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New Evidence on predictable validity of grip strength on later outcomes in Japan*

by

Midori Matsushima, Satoshi Shimizutani and Hiroyuki Yamada**

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This study provides new evidence on predictable validity of grip strength on later life outcomes using a population based longitudinal survey for the middle and older generations in Japan. We show level of grip strength contains significant information on health outcome or mortality in subsequent years although the loss of grip strength does not. Moreover, we confirm that grip strength is associated with socio-economic status, particularly educational attainment.

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1. Introduction

Hand grip strength is a widely used as objective and inexpensive measure to predict health outcome and mortality in later years (Lantanen et al. 1999, Bohannnon 2008 for review). A large volume of research have validated predictive information of grip strength on mortality (Lantanen et al. 2003; Leong et al. 2015; Syddall et al. 2016; Ling et al. 2010; Oksuzyan et al. 2010; Hirsch et al. 2012), cognitive decline (Alfaro-Acha, et al. 2006) or functional decline (Taekema et al. 2010). Another line of research examined an association between grip strength and socio-economic status (SES); grip strength is significantly associated with wealth in continental Europe (Hairi et al. 2010) and long-term country-level inequality in U.S. and European countries (de Vries et al. 2014).

In contrast, research on grip strength has been scarce in Japan except two studies. Sasaki et al. (2007) showed that the grip strength is a valid predictor for all causes of mortality more than 20 years after the Atomic Bomb Survivors in Hiroshima. Ishizaki et al. (2011) showed that hand grip strength declined at significantly higher speed for men than women in a small village in northern Japan.[1] If grip strength contains predictable information on later life in Japan as well, this is useful to measure a component of future which may affect current economic decision. This study contributes to the literature by providing the first population-based evidence on the predictability of grip strength in Japan.

2. Data

The data used in this study is Japanese Study on Aging and Retirement (JSTAR)

[1] Rantanen et.al. (1999) examined the data on Japanese-American males who lived in Hawaii. Frederiksen et.al. (2006) describes age profile of grip strength among the Dutch by attributes.

which is a longitudinal data on the middle and older generations in Japan.[2] The base line is individuals who were aged 50-75 randomly chosen on household registration in selected municipalities. Respondents in the survey is interviewed every two year. JSTAR started to collect data in five municipalities in 2007 and conducted a second survey for those respondents as well as new respondents in two municipalities in 2009. Moreover, the survey performed the third wave those respondents as well as new respondents in three municipalities in 2011-12. Those respondents were surveyed in 2013 too. The total sample size at baseline is approximately 5,800. In addition to a wide variety of variables on health, economic, employment, family aspects, grip strength was measured using a handheld dynamometer (Smedley type) in the dominant hand in interview.

3. Empirical analysis

3.1 Grip strength and later life health outcomes

The basic specification is described as follows.

(1) $Y_{i2013} = \beta Grip_{i2011,2009,or\ 2007} + \gamma X_{i2011} + \varepsilon_i$

where dependent variable, Y_{i2013}, is health outcomes in 2013; mortality, functional ability and cognitive ability. "Mortality" is binary to take 1 for respondents who deceased due to illness between 2011 and 2013 and 0 otherwise. Functional ability consists of two measures; "mobility" is binary to take 1 for respondents who has one or more difficulty in ADL (Activities of Daily Living) and 0 otherwise, and IADL (Instrumental Activities of Daily Living) in terms of standardized sum of "capable" items. Cognitive ability is

[2] JSTAR is a Japanese counterpart of Health and Retirement Study (HRS) in the US. See Ichimura, Hashimoto and Shimizutani (2009) for the procedure to measure grip strength.

measured by the standardized sum of correct answers in the instant word recall in interview.

Turning to the covariates, the main variable is grip strength measured in kilogram at two, four or six year prior to the timing of outcome variables ($Grip_{i2011,2009,or\ 2007}$). Other covariates ($X_{i2011}$) include age of respondents, educational attainment, housing, smoking behavior, and number of chronic illnesses as well as municipality of residence. In our analysis, we limit our analytical sample to the ones aged between 60 and 80 in 2013 who have responded to all questions we use in our regression analysis. The number of observation sample becomes to 1618 (male) and 1715 (female) though the number depends on the variables used in a regression. The summary statistics of those variables is presented in Appendix. The regressions run separately for males and females and standard errors are clustered at municipal level.

Table 1 shows the estimated coefficients. We focus on those on the main variable. For males, grip strength predict all health outcomes with 2 year interval; a 1kg increase in grip strength is associated with 0.1% point decrease in probability of death from illness, 1.0 % point decrease in having mobility problems, 0.01 standard deviation increase in IADL, and 0.01 standard deviation increase in cognitive ability score. This is also the case for the effect with 4 year interval though the coefficient is not significant for cognitive ability. In contrast, the signs of the coefficients with 6 year interval are expected one but not significant. For females, the coefficients on grip strength is negative and significant except mortality. The coefficients are significant and hold expected signs in mobility and IADL with 4 year interval, though the coefficients are not significant for mortality or cognitive ability. The pattern in the coefficients is same for those with 6 year interval.

Overall, the effect of grip strength on later health outcomes is expected, significant especially with a shorter interval and pronounced in mobility/IADL. In particular, level of grip strength can play a role as a predictor of health outcomes for male in Japan. While we do not perform direct comparison, the size of the impact is similar to Sasaki et al (2017) and seems to be somewhat smaller than that found in international study (Leong et. al. 2015). Our further analysis, the effect of changes in grip strength, did not show statistically significant association with any outcome variable (results not shown).

3.2 Grip strength and SES

Next, we examine relationship between socio-economic status and grip strength. We include age, education attainment, a house ownership dummy as a proxy of wealth status, a dummy of atomic bomb survivors in Hiroshima as an adverse shock in early childhood, marital status, health status used in the above regression, BMI as well as municipality of residence. In order to diminish the attrition in the sample, we use data from the first round survey for each municipality and pool them for this analysis.

Table 2 shows that educational attainment correlates with grip strength but the pattern differs between male and female. For male, the coefficients are positive and significant except postgraduates and the size peaks out for vocational/two-year college graduates. For female, the coefficients are positive and significant except high school graduates and the size is clearly larger for higher educational attainment. Moreover, having owned house and land positively correlates with grip strength for both sexes although the magnitude is larger for male. Male atomic bomb survivors have weaker grip strength, which are not observed for female. Marital status also have some effect on male grip strength, but not on female's.

4. Conclusion

We provide new evidence on predictable validity of grip strength on later life outcomes using population based data in Japan for the first time. Moreover, we reveal the significant impact of SES on grip strength in Japan.

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Table 1.Grip strength and later health outcomes

	Mortality (1: died from illness, 0: otherwise)						*Mobility (1: having difficulties in ADL, 0: otherwise)*						*IADL (Z-score for IADL score)*						*Cognitive ability (Z-score for word recall)*					
	Male			*Female*			*Male*			*Female*			*Male*			*Female*			*Male*			*Female*		
Grip strength 2011	-0.001**			-0.000			-0.010***			-0.015***			0.010***			0.017***			0.013**			0.017*		
	(0.000)			(0.000)			(0.002)			(0.003)			(0.002)			(0.004)			(0.004)			(0.008)		
Grip strength 2009		-0.002**			0.000			-0.009**			-0.013**			0.012**			0.011**			0.006			0.017	
		(0.001)			(0.001)			(0.003)			(0.004)			(0.005)			(0.003)			(0.006)			(0.011)	
Grip strength 2007			-0.001			0.000			-0.006*			-0.017**			0.006			0.009**			0.007			0.002
			(0.001)			(0.001)			(0.003)			(0.004)			(0.004)			(0.002)			(0.007)			(0.011)
Age	0.001	0.001	0.001	0.000	-0.000	0.000	0.009***	0.011***	0.011***	0.015***	0.020***	0.016**	-0.001	-0.001	-0.002	-0.007*	-0.010***	-0.012*	-0.027***	-0.029***	-0.028***	-0.035***	-0.030***	-0.031***
	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.002)	(0.003)	(0.003)	(0.004)	(0.002)	(0.003)	(0.004)	(0.004)	(0.002)	(0.005)	(0.004)	(0.002)	(0.005)	(0.005)	(0.006)	(0.007)
Highest education	-0.006	-0.011	-0.015	-0.001	-0.004	-0.004	-0.037	-0.020	-0.049	0.009	-0.013	-0.008	0.112**	0.030	0.074	-0.001	0.013	-0.046	0.173**	0.104	0.087	0.165**	0.147	0.104
_High school	(0.009)	(0.012)	(0.010)	(0.004)	(0.005)	(0.008)	(0.028)	(0.031)	(0.032)	(0.025)	(0.036)	(0.043)	(0.049)	(0.047)	(0.060)	(0.038)	(0.050)	(0.050)	(0.063)	(0.083)	(0.089)	(0.072)	(0.111)	(0.086)
	-0.008	-0.007	-0.009	-0.001	-0.005	-0.006	-0.020	-0.014	-0.053	-0.011	-0.008	0.013	0.214**	0.141	0.214**	0.024	0.032	0.001	0.314	0.169	0.306	0.331***	0.275***	0.297**
_Vocational or college	(0.012)	(0.018)	(0.021)	(0.004)	(0.005)	(0.007)	(0.047)	(0.051)	(0.058)	(0.015)	(0.022)	(0.024)	(0.085)	(0.086)	(0.066)	(0.031)	(0.025)	(0.037)	(0.189)	(0.229)	(0.227)	(0.057)	(0.067)	(0.077)
	-0.000	-0.010	-0.023	0.018	-0.005	0.029	-0.072**	-0.070*	-0.101**	-0.029	-0.028	0.009	0.150***	0.087**	0.155**	-0.119*	-0.021	-0.139	0.351***	0.290**	0.312*	0.519***	0.677**	0.809**
_University	(0.014)	(0.019)	(0.015)	(0.014)	(0.005)	(0.030)	(0.029)	(0.030)	(0.034)	(0.059)	(0.064)	(0.086)	(0.031)	(0.033)	(0.038)	(0.065)	(0.057)	(0.085)	(0.063)	(0.096)	(0.120)	(0.121)	(0.189)	(0.283)
	-0.023**	-0.022	-0.028	-0.007*	-0.005	-0.015***	-0.097*	-0.080	-0.143*	-0.224**	-0.267*	-0.313***	0.108	-0.198	0.255***	0.098*	0.152**	0.151***	0.048	-0.289*	-0.141	0.816***	0.796***	0.977***
_Postgraduate	(0.009)	(0.014)	(0.015)	(0.004)	(0.004)	(0.002)	(0.050)	(0.061)	(0.053)	(0.096)	(0.109)	(0.055)	(0.151)	(0.189)	(0.044)	(0.045)	(0.061)	(0.032)	(0.153)	(0.130)	(0.157)	(0.177)	(0.177)	(0.084)
Housing (1: owning house and land, 0: otherwise)	0.005	-0.001	0.002	-0.002	0.003	0.005	-0.009	-0.033	-0.011	-0.030	-0.055	-0.104***	-0.019	-0.009	-0.004	-0.030	-0.101	0.039	-0.090	-0.069	0.026	0.060	-0.065	0.017
	(0.009)	(0.016)	(0.022)	(0.004)	(0.002)	(0.003)	(0.014)	(0.021)	(0.038)	(0.027)	(0.040)	(0.018)	(0.040)	(0.068)	(0.100)	(0.070)	(0.119)	(0.080)	(0.071)	(0.105)	(0.079)	(0.089)	(0.148)	(0.112)
Smoking (1: currently smoking, 0: otherwise)	-0.003	-0.006	0.001	0.029*	0.016	0.036	0.002	0.005	0.000	-0.012	-0.012	0.015	-0.054	-0.046	-0.055	-0.171**	-0.114*	-0.135	-0.124	-0.120	0.013	-0.104	-0.040	-0.038
	(0.009)	(0.010)	(0.012)	(0.015)	(0.017)	(0.024)	(0.018)	(0.021)	(0.025)	(0.029)	(0.025)	(0.039)	(0.049)	(0.045)	(0.050)	(0.054)	(0.058)	(0.083)	(0.105)	(0.134)	(0.102)	(0.121)	(0.159)	(0.189)
Number of chronic illness	0.007	0.005	0.005	0.002	0.002	0.002	0.029**	0.032**	0.039**	0.076***	0.067***	0.089***	-0.035*	-0.030	-0.026	-0.006	-0.009	-0.006	0.001	0.018	0.049	0.012	0.017	0.033
	(0.006)	(0.006)	(0.007)	(0.001)	(0.003)	(0.003)	(0.010)	(0.009)	(0.013)	(0.008)	(0.014)	(0.011)	(0.017)	(0.019)	(0.018)	(0.010)	(0.011)	(0.016)	(0.037)	(0.053)	(0.044)	(0.016)	(0.030)	(0.025)
No. of Obs.	1618	1005	815	1715	984	801	1618	1005	815	1715	984	801	1618	1005	815	1715	984	801	1234	763	600	1423	827	665
R-Squared	0.02	0.02	0.02	0.02	0.01	0.03	0.12	0.12	0.12	0.19	0.20	0.21	0.06	0.05	0.05	0.06	0.07	0.04	0.09	0.09	0.09	0.09	0.09	0.08

NOTE :

1. Standard errors are clustered at municipality level. *** p<0.01, ** p<0.05, * p<0.1

2. Coefficients of municipal dummies are not shown here for brevity.

3. Reference category for "*Highest education*" is "*Less than high school*".

4. Number of observations decreases when including *Grip strength 2009* and *Grip strength 2007* because only five municipalities have four rounds of data (expanding to eight years), and seven municipalities have three rounds of data (for six years).

Table 2. Grip strength and SES

	Grip	
	Male	*Female*
Age	-0.407***	-0.210***
	(0.0281)	(0.0203)
Highest education		
_High school	1.384**	0.197
	(0.450)	(0.280)
_Vocational or college	1.782*	0.535**
	(0.867)	(0.168)
_University	1.380**	1.337**
	(0.511)	(0.437)
_Postgraduate	1.575	4.139**
	(1.049)	(1.422)
Housing	1.655**	0.786**
(1: owning house and land, 0: otherwise)	(0.615)	(0.312)
Atomic bomb survivor	-2.218***	0.0898
	(0.129)	(0.155)
Marital status	1.894***	0.0116
(1: married, 0: otherwise)	(0.566)	(0.104)
Observations	1,844	2,028
R-squared	0.228	0.140

1. Standard errors are clustered at municipality level. *** p<0.01, ** p<0.05, * p<0.1

2. Covariates (health behaviour including smoking, chronic illness, and BMI, and city dummmies) are not shown for brevity.

3. Reference category for "*Highest education*" is "*Less than high school*".

Appendix. Summary statistics

Variable	Male		Female	
	Number /Mea	%/SD	Number /Mean	%/SD
GRIP STRENGTH				
Grip strength 2011, mean, SD	33.94	6.92	21.95	4.15
Grip strength 2009, mean, SD	34.22	6.32	22.08	4.19
Grip strength 2007, mean, SD	35.92	6.56	22.99	4.45
HEALTH OUTCOMES				
Mortality, number of people died from illness, %	27	1.67	10	0.58
Mobility, number of people who have any difficulties in ADL, %	288	17.79	460	26.81
IADL (Z-score for IADL score), mean, SD	0.65	0.59	0.70	0.53
Cognitive ability (Z-score for word recall), mean, SD	-0.17	0.94	0.21	1.00
RESPONDENT'S CHARACTERISTICS				
Age (years), mean, SD	69.51	5.60	69.50	5.67
Highest education				
- number of people who have less than high school education, %	411	25.39	456	26.57
- number of people who have at least some high school education, %	699	43.17	817	47.61
- number of people who have at least some vocational education, %	99	6.11	333	19.41
- number of people who have at least some university education, %	380	23.47	97	5.65
- number of people who have at least some post graduate education, %	27	1.67	3	0.17
Housing, number of people who owns house and land, %	1339	82.71	1380	80.42
Smoking, number of people who are currently smoking, %	278	17.17	92	5.36
Number of chronic illness, mean, SD	1.07	1.19	1.020	1.134
Municipality				
- Chofu	99	6.11	119	6.93
- Sendai	153	9.45	156	9.09
- Kanazawa	167	10.32	191	11.13
- Takikawa	155	9.57	130	7.58
- Shirakawa	238	14.70	194	11.31
- Adachi	128	7.91	146	8.51
- Naha	132	8.15	168	9.79
- Tosu	164	10.13	148	8.62
- Hiroshima	268	16.55	333	19.41
- Tondabayshi	115	7.1	131	7.63
(Additional covariates for the association between grip strength and SES)				
Number of atomic bomb survivor, %	15	0.79	14	0.67
Number of married people, %	1802	91.24	1694	76.97
Number of people who are underweight, %	54	2.73	122	5.54
Number of people who are normal weight, %	1117	56.56	1300	59.06
Number of people who are overweight, %	788	40.22	744	34.35

NOTE: For IADL and cognitive ability, we standardized them by all available data before limiting our sample for analysis.