80.4	79.1		46.9	36.1		41.5	31.3		40.4	39.1	
3–6	3.3	6.8		4.5	8.1		4.7	5.7		15.2	19.1		16.9	22.0		16.9	21.1	
7	0.8	2.2		1.4	1.9		1.4	1.3		11.8	17.9		15.0	19.4		15.2	17.6	
Not reported	4.7	7.6		6.0	6.6		6.1	5.8		17.2	22.8		20.7	20.3		21.5	16.5	
Mean (SD) sleep duration (h/d)	6.2 (0.8)	6.3 (0.8)	**0.015**	6.2 (0.8)	6.3 (0.8)	0.236	6.3 (0.8)	6.3 (0.8)	0.537	6.7 (0.9)	6.8 (0.9)	**0.001**	6.8 (0.9)	6.9 (0.9)	**0.004**	6.8 (0.9)	6.9 (0.8)	0.070
Subjective insufficient sleep[a]	0.0	0.0	–	0.0	0.0	–	0.0	0.0	–	0.0	0.0	–	0.0	0.0	–	0.0	0.0	–

(continued on next page)

Table 2. Baseline Characteristics by Physical Activity Level in Analysis for Subjective Insufficient Sleep (*continued*)

Baseline variables	Middle-aged adults (n=5,664, mean age=45.5±8.8 years, male=52.7%)									Older adults (n=1,721, mean age=65.3±4.7 years, male=63.5%)								
	MLPA			MHPA			VPA			MLPA			MHPA			VPA		
	<1-x/w	≥1-x/w	*p*-value	<1-x/w	≥1-x/w	*p*-value	<1-x/w	≥1-x/w	*p*-value	<1-x/w	≥1-x/w	*p*-value	<1-x/w	≥1-x/w	*p*-value	<1-x/w	≥1-x/w	*p*-value
MLPA (≥1x/w)	–	–	–	45.5	37.0	**<0.001**	47.2	31.1	**<0.001**	–	–	–	65.7	41.4	**<0.001**	66.1	44.0	**<0.001**
MHPA (≥1x/w)	11.8	8.6	**<0.001**	–	–	–	9.8	13.8	**<0.001**	20.6	8.7	**<0.001**	–	–	–	12.2	18.0	**0.009**
VPA (≥1x/w)	20.0	11.2	**<0.001**	15.4	21.2	**<0.001**	–	–	–	24.6	11.6	**<0.001**	15.6	22.5	**0.009**	–	–	–

Note: Boldface indicates statistical significance ($p<0.05$). Values are percentages unless stated otherwise.
[a]People who reported insufficient sleep were excluded.
MLPA, moderate low-intensity physical activity; MHPA, moderate high-intensity physical activity; VPA: vigorous-intensity physical activity

sleep duration and 165 of 1,712 (9.6%) older adults (5,791 person-years, 3.1 follow-up visits per person) newly reported short sleep duration. Furthermore, during the same period, 1,300 of 5,664 (23.0%) middle-aged adults (19,208 person-years, 3.0 follow-up visits per person) newly reported insufficient sleep and 164 of 1,721 (9.5%) older adults (5,836 person-years, 3.1 follow-up visits per person) newly reported insufficient sleep.

In the final hazard models for incident short sleep duration (Table 3), middle-aged adults performing VPA (hazard ratio [HR]=0.85, 95% CI=0.72, 1.01, p=0.067) and older adults performing MLPA (HR=0.74, 95% CI=0.53, 1.02, p=0.067) were more likely to link with lower HRs; however, no PA intensities were significantly associated with incident short sleep duration. Incident insufficient sleep among middle-aged adults was significantly prevented by engaging in MHPA (HR=0.81, 95% CI=0.67, 0.98, p=0.034) and VPA (HR=0.83, 95% CI=0.71, 0.97, p=0.022) (Table 4). In older adults, although there were also decreasing HRs for MHPA (HR=0.70, 95% CI=0.41, 1.19, p=0.186) and VPA (HR=0.83, 95% CI=0.53, 1.30, p=0.411), the significant preventive effect on incident insufficient sleep was only confirmed with MLPA (HR=0.58, 95% CI=0.42, 0.81, p=0.001). Appendix Figures 1 and 2 present Kaplan–Meier curves for the final models.

Discussion

This study investigated whether MLPA, MHPA, and VPA could prevent incident short sleep duration and subjective insufficient sleep in both middle-aged and older adults. Although there were no significant associations between any type of PA and incident short sleep duration in either middle-aged or older adults, there was a clear age difference in the association between PA intensity and incident insufficient sleep: in middle-aged adults, higher intensities of PA more effectively prevented incident insufficient sleep, but in older adults, MLPA was more effective for preventing incident insufficient sleep. This study supports the few studies that have confirmed the prospective association between PA and risk of sleep problems[32,33] and adds new information on the benefits of three types of PA for improving sleep based on age.

At baseline, the prevalence of both short sleep duration and subjective insufficient sleep were higher in middle-aged adults than in older adults. Increased sleep problems that occur with age is well known[34] and a previous Japanese study[2] reported on this phenomenon, but the data presented here dispute that conclusion. The study data were obtained from health checkups in Shinjuku,

Table 3. Hazard Ratios of Incident Short Sleep Duration by Physical Activity Levels

	Middle-aged adults		Older adults	
	<1x/w	≥1x/w	<1x/w	≥1x/w
Moderate low-intensity physical activity				
No. of person-years	9,847	8,121	2,114	3,677
No. of cases for short sleep duration	719	526	76	89
Incidence rates per 1,000 person-years	73	65	36	24
Unadjusted	1.00	**0.89 (0.79, 0.99)**	1.00	**0.68 (0.50, 0.92)**
Adjusted for age and gender	1.00	0.94 (0.84, 1.05)	1.00	**0.72 (0.53, 0.98)**
Model 1[a]	1.00	0.98 (0.87, 1.10)	1.00	0.79 (0.58, 1.08)
Model 2[b]	1.00	0.96 (0.86, 1.08)	1.00	0.74 (0.53, 1.02)
Moderate high-intensity physical activity				
No. of person-years	16,106	1,862	4,967	824
No. of cases for short sleep duration	1,128	117	149	16
Incidence rates per 1,000 person-years	70	63	30	19
Unadjusted	1.00	0.90 (0.74, 1.09)	1.00	0.65 (0.39, 1.09)
Adjusted for age and gender	1.00	0.92 (0.76, 1.11)	1.00	0.66 (0.39, 1.10)
Model 1[a]	1.00	0.96 (0.80, 1.17)	1.00	0.69 (0.41, 1.16)
Model 2[b]	1.00	0.97 (0.80, 1.17)	1.00	0.65 (0.38, 1.10)
Vigorous-intensity physical activity				
No. of person-years	15,224	2,744	4,797	994
No. of cases for short sleep duration	1,087	158	143	22
Incidence rates per 1,000 person-years	71	58	30	22
Unadjusted	1.00	**0.81 (0.68, 0.95)**	1.00	0.74 (0.48, 1.17)
Adjusted for age and gender	1.00	**0.80 (0.68, 0.95)**	1.00	0.77 (0.49, 1.20)
Model 1[a]	1.00	0.86 (0.72, 1.01)	1.00	0.85 (0.54, 1.34)
Model 2[b]	1.00	0.85 (0.72, 1.01)	1.00	0.81 (0.51, 1.29)

Note: Boldface indicates statistical significance ($p < 0.05$).
[a]Adjusted for age, gender, BMI, smoking, alcohol consumption, days off from work, milk products intake, coffee intake, and sleep sufficiency.
[b]Additional adjustment of Model 1 for other intensity types of physical activity.

Tokyo, which is a major business center; some of the middle-aged workers may be more affected and stressed by their work than the older adults. Indeed, the latest survey data from 2013 confirms that middle-aged adults are more likely than older adults to have higher depression scores as assessed by K6[35] (Appendix Table 2). Work burden is a known risk factor for sleep problems,[22,23] and the current data may reflect this urban working population. As another large, Japanese cohort survey also confirmed that middle-aged adults experience short sleep duration and subjective insufficient sleep compared with older adults,[36] the current data may not be specific to Japan.

Incident subjective insufficient sleep was significantly prevented by MHPA and VPA in middle-aged adults and by MLPA in older adults. Some researchers have suggested that PA leads to better sleep via circadian rhythm adjustment, body temperature downregulation, restoration from fatigue, and reduction of stress and anxiety[17,18]; we believe the present epidemiologic results reflect the effect of a combination of these factors on sleep. When looking at HRs, MHPA and VPA indicated decreasing HRs for insufficient sleep in both middle-aged and older adults, but MLPA was significantly associated with sleep sufficiency only in older adults. Because physical fitness level gradually decreases with age,[20,21]

Table 4. Hazard Ratios of Incident Subjective Insufficient Sleep by Physical Activity Levels

	Middle-aged adults		Older adults	
	<1x/w	≥1x/w	<1x/w	≥1x/w
Moderate low-intensity physical activity				
No. of person-years	10,498	8,710	2,125	3,711
No. of cases for insufficient sleep	755	545	86	78
Incidence rates per 1,000 person-years	72	63	40	21
Unadjusted	1.00	**0.87 (0.78, 0.98)**	1.00	**0.52 (0.38, 0.71)**
Adjusted for age and gender	1.00	**0.89 (0.79, 0.99)**	1.00	**0.56 (0.41, 0.76)**
Model 1[a]	1.00	0.92 (0.83, 1.03)	1.00	**0.62 (0.45, 0.85)**
Model 2[b]	1.00	0.90 (0.81, 1.01)	1.00	**0.58 (0.42, 0.81)**
Moderate high-intensity physical activity				
No. of person-years	17,177	2,031	5,025	811
No. of cases for insufficient sleep	1,189	111	148	16
Incidence rates per 1,000 person-years	69	55	29	20
Unadjusted	1.00	**0.79 (0.65, 0.96)**	1.00	0.67 (0.40, 1.13)
Adjusted for age and gender	1.00	**0.79 (0.65, 0.96)**	1.00	0.68 (0.41, 1.14)
Model 1[a]	1.00	**0.81 (0.67, 0.99)**	1.00	0.78 (0.46, 1.32)
Model 2[b]	1.00	**0.81 (0.67, 0.98)**	1.00	0.70 (0.41, 1.19)
Vigorous-intensity physical activity				
No. of person-years	16,049	3,159	4,849	987
No. of cases for insufficient sleep	1,122	178	140	24
Incidence rates per 1,000 person-years	70	56	29	24
Unadjusted	1.00	**0.81 (0.69, 0.95)**	1.00	0.84 (0.55, 1.30)
Adjusted for age and gender	1.00	**0.81 (0.69, 0.95)**	1.00	0.86 (0.56, 1.32)
Model 1[a]	1.00	**0.83 (0.71, 0.98)**	1.00	0.92 (0.59, 1.43)
Model 2[b]	1.00	**0.83 (0.71, 0.97)**	1.00	0.83 (0.53, 1.30)

Note: Boldface indicates statistical significance ($p < 0.05$).
[a]Adjusted for age, gender, BMI, smoking, alcohol consumption, days off from work, milk products intake, coffee intake, and sleep duration.
[b]Additional adjustment of Model 1 for other intensity types of physical activity.

the required PA intensity that leads to better sleep would differ through different age stages: MLPA may be insufficient for middle-aged adults, whereas older adults may benefit from this level of PA. To provide a PA program that leads to better sleep, relative intensity of PA should correspond to an individual's fitness level.

Similar to subjective insufficient sleep, people who engaged in PA were less likely to have incident short sleep duration, but this association was not significant. As adequate sleep duration can vary greatly among individuals,[37] the absolute cut-off point of sleep duration (i.e., ≥6.0 hours/day) may not necessarily correspond to an individual's required sleep duration. A previous study assessed a gap between required sleep duration and actual sleep duration as an assessment of insomnia.[38] If using this gap as an insomnia assessment, its association with PA may be similar to that between PA and sleep sufficiency.

As mentioned previously, the level of intensity of PA that can lead to better sleep differs by age. However, when looking at HRs, in general, PA was more effective at improving sleep in older adults than in middle-aged adults. Insomnia among middle-aged adults is frequently due to work-related stressors, including working long hours,[22,23] whereas older adults' insomnia is mainly caused by circadian phase shifts.[24] Because PA can help readjust circadian rhythm,[39,40] older adults' sleep may be more directly and strongly affected by PA than middle-aged adults. However, we have not determined the reason for this trend. Future studies should examine the sociologic and physiologic reasons why older adults' sleep is more affected by PA.

Limitations

Although this study has the advantage of being a prospective cohort study that reveals the association between PA intensity types and incident sleep problems in middle-aged and older adults, there are still some limitations. First, PA and sleep variables were assessed by a self-reported questionnaire, which may induce recalling/reporting bias. Second, although people who had a history of mental illness were excluded from the study population, psychological status at baseline could not be adjusted; this limits confidence in the results. Third, the sample size of older adults was smaller than the sample size of middle-aged adults. If this study used similar sample sizes of older and middle-aged adults, a more significant effect may be observed. Additionally, PA items were categorized into dichotomous variables to obtain sufficient statistical power, and this study could not reveal a dose–response relationship between PA and sleep. Future studies should confirm a dose–response relationship based on an adequately large sample size. Fourth, this study assessed sleep duration primarily corresponding to a weekday sleep pattern. Because weekend sleep duration is typically longer than weekday sleep duration, especially in middle-aged adults,[41] the association between PA and sleep duration may differ between weekday and weekend sleep patterns. Finally, the influence of selection bias cannot be excluded: the majority of participants were employees and their spouses living in Tokyo, and they might have a higher social status than a rural population. There was a general lack of socioeconomic variability such as education and income in the study's participants. The 2013 survey included education level, which revealed that the tertiary education rate of the cohort (84.1% of middle-aged and 62.9% of older adults) was higher than the general Japanese population (40.8% of middle-aged and 13.7% of older adults).[42] Generalization of the study findings should be confirmed, especially in rural areas.

Conclusions

This study explored the PA intensities that could effectively prevent future incident short sleep duration and subjective insufficient sleep in both middle-aged and older adults. Through a prospective investigation, this study found that PA helps to maintain subjective sleep sufficiency, but it was not significantly associated with sleep duration. Additionally, this study revealed an age difference in the association between PA intensity and sleep sufficiency: MHPA to VPA in middle-aged adults, and MLPA in older adults, effectively prevents incident insufficient sleep. Further prospective and intervention studies are needed to clarify the optimal PA pattern for better sleep in various populations.

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References

1. Doi Y, Minowa M, Uchiyama M, Okawa M. Subjective sleep quality and sleep problems in the general Japanese adult population. *Psychiatry Clin Neurosci.* 2001;55(3):213–215. http://dx.doi.org/10.1046/j.1440-1819.2001.00830.x.
2. Kim K, Uchiyama M, Okawa M, Liu X, Ogihara R. An epidemiological study of insomnia among the Japanese general population. *Sleep.* 2000;23(1):41–47.
3. Hung HC, Yang YC, Ou HY, Wu JS, Lu FH, Chang CJ. The association between self-reported sleep quality and overweight in a Chinese population. *Obesity (Silver Spring).* 2013;21(3):486–492. http://dx.doi.org/10.1002/oby.20259.
4. King CR, Knutson KL, Rathouz PJ, Sidney S, Liu K, Lauderdale DS. Short sleep duration and incident coronary artery calcification. *JAMA.* 2008;300(24):2859–2866. http://dx.doi.org/10.1001/jama.2008.867.
5. Tu X, Cai H, Gao YT, et al. Sleep duration and its correlates in middle-aged and elderly Chinese women: the Shanghai Women's Health Study. *Sleep Med.* 2012;13(9):1138–1145. http://dx.doi.org/10.1016/j.sleep.2012.06.014.
6. Ford DE, Kamerow DB. Epidemiologic study of sleep disturbances and psychiatric disorders. An opportunity for prevention? *JAMA.* 1989;262(11):1479–1484. http://dx.doi.org/10.1001/jama.1989.03430110069030.
7. Okajima I, Komada Y, Nomura T, Nakashima K, Inoue Y. Insomnia as a risk for depression: a longitudinal epidemiologic study on a Japanese rural cohort. *J Clin Psychiatry.* 2012;73(3):377–383. http://dx.doi.org/10.4088/JCP.10m06286.
8. Amagai Y, Ishikawa S, Gotoh T, et al. Sleep duration and mortality in Japan: the Jichi Medical School Cohort Study. *J Epidemiol.* 2004;14(4):124–128. http://dx.doi.org/10.2188/jea.14.124.
9. Gallicchio L, Kalesan B. Sleep duration and mortality: a systematic review and meta-analysis. *J Sleep Res.* 2009;18(2):148–158. http://dx.doi.org/10.1111/j.1365-2869.2008.00732.x.
10. Daley M, Morin CM, LeBlanc M, Gregoire JP, Savard J. The economic burden of insomnia: direct and indirect costs for individuals with insomnia syndrome, insomnia symptoms, and good sleepers. *Sleep.* 2009;32(1):55–64.
11. Uchiyama M. Impacts of sleep disorders on human social activities and their economic cost. *J Jpn Assoc Psychiatr Hosp.* 2012;31(11):1163–1169.
12. Irwin MR, Olmstead R, Motivala SJ. Improving sleep quality in older adults with moderate sleep complaints: a randomized controlled trial of Tai Chi Chih. *Sleep.* 2008;31(7):1001–1008.
13. Khalsa SBS. Treatment of chronic insomnia with yoga: a preliminary study with sleep? Wake Diaries. *Appl Psychophysiol Biofeedback.* 2004;29(4):269–278.

14. King AC, Oman RF, Brassington GS, Bliwise DL, Haskell WL. Moderate-intensity exercise and self-rated quality of sleep in older adults. A randomized controlled trial. *JAMA*. 1997;277(1):32–37. http://dx.doi.org/10.1001/jama.1997.03540250040029.
15. Kubitz KA, Landers DM, Petruzzello SJ, Han M. The effects of acute and chronic exercise on sleep. A meta-analytic review. *Sports Med*. 1996;21 (4):277–291. http://dx.doi.org/10.2165/00007256-199621040-00004.
16. Reid KJ, Baron KG, Lu B, Naylor E, Wolfe L, Zee PC. Aerobic exercise improves self-reported sleep and quality of life in older adults with insomnia. *Sleep Med*. 2010;11(9):934–940. http://dx.doi.org/10.1016/j.sleep.2010.04.014.
17. Buman MP, King AC. Exercise as a treatment to enhance sleep. *Sleep Biol Rhythms*. 2010;4(6):500–514.
18. Driver HS, Taylor SR. Exercise and sleep. *Sleep Med Rev*. 2000;4(4): 387–402. http://dx.doi.org/10.1053/smrv.2000.0110.
19. Youngstedt SD, Kline CE. Epidemiology of exercise and sleep. *Sleep Biol Rhythms*. 2006;4(3):215–221. http://dx.doi.org/10.1111/j.1479-8425.2006.00235.x.
20. Lauretani F, Russo CR, Bandinelli S, et al. Age-associated changes in skeletal muscles and their effect on mobility: an operational diagnosis of sarcopenia. *J Appl Physiol (1985)*. 2003;95(5):1851–1860.
21. Sanada K, Kuchiki T, Miyachi M, McGrath K, Higuchi M, Ebashi H. Effects of age on ventilatory threshold and peak oxygen uptake normalised for regional skeletal muscle mass in Japanese men and women aged 20-80 years. *Eur J Appl Physiol*. 2007;99(5):475–483. http://dx.doi.org/10.1007/s00421-006-0375-6.
22. Akerstedt T, Knutsson A, Westerholm P, Theorell T, Alfredsson L, Kecklund G. Sleep disturbances, work stress and work hours: a cross-sectional study. *J Psychosom Res*. 2002;53(3):741–748. http://dx.doi.org/10.1016/S0022-3999(02)00333-1.
23. Virtanen M, Ferrie JE, Gimeno D, et al. Long working hours and sleep disturbances: the Whitehall II prospective cohort study. *Sleep*. 2009;32 (6):737–745.
24. Ancoli-Israel S, Cooke JR. Prevalence and comorbidity of insomnia and effect on functioning in elderly populations. *J Am Geriatr Soc*. 2005;53(7 suppl):S264–S271. http://dx.doi.org/10.1111/j.1532-5415.2005.53392.x.
25. Taylor DJ, Lichstein KL, Durrence HH, Reidel BW, Bush AJ. Epidemiology of insomnia, depression, and anxiety. *Sleep*. 2005;28(11): 1457–1464.
26. Ayas NT, White DP, Manson JE, et al. A prospective study of sleep duration and coronary heart disease in women. *Arch Intern Med*. 2003;163(2):205–209. http://dx.doi.org/10.1001/archinte.163.2.205.
27. Tsushita K, Nakamura M, Miyachi M, et al. *Standard health checkup and health guidance programs*. 2014. http://tokutei-kensyu.tsushitahan.jp/manage/wp-content/uploads/2014/05/36ec0bcdf91b61a94a1223627abffe8d.pdf.
28. Buysse DJ, Reynolds CF, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. *Psychiatry Res*. 1989;28(2):193–213. http://dx.doi.org/10.1016/0165-1781(89)90047-4.
29. Cohen J. *Statistical Power Analysis for the Behavioral Sciences*. 2nd ed., Hillsdale, NJ: Lawrence Erlbaum Associates, 1988.
30. Ainsworth BE, Haskell WL, Herrmann SD, et al. Compendium of Physical Activities: a second update of codes and MET values. *Med Sci Sports Exerc. 2011*. 2011;43(8):1575–1581. http://dx.doi.org/10.1249/MSS.0b013e31821ece12.
31. WHO. Global Recommendations on Physical activity for Health. 2010. www.who.int/dietphysicalactivity/factsheet_recommendations/en/.
32. Inoue S, Yorifuji T, Sugiyama M, Ohta T, Ishikawa-Takata K, Doi H. Does habitual physical activity prevent insomnia? A cross-sectional and longitudinal study of elderly Japanese. *J Aging Phys Act*. 2013;21(2): 119–139.
33. Morgan K. Daytime activity and risk factors for late-life insomnia. *J Sleep Res*. 2003;12(3):231–238. http://dx.doi.org/10.1046/j.1365-2869.2003.00355.x.
34. Ohayon MM, Carskadon MA, Guilleminault C, Vitiello MV. Meta-analysis of quantitative sleep parameters from childhood to old age in healthy individuals: developing normative sleep values across the human lifespan. *Sleep*. 2004;27(7):1255–1273.
35. Kessler RC, Barker PR, Colpe LJ, et al. Screening for serious mental illness in the general population. *Arch Gen Psychiatry*. 2003;60(2): 184–189. http://dx.doi.org/10.1001/archpsyc.60.2.184.
36. Ohida T, Kamal AM, Uchiyama M, et al. The influence of lifestyle and health status factors on sleep loss among the Japanese general population. *Sleep*. 2001;24(3):333–338.
37. Ursin R, Bjorvatn B, Holsten F. Sleep duration, subjective sleep need, and sleep habits of 40- to 45-year-olds in the Hordaland Health Study. *Sleep*. 2005;28(10):1260–1269.
38. Hublin C, Kaprio J, Partinen M, Koskenvuo M. Insufficient sleep: a population-based study in adults. *Sleep*. 2001;24(4):392–400.
39. Edwards BJ, Reilly T, Waterhouse J. Zeitgeber-effects of exercise on human circadian rhythms: what are alternative approaches to investigating the existence of a phase-response curve to exercise? *Biol Rhythm Res*. 2009;40(1):53–69. http://dx.doi.org/10.1080/09291010802067072.
40. Youngstedt SD, Kripke DF, Elliott JA. Circadian phase-delaying effects of bright light alone and combined with exercise in humans. *Am J Physiol Regul Integr Comp Physiol*. 2002;282(1):R259–R266.
41. Unruh ML, Redline S. An MW, et al. Subjective and objective sleep quality and aging in the sleep heart health study. *J Am Geriatr Soc*. 2008;56(7): 1218–1227. http://dx.doi.org/10.1111/j.1532-5415.2008.01755.x.
42. Statistics Bureau, Ministry of Internal Affairs and Communications. *Population 15 years old and over by age group and educational level*. 2011. www.stat.go.jp/english/data/nenkan/1431-02.htm.

Appendix

Supplementary data

Supplementary data associated with this article can be found at http://dx.doi.org/10.1016/j.amepre.2014.12.006.

活動報告

宮城県石巻市「大橋メンズクラブ」における体組成，下肢筋機能，歩数評価を活用した活動支援

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はじめに

2011(平成23)年3月11日に発生した東日本大震災により宮城県石巻市は甚大な被害を受け，2015(平成27)年1月時点でもなお1万2585人(5812戸)もの住民が応急仮設住宅での生活を余儀なくされている[1]。これは，石巻市の人口約15万人の1割弱に相当する。

仮設住宅での生活は，物理的かつ社会的に行動範囲を狭小化させ，身体面と精神面のいずれの健康状態にも悪影響を及ぼしかねない。とくに男性において注意すべき健康問題に，孤独死とアルコール依存がある[2]。

阪神淡路大震災後の応急仮設住宅で孤独死が確認された217人のうち151人(69.6%)が男性であった[2]。さらに，死因が肝疾患であった45人のうち42人(93.3%)は男性であり，その67.7%がアルコール性であった[2]。

同震災後の仮設住宅で飲酒量が増加した男性の特徴を検証した報告[3]では，「毎日の楽しみがない」「外出することが少ない」「近所との付き合いが少ない」など，いわゆる社会から孤立した状況にある者の割合が高かった。

石巻市の仮設住宅においても，入居が始まり間もなくして同様の問題が見受けられるようになっていた。この状況を改善すべく講じた一手が，石巻市，宮城県看護協会，訪問支援員らが主催して開催した男性限定健康教室「大橋メンズクラブ」であった。

地域で健康教室を開催すると，男性参加者がきわめて少ない，もしくはゼロであるというケースは珍しくない。そこで，はじめから対象者と活動内容を男性向けに限定することで，男性の興味を惹きつけやすくする，女性との交流が苦手な男性でも参加しやすくなるなどのメリットが生じると主催者らは考えた。さらに，主催者側にとっても，男性特有の問題に効率的にアプローチできる利点もある。

筆者らはこの活動の運動面の支援者として携わり，運動指導を行うとともに，測定評価を大いに活用した支援(以下，本支援)を試みた。男性は，論理的な思考が得意な者が多いとされるため[4]，データをもとに自身で納得することで，クラブ参加や運動への意欲が増進されると考えた。そこで，クラブ活動を通して変化が期待される体組成，下肢筋機能，ならびに毎日の歩数の評価を行った。

本稿では，その取り組みについて報告するとともに，本支援が男性参加者の身体的特徴および運動意欲や習慣にいかなる効果をもたらしたのかをまとめた。

活動支援の内容

大橋メンズクラブの概要

大橋メンズクラブ(以下，本クラブ)は，石巻市大橋地区仮設住宅(以下，仮設大橋団地)に入居している男性を対象とし，石巻市，宮城県看護協会，訪問支援員が主催する健康教室である。会場は仮設住宅団地内の集会所とした。

仮設大橋団地は，市の中心地(市役所，石巻駅)から北東約1kmに位置し，市内で最大規模の仮設住宅団地である。本クラブは2012(平成24)年7月に開始し，2015年3月時点でも継続されている。本クラブの設立の背景や活動経緯の詳細は引用資料[5]を参照されたい。

各種評価を活用した支援(2013年度)

本クラブ設立当初の目的である，閉じこもりやアルコール依存の予防とともに，2013(平成25)年度は運動に取り組む時間を多く確保し，身体機能の維持・向上や肥満予防が主要な目的に加えられた。これに伴い，それらの活動への意欲を高め，得られる効果を最大化することをねらいとして，2013年7月から，体組成，下肢筋機能，歩数の定期的な測定評価を活用した活動支援を行うこととした。

2013年度の活動支援の内容

2013年度の主な活動内容を表1に示した。本支援を開始した7月から，クラブ活動の頻度をこれまでの月1回から月2回へと増加させた。1回あたりの活動時間は90〜120分間とした。運動を中心とする13回と食事栄養(調理実習)の3回，計16回のクラブ活動が期間中に開催された。

運営スタッフは，主催者である市の栄養士および保健師，県看護協会員，訪問支援員，ならびに支援者である著者らや地域の運動ボランテ

表1　大橋メンズクラブの活動スケジュール

回	開催日	主な活動内容
1	2013年 7月25日	・支援活動についての説明，質疑応答 ・体組成，立ち上がり測定 ・ラジオ体操，玄米ダンベル体操，ロコモ体操 ・活動量計の使用，記録法についての説明 ・茶話会
2	8月 8日	・体組成，立ち上がり測定 ・ラジオ体操，玄米ダンベル体操，ロコモ体操 ・茶話会
3	8月29日	・男の料理教室(おくずかけ，いなりずし)
4	9月12日	(第2回と同様)
5	9月26日	・体力測定会(体組成・立ち上がり測定を含む)
6	10月11日	(第2回と同様)
7	10月24日	・健康講話(お口の健康) ・体組成，立ち上がり測定 ・ラジオ体操，玄米ダンベル体操，ロコモ体操
8	11月14日	(第2回と同様)
9	11月28日	・健康講話(ストレスと上手に付き合うには) ・体組成，立ち上がり測定 ・ラジオ体操，玄米ダンベル体操，ロコモ体操
10	12月17日	・クリスマス会 ・男の料理教室(カレー，サラダ，シュークリーム) ・ゲーム，余興など
11	2014年 1月 9日	(第2回と同様)
12	1月23日	・体組成，立ち上がり測定 ・スクエアステップ ・ラジオ体操，玄米ダンベル体操，ロコモ体操
13	2月 6日	(第12回と同様)
14	2月18日	・男の料理教室(たこ焼き) ・体組成，立ち上がり測定
15	3月13日	・体組成，立ち上がり測定 ・ラジオ体操，玄米ダンベル体操，ロコモ体操 ・これまでの測定結果のまとめ，報告
16	3月27日	・反省会(1年間の振り返り，次年度に向けて) ・体組成，立ち上がり測定

ィアなど，毎回計 10 名前後で構成された。

体組成，下肢筋機能の測定評価は，調理実習の 2 回を除く計 14 回行った。参加者が来場し，問診，体調チェックを受けた後に実施した。

運動の回では，ウォーミングアップとしてラジオ体操を行った後，主運動としてダンベル体操ならびにオリジナル体操(ロコモ体操)を実践した。

玄米 300 g を詰めたダンベルを使用する「玄米ダンベルニギニギ体操」[6,7] は，12 ポーズから構成され，上肢体幹の筋群を満遍なく活動させると同時に，常に浅いスクワットの姿勢を維持しながら行うことで，下肢筋群の強化にもつながる運動である。ロコモ体操[8] は，その名のとおりロコモティブシンドロームの予防改善をめざしたものであり，軽快な音楽に合わせて片足立ちや全身運動を行う。手を取り合うパートがあるなど，楽しみながら交流を深めることにも役立つ。

1 月からはスクエアステップ[9,10] を取り入れた。升目で区切られたマットの上を，あらかじめ記憶した順序にステップするこの運動は，下肢筋機能と認知機能の向上に寄与する[9,10]。また，参加者同士で教え合う機会が自然と生まれ，交流を深めるきっかけにもなる。

これらの運動を約 60 分間行った後，茶話会を開いた。参加者同士の近況報告などの雑談，今後の活動に対する意見交換，各種測定についての質疑応答や表彰など，和気あいあいと過ごす時間を設けた。

●体組成評価

マルチ周波数体組成計(MC-980A，タニタ)を用い，体重，全身筋量，脚部筋量，体脂肪量(kg)を測定した。測定値が標準範囲に照らしてどの水準なのかを示した返却票が直ちに印刷される。これをもとに支援者が参加者に対し，クラブ活動や日常生活での心掛けについてのコメントを添えて返却した。また，測定値の推移を示したグラフを作成し可視化することで，参加者がこれまでの食習慣や運動習慣を振り返るきっかけを与えるとともに，今後の活動に対する意欲の維持・増進をねらった。

●下肢筋機能評価

改良型体重計(BM-101，タニタ)を用い，その上で椅子立ち上がり動作を行わせた際の地面反力を測定し，下肢筋機能評価を行った。本評価法は，簡便かつ短時間で測定実施が可能であるとともに，椅子立ち上がり動作という日常生活動作遂行中の筋力発揮を評価できる新たなフィールドテストである[11]。

このたびの活動では，地面反力の最大値体重比(体重の何倍の力で踏み込んだかを評価する。単位は $kgf \cdot kg^{-1}$)と，最大増加率体重比(踏み込む力の発揮の素早さを評価する。単位は $kgf \cdot s^{-1} \cdot kg^{-1}$)の 2 項目を評価した。これらは，高齢者における等尺性膝伸展筋力，起居移動動作の遂行能力や転倒経験と関連することが報告されている[11,12]。測定結果は，これまでの推移を示す折れ線グラフに 5 段階評価を添えて書き加え，スタッフによる褒めや励ましのコメントとともに返却した。

●歩数評価

毎日の歩数を活動量計(HALND，タニタ)により調査した。起床から就寝まで(入浴などの水中活動時間を除く)の間，活動量計をズボンのポケットに入れるよう指示した。データは活動量計に記録され，クラブ参加時にコンピューターに吸い出した。また，参加者が歩数の増加に意欲的に取り組めるように，以下の仕掛けを行った。

まず，参加者 1 人ひとりの取り組みとして，石巻から東京までの約 400 km の踏破をめざす「そうだ東京へ行こう！」と題した記録票を配布し，自身で毎日記録をつけるように促した。その旅路の途中には名所や名物が紹介されており，楽しみながら歩を進められる工夫を凝らした。また，たくさん歩いている人を表彰し，自己効力感を高めたり競争意識を刺激したりする試みを取り入れた。

さらに，参加者全員での取り組みとして，活動量計により目安として算出される脂肪燃焼量の値を積算し，37.76 kg(当時，富士山の世界遺産登録が話題になったことにちなむ)をめざすという取り組みを行った。皆で 1 つの目標をめざすことで連帯感を生み出すことをねらいとした。

●支援内容に対するアンケート調査

各種測定評価を行ったことで，“クラブへの参加意欲”ならびに“毎日の運動習慣”についての変化を尋ねる無記名のアンケート調査を，最終回に行った。測定項目ごとに，参加意欲と運動習慣それぞれに対して「とても増した(10)」から「変化なし(5)」「とても減った(0)」までの 11 段階のスケールで尋ねた。また，そのように回答した理由を，測定項目ごとに自由記述で求めた。

●統計解析

本支援を行った 8 か月間のうち，6 か月間以上の追跡データを有する者を，測定値の推移を算出する対象者とした。体組成および下肢筋機能評価については，0，2，4，8 か月時点での測定値を，繰り返しのある一要因分散分析により比較した。指定した時点でのデータが欠損している場合は，直近に得られた値を代入した。

歩数の推移は，装着日 1 日あたりの平均歩数を月ごとに算出した。毎日の歩数が体重と体脂肪量の変化に及ぼす影響を検証するため，支援期間中の平均歩数をもとに 2 分位し，支援期間中の体重と体脂肪量の変化量を t 検定により比較した。解析には，SPSS Statistics 20 (IBM，NY，USA)を用いた。有意水準は危険率 5% とした。

表 2　6 か月間以上の追跡データを有する 14 名の基本情報

項目	平均値(標準偏差)	範囲
年齢(歳)	69.9 (7.2)	54～81
身長(cm)	163.6 (4.2)	158.0～172.5
体重(kg)	61.3 (7.7)	45.4～75.3
BMI(kg/m^2)	23.0 (3.1)	15.3～27.0
体脂肪量(kg)	13.7 (4.6)	6.6～22.0
全身筋量(kg)	45.1 (4.2)	36.7～55.1
脚部筋量(kg)	14.9 (1.6)	11.8～19.0
最大値体重比($kgf \cdot kg^{-1}$)	1.48 (0.11)	1.30～1.66
最大増加率体重比($kgf \cdot s^{-1} \cdot kg^{-1}$)	11.4 (1.8)	8.1～15.4

本支援の開始に先立ち，主催者および参加者に対し，支援内容の説明を書面ならびに口頭で行い，実施の承認を得た。また，参加者に対して，本測定への参加は自由意思であること，参加を拒否しても一切の不利益を受けないこと，得られた個人情報は保護されることを口頭で伝え，理解を得た者が各測定に参加した。

活動支援の成果

■大橋メンズクラブの参加状況

本支援の期間中，計 27 名(54～83 歳)の参加者が 1 回以上参加した。1 回あたりの測定参加人数は 6～15 名であった。6 か月間以上の追跡データが得られた参加者は 14 名であった。彼らの初回測定の結果を表 2 に示した。

■各測定値の推移

●体重，体組成

14 名の体重，体脂肪量，全身筋量，脚部筋量の推移を表 3 に示した。8 か月間で有意な変化は見られず，いずれも維持が確認された。

表３　体重，体組成測定値の推移と変化量（14 名）

項目	経過月	平均値（標準偏差）	P^{a}
体重（kg）	0 か月	61.3　(7.7)	0.56
	2 か月	61.9　(7.7)	
	4 か月	61.9　(7.7)	
	8 か月	62.0　(8.2)	
	変化量[b]	＋0.7（−3.7〜＋6.7）	
体脂肪量（kg）	0 か月	13.7　(4.6)	0.24
	2 か月	14.1　(4.4)	
	4 か月	14.5　(4.2)	
	8 か月	14.2　(4.8)	
	変化量[b]	＋0.5（−3.3〜＋2.3）	
全身筋量（kg）	0 か月	45.1　(4.2)	0.66
	2 か月	45.3　(4.4)	
	4 か月	44.9　(4.4)	
	8 か月	45.3　(4.6)	
	変化量[b]	＋0.2（−1.8〜＋5.7）	
脚部筋量（kg）	0 か月	14.9　(1.6)	0.53
	2 か月	15.1　(1.7)	
	4 か月	14.8　(1.7)	
	8 か月	15.1　(1.9)	
	変化量[b]	＋0.2（−1.0〜＋3.4）	

a：繰り返しのある一要因分散分析
b：8 か月間の平均変化量（最小値〜最大値）

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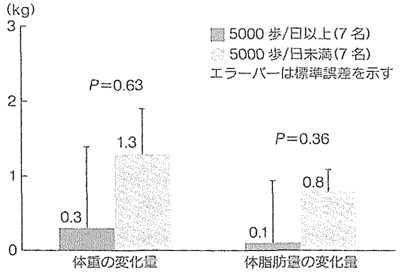
支援期間中の１日あたりの平均歩数により２分位（5000 歩以上 vs. 未満）し，８か月間の体重，体脂肪量の変化量を比較した（図１）。その結果，5000 歩以上であった者において，体重と体脂肪量の増加が抑制される傾向が見られた。

図１　平均歩数別の，８か月間の体重・体脂肪量の変化量の比較（対応のない t 検定による）



◎下肢筋機能

椅子立ち上がり動作時の地面反力（床を踏み込む力）の最大値体重比と最大増加率体重比の推移を図２に示した。最大値体重比で有意な増加が確認された（$p=0.02$）。最大増加率体重比では有意な変化は見られなかった（$p=0.26$）。

◎歩数

参加者ごとの各月１日あたりの歩数を，平均１日あたり 5000 歩以上（7 名），未満（7 名）別に図３に示した。14 名全員の１日あたり平均歩数の推移は，6209（7・8 月）→ 7039（9 月）→ 6152（10 月）→ 5163（11 月）→ 5257（12 月）→ 6894（1 月）→ 5921（2 月）→ 4898（3 月）歩であった。

図２　椅子立ち上がり動作時の地面反力測定による下肢筋機能評価の推移（繰り返しのある一要因分散分析による）

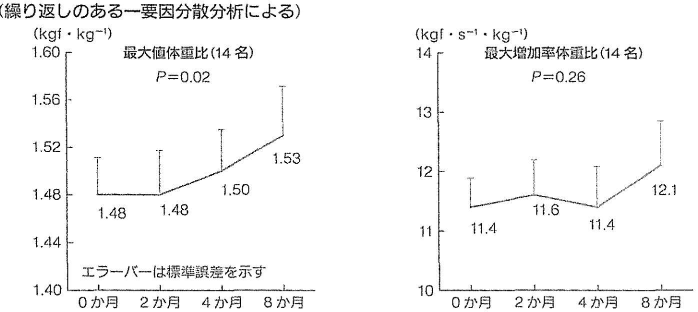


図３　月ごと１日あたりの平均歩数の推移（太線：群内平均，各細線：個人推移）

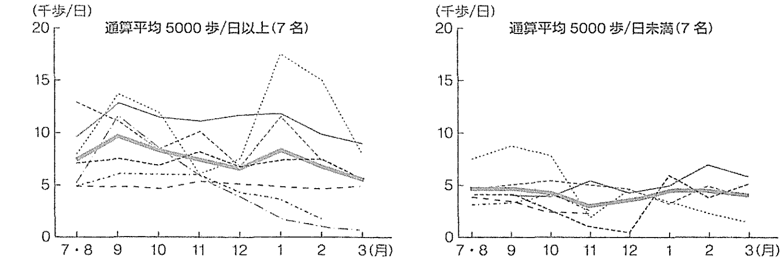
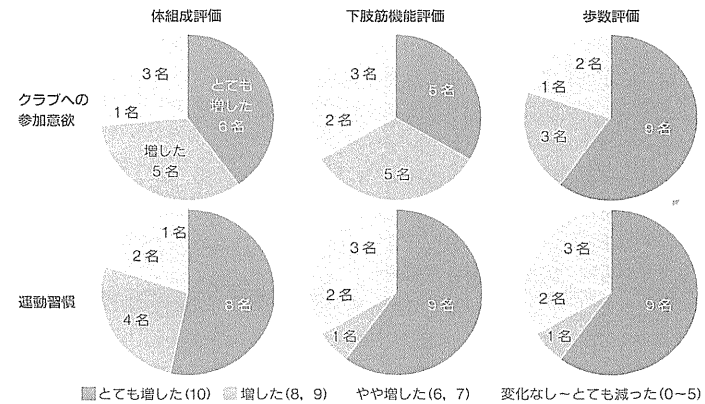


図４　各測定評価が，参加者のクラブへの参加意欲，運動習慣に及ぼした影響



◎支援内容に対するアンケート調査

15 名から有効回答を得た。定期的に各種測定評価を行ったことが，クラブへの参加意欲と毎日の運動習慣に与えた影響を，図４に示した。また，そのように感じた理由や感想についての自由記述を表４に列挙した。

活動の評価

■各測定項目から

各種測定評価を活用した８か月間の活動支援により，下肢筋機能評価項目である，椅子立ち上がり動作時の地面反力の最大値体重比の向上が確認された。この効果は，主運動として提供したダンベル体操やロコモ体操，スクエアステップなどへの継続的な取り組みや，日常生活における歩数の増加など，筋の活動性が高まった

表4　支援に対する意見や感想(自由記述)

サークル活動全般に関して
- 定期的に集まることはとてもよい。
- 仲間ができ，よかった。
- 健康について考えるきっかけが増えた。
- こういうのをやるべきだ。
- 腰が痛く，測定や運動に思うように参加できなかった。

体組成測定
- 長い間やっていると，自分の筋力など，よくなっているという感じがわかる。
- 自分の体をきちんと見つめ直すきっかけになった。
- 肥満を改善することができ，うれしい。
- 数値をよく保ちたい。自分の体のためになる。
- 変化を確認できるので，大変頑張れる。

立ち上がり測定
- もっと筋力をつけたいと思った。測定があると思うと意欲的になる。
- 足のばねが上がった。
- 大きく変化はなかったが，よい取り組みだった。楽しかった。
- 瞬発力をつける運動に興味をもった。

活動量計
- 必ず歩くという気持ちになり，少しの時間でも歩いたり動いたりするようになった。
- よい習慣ができ，うれしく思う。
- 毎日1歩でも多く歩くように気をつけるようになった。
- 仲間との競争意識が芽生えた。仲間との話が弾む。
- 継続したいと強く思っている。

ことに伴う神経筋系の機能の改善によるものと推察される[13]。すなわち，眠っていた筋線維を呼び起こしたことが期待される。

なお，平均値1.48→1.53 kgf･kg^{-1}の変化がもつ意味を考察する。地域在住の男性高齢者160名(平均年齢74.1歳)の平均値は1.46 kgf･kg^{-1}と報告されている[11]。また，本クラブの参加者の初回測定値は上記の報告における第3五分位に該当し，すなわち平均的な水準であった。8か月後の1.53 kgf･kg^{-1}は第4五分位へと1段階上がり，起居移動動作能力の制限を有する可能性が約10%低下したこととなる[11]。このような客観的な測定値の変化と，アンケートの回答に見られる「足のばねが上がった」などの自覚的な認識とが結びつくことで，参加者が運動に対する意欲や自己効力感を一層高めたことが期待される。

体重，体脂肪量，筋量に有意な変化は見られず，維持が確認された。宮城県が2013年9～11月に実施した応急仮設住宅入居者を対象とした調査[14]では，男性50歳台の21.5%，60歳台の22.1%，70歳台の19.5%が過去1年間の体重増加を(同10.7%，12.5%，18.1%が減少を)自覚している。すなわち，本クラブの参加者は体重増加の可能性が高い者が多かったと推察される。その状況下で平均値として維持が確認できたことは，定期的な体組成評価や歩行量の増加を促した支援内容が奏功したと判断できる。支援期間中に歩数を多く確保できた者は，体重や体脂肪量の増加が抑制される傾向を示していたことも，その点を支持する。また，70歳台前半の男性では脚部筋量が1年あたり約1%減少するとされる[15]。その上，仮設住宅での不活動状態が長引けば，その減少率はさらに急速となりえただろう。

平均歩数と参加者の声

参加者の平均歩数は，9月が最多の1日あたり7039歩であり，3月が最少の4898歩であった。岩手県釜石市の仮設住宅における2011年10～11月の調査結果(4521歩)[16]と比較して全期間で上回っていることが確認され，本支援が歩数の増加に寄与したことが示唆された。活動量計の配布と併せて，仲間との競争意識や協力意識を刺激し，楽しみながら歩数を増やせる仕掛けを講じたことが奏功した。

実際の参加者との関わりの中でも，「ユニークな記録票が励みになる」「表彰状をもらえて嬉しい」との声が多く聞かれた。しかしながら，寒冷地という地域特性の影響を受けたことも予想され，平均歩数の最多を記録した9月以降は減少傾向を示した。その状況の中でも，活動量計で算出される目安の脂肪燃焼量を全員で積算する取り組みでは，目標達成間近の1月に1日あたり7000歩近くまで再増加し，この取り組みの効果がデータにも表れた。

ただし，本支援がすべての参加者に受容されたとは言えない点に改善の余地がある。活動量計の装着や記録が億劫であるという参加者が少ないながらも見られ，冬以降に装着の習慣が無くなる者も見られた。また，自転車が主な移動手段であるが，それが反映されなくて残念との声もあった。このような参加者には，必要に応じて個別の対応が求められる。

アンケート調査から見えてきたもの

支援内容に関するアンケートでは，各種測定評価は大半の参加者にとって，クラブへの参加意欲や毎日の運動習慣に好影響を与えたことが確認された。測定結果を評価してフィードバックすることは「学習者を活気づける動機づけ」「正しい行為を繰り返す強化」「修正を行うための基準としてのエラー情報」の機能をもつとされる[17]。参加者からは「自身の状況を振り返るきっかけとなった」「変化を数値として確認できた」などの意見が聞かれ，筆者らが本支援を通して狙っていた効果が表れた。

一方，いずれの評価項目においても1～3名は，「参加意欲や運動習慣に変化がなかった」もしくは「減った」と回答していた。その理由として「腰痛のため，思うように測定に参加できなかった」との回答や，「他人より劣っている状況を知る・知られるのが嫌だ」などの声も聞かれた。本支援における測定への参加は強制ではなく本人の自由意思としたが，多数が積極的に参加する状況において，参加できない・しない者は引け目を感じていたかもしれない。今後は，これらの参加者も積極的にクラブへ参加したいと思わせる工夫を考える必要がある。

おわりに

体組成，下肢筋機能，歩数の定期的な評価は，本クラブ参加者の下肢筋機能の向上や，体重，体脂肪量，筋量の維持，歩数の増加に寄与することが示唆された。また，このような評価を活用した取り組みは，男性中年・高齢者のクラブ参加や身体活動意欲の増進に好影響を与えることを確認した。

最後に，本報告が仮設住宅における支援に留まらず，全国各地の介護予防事業などにおける健康教室にて男性参加者を募り，高い効果と満足度とを両立させた教室運営に大いに役立つことを期待する。

本支援活動は，大橋メンズクラブ主催者である石巻市健康推進課，公益社団法人宮城県看護協会，訪問支援員の皆様のご理解ご協力のもとに実施することができました。また，NPO法人健康応援・わくわく元気ネットの金澤明様，現地の運動ボランティア「スマイルダンベルクラブ」の皆様には，運動指導，各種測定にて多大なるご協力を賜りました。皆様への深甚なる謝意を表します。そして何より，私たちをいつも笑顔で出迎え，さまざまな測定や調査にご協力戴いた大橋メンズクラブ参加者の皆様に万謝いたします。

本支援活動は，筑波大学復興・再生支援プログラム「被災地高齢者の心と体を元気にする運動プログラム開発と普及のための人材養成プログラム」の一環として実施した。

文献

1）石巻市：東日本大震災からの復興―最大の被災都市から世界の復興モデル都市を目指して．2015．http://www.city.ishinomaki.lg.jp/cont/10181000/8235/20140624130932.html(2015/3/16確認)
2）上野易弘：「孤独死」の中のアルコール問題．日本アルコール・薬物医学会雑誌，33(4)：406-407，1998．
3）高鳥毛敏雄：都市住民男性の飲酒習慣ならびに飲酒量増加に関する要因―大震災後の応急仮設住宅入居者における分析．日本公衆衛生雑誌，48(5)：344-355，2001．
4）Ingalhalikar M，Smith A，Parker D，et al.：Sex differences in the structural connectome of the human brain．Proc Natl Acad Sci U S A，111(2)：823-828，2014．
5）内閣府男女共同参画局：東日本大震災からの復興に関する男女共同参画の取組状況調査(ヒアリング調査結果)―仮

設住宅での男性向け健康教室の開催(大橋メンズクラブ), 宮城県石巻市. 27-32, 2013.
http://www.gender.go.jp/policy/saigai/report2012FY/pdf/hearing_jirei05.pdf(2015/3/16 確認)
6) 鈴木玲子：玄米ダンベルニギニギ体操. 社会保険出版社, 2013.
7) 鈴木玲子：ダンベル体操によって期待できる効果にはどんなことがありますか. 社会保険研究所, 2014.
8) 佐々木信之, 鈴木玲子：ロコモ体操. 社会保険出版社, 2014.
9) 大藏倫博, 尹智暎, 真田育依ほか：新転倒・認知症予防プログラムが地域在住高齢者の認知・身体機能に及ぼす影響—脳機能賦活を意図した「スクエアステップ」エクササイズの検討. 日本認知症ケア学会誌, 9(3)：519-530, 2010.
10) Shigematsu R, Okura T, Nakagaichi M, et al：Square-stepping exercise and fall risk factors in older adults：a single-blind, randomized controlled trial. J Gerontol A Biol Sci Med Sci, 63(1)：76-82, 2008.
11) 辻大士, 三ッ石泰大, 角田憲治ほか：地域在住高齢者を対象とした椅子立ち上がり動作時の地面反力と身体機能, 転倒経験, 転倒不安, 起居移動動作能力との関連性. 体力科学, 60(4)：387-399, 2011.
12) 中谷敏昭, 上英俊：椅子からの立ち上がり動作を利用した下肢筋力評価法. 体力科学, 53(1)：183-188, 2004.
13) Hakkinen K, Alen M, Kallinen M, et al：Neuromuscular adaptation during prolonged strength training, detraining and re-strength-training in middle-aged and elderly people. Eur J Appl Physiol, 83(1)：51-62, 2000.
14) 宮城県：平成25年度応急仮設住宅(プレハブ)入居者健康調査結果. 2014.
http://www.pref.miyagi.jp/soshiki/kensui/25purehabu.html(2015/3/16 確認)
15) Goodpaster BH, Park SW, Harris TB, et al：The loss of skeletal muscle strength, mass, and quality in older adults：the health, aging and body composition study. J Gerontol A Biol Sci Med Sci, 61(10)：1059-1064, 2006.
16) 村上晴香, 吉村英一, 髙田和子ほか：東日本大震災被災者健康調査の質問票における身体活動関連項目の妥当性および再現性の検討. 日本公衆衛生雑誌, 60(4)：222-230, 2013.
17) 澁谷智久, 中村剛, 中島宣行：フィードバックを用いた情報処理活動の活性化が運動学習に及ぼす影響. 順天堂大学スポーツ健康科学研究, 7：80-84, 2003.

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【Brief Communication】

Domains of physical activity and self-reported health

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Introduction

Physical activity (PA) can be achieved through various domains such as leisure-time, travel and occupational PA. Although PA provides numerous health benefits, the effects of individual PA domains may differ. For example, some studies[4,6)] reported that spending an extended period of time engaged in occupational PA was linked with mental distress, whereas they confirmed the positive association between leisure-time PA and mental status. Additionally, Wanner et al.[10)] confirmed a longevity effect with leisure-time PA but not with work-related PA. However, the health benefits associated with non-leisure time PA, such as travel, household activity and work PA, are still uncertain, and there may be a positive association between non-leisure-time PA and other beneficial health-related outcomes.

Self-reported health is a simple and powerful indicator of physical and psychological health,[8)] and it can also predict mortality.[3)] An Estonian study,[5)] found a positive association between leisure-time PA and self-reported health, and a negative association between work PA and self-reported health. However, the study was limited only to women. Additionally, findings from western populations are not always applicable to Japanese people.

The purpose of this study is to investigate whether there are associations between individual PA domains and self-reported health in Japanese men and women.

Methods

A. Participants and data collection

Data were gathered at health check-ups conducted in Meiji Yasuda Shinjuku Medical Center in Shinjuku Ward, Tokyo, Japan. The majority of participants were employees and their spouses, with employers providing financial support for the annual health check-ups. We obtained 13498 examinees' data from May 2013 to March 2014. Of these people, 2630 individuals were excluded due to incomplete data, leaving 10868 men and women for the data analysis. All participants provided informed consent. The Ethical Committee of Meiji Yasuda Life Foundation of Health and Welfare approved this study (Approval number: 25005).

B. Measurement variables

1. Physical activity

We assessed PA with the long version of the International Physical Activity Questionnaire (IPAQ).[1)] The IPAQ evaluates PA in a typical week in segments of at

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least 10 minutes and 3 metabolic equivalents (METs). The IPAQ considers the following 4 domains: leisure-time, household, travel and work PA. In each PA domain, we categorized participants as either not engaging, or engaging at less than 5.0 MET-h/wk, at 5.0 to 9.9 MET-h/wk or at 10.0 or more MET-h/wk. Additionally, as basic information, we made 4 categories for total PA: less than 10.0 MET-h/wk, 10.0 to 19.9 MET-h/wk, 20.0 to 29.9 MET-h/wk and 30.0 or more MET-h/wk.

2. Self-reported health

To assess self-reported health, participants responded to the question "Overall, how would you rate your health during the past month?" on a 6 point Likert scale (excellent, very good, good, fair, poor and very poor) by referencing the SF-8 health survey.[2] For analysis, we coded the responses of self-reported health into binary variables: excellent, very good and good were coded as good; and fair, poor and very poor were coded as poor.

3. Other variables

Demographic variables included age, gender, body mass index (BMI), education years, economic status (very good, good, poor and very poor), living arrangement (alone or living with someone), working status (engaging or not engaging), alcohol consumption (never, < 20.0 grams/day and ≥ 20.0 grams/day), smoking status (never, former and current), meat and green/yellow vegetable intake (never or seldom, once every two days and one or more times per day). We determined all demographic variables except BMI through a self-administered questionnaire.

C. Statistical analysis

Analyses were conducted by gender. We confirmed gender differences in characteristics using chi-squared tests for categorical variables and the Student's t-test for continuous variables. Logistic regression analysis was used to confirm the associations between PA domains and self-reported health. The odds ratios (ORs) and 95% confidence intervals (95% CIs) were adjusted by age, BMI, education years, economic status, living arrangement, working status, alcohol consumption, smoking status and meat and vegetable intake. Additionally, we entered the four domains of physical activity simultaneously into the model to adjust for their effects on each other as covariates. We used SPSS 21.0 for statistical analysis with the level of significance set at $P < 0.05$.

Results

Table 1 shows characteristics of participants. The rate of self-reported poor health was higher in women (32.2%) than in men (27.7%). Men were more likely to engage in leisure-time and work PA compared with women, whereas women engaged in household PA at a higher rate than men.

Table 2 presents the associations between PA domains and self-reported health. In both men and women, higher levels of leisure-time PA were associated with a lower rate of self-reported poor health. However, men who engaged in 10 or more MET-h/wk of work PA were more likely to report poor health compared with men who did not engage at this level of work PA. Similarly, in women there was a significant linear trend between higher levels of work PA and a higher rate of poor health. Women were also more likely to report poor health when they engaged in 1 to 9 MET-h/wk of travel PA. There was no association between household PA and self-reported health in either men or women. Higher levels of total PA were associated with a lower rate of self-reported poor health in both men and women.

Discussion

This study investigated the association between PA domains and self-reported health. Although increasing leisure-time PA corresponded with a decreasing rate of poor health in both men and women, higher levels of travel PA in women and work PA in both men and women were associated with a higher rate of perceived