# Physical Inactivity of Workers and its Relation to Uneven Allocation of Public Sports Facilities

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**Abstract**

Personal lifestyle choices such as leisure-time physical activity are major determinants of both the health and happiness of individuals. However, price discrimination exists between municipalities at almost public sports facilities. An economic intervention to change the cost of using public sports facilities could affect both the level of participation in sports and the health of the participants.

Workers in rural areas have better access to public sports facilities, but lower income workers did not tend to engage in leisure-time physical activity. Using micro-data from nationwide surveys, we examined the effects of the policy to promote cross-border use of public sports facilities by workers in Japan, taking into account the endogeneity problem among physical activity, self-assessed health and happiness.

We analyzed the relationship between physical inactivity and health using two latent dichotomous variables. As a proxy variable of the number of potential users of public sports facilities, the ratio of population to the number of public sports facilities was used. The seemingly unrelated bivariate probit model of latent physical inactivity and latent health provided the best specification. The ratio of population to the number of public sports facilities had two opposite effects. One was a negative effect on physical inactivity and the other was a positive effect on latent health.

We concluded that abolishing price discrimination between municipalities to promote the cross-border use of public sports facilities would increase the health of the individuals. Since population has been decreasing in most municipalities in Japan, with the exception of several large cities, a policy which abolishes the price discrimination between municipalities would seem to be a good health policy.

## 1. Introduction

Individual health is heavily influenced by personal lifestyle choices such as drinking, smoking, and leisure-time physical activity. Unhealthy diets and physical inactivity are the main contributors to overweight and obesity, which are among the leading risk factors for the major non-communicable diseases (World Health Organisation, 2005). Heart disease is a costly outcome of physical inactivity (Garrett *et al.*, 2004). Nevertheless, although the negative effects of physical inactivity on health are well known, half of Japanese workers are physically inactive because they do not engage in enough physical activity during their leisure time and because jobs are increasingly sedentary in nature.[1] The prevalence of overweight or obesity in Japan (a body mass index of 25 or higher) has shown a tendency to increase in males regardless of age group compared with 1997 statistics. The 2007 National Health and Nutrition Survey in Japan indicated that one out of two males 40–74 years old was likely to develop metabolic syndrome.

Personal lifestyle would be a major determinant of the happiness of individuals. Oswald and Powdthavee (2007) showed that greater body mass index (BMI) values were associated with lower happiness and levels of mental health.[2] The empirical literature confirms that health is a major determinant of subjective happiness and that the converse is also true (Borghesi and Vercelli, 2010).[3] As Rasciute and Downward (2010) argued, it may well be the case that happier individuals are better able to participate in sports activities.[4] According to Veenhoven (2008), the effect of happiness (or positive attitudes towards life) on longevity in healthy populations is so strong as to be comparable to the effect of smoking status.[5] The self-assessed health status may also

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[1] According to National Health and Nutrition Survey in Japan, regular exercisers were defined as those who exercise at least two days a week for 30 minutes or more, for at least one year. The proportion of regular exercisers among males was 29.1%, which was larger than the value of 25.6% observed in females. The change in the prevalence of overweight or obesity in males aged 50–59 in a decade was 10.2 percentage points (from 24.1% to 34.3%), the largest value among the working generations. In contrast, the proportion of regular exercisers among males aged 50–59 was 21.0%, which was smaller than the value of 24.7% for females.

[2] They showed that someone who was 200 pounds was more likely to see themselves as overweight if educated and rich than if poorly educated and on a low income. BMI values were included in the regressions for life satisfaction and psychological distress.

[3] They ascertained that the other main factors affecting both happiness and health have a common kernel and the specification of their causal influences is very similar.

[4] Rasciute and Downward (2010) discussed the endogeneity problem among physical activity, self-assessed health and happiness. They pointed out two potential sources of endogeneity. The first endogeneity is between the health and well-being variables, and the second endogeneity is between the physical activity and respective health and well-being variables.

[5] Diener and Chan (2011) described the evidence that subjective well-being causally affects health and longevity.

be affected by perceived happiness.

Previous studies which have focused on the socioeconomic determinants of health found two important facts. First, individuals at the highest levels of income, education, and job classifications were more likely to engage in regular physical activity during their leisure time than those with lower job status and incomes (Ford *et al*., 1991; Giles-Corti and Donovan, 2002; Jeffery *et al*., 1991). Second, several important behavioral risk factors for poor health are more common among people in lower socioeconomic status (SES) groups. Adults with lower incomes or less education are more likely to smoke and be obese than adults with higher incomes and more education.

Cerin and Leslie (2008) confirmed their hypothesis that SES differences in leisure-time physical activity are explained by individual, social and environmental variables as well as SES differences in self-reported health status. They emphasized that physical barriers to walking and access to public open spaces partly explained the associations between income and walking for recreation. Poortinga (2006) found that positive perceptions of the social environment (i.e., social support and social capital) were associated with higher levels of physical activity in an analysis using data from the 2003 Health Survey in England. In Japan, workers with greater disposable incomes may obtain social and material resources (e.g., gym memberships) that help to maintain physical activity.

In the current paper, we focus on environmental variables that affect the participation in physical activity. First, we analyze the unequal access to public sports facilities in Japan. Second, we investigate the influence of social environmental factors on both self-assessed health and the participation in physical activity, taking into account the endogeneity problem among physical activity, self-assessed health and happiness. Following Rasciute and Downward (2010), we can consider that health-enhancing activities such as regular physical activity can be viewed as inputs to the production of health. Finally, we examine the health policies to promote the participation of physical activity.

## 2. Inequality in public sports facilities access

### 2.1. Allocation of sports facilities

Previous studies have suggested that poverty reduces access to health care resources, which in turn results in poor health. People in poorer health are then less likely to be physically active than those in good health (McNeill *et al*., 2006).[6] By extension,

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[6] Poortinga (2006) found a strong gradient for age and social class: older age groups and people from

differences in environmental factors such as access to sports facilities may affect participation in sport and, in turn, individual health. People living near green spaces, including parks, playgrounds and athletic fields, appear to be more likely to walk and to have higher levels of physical activity.

In Japan, physical activity resources such as private sports facilities and gymnasiums are usually located in areas of high population density. Thus individuals living in a large city gain better access to private sports facilities than individuals living in rural areas. The Survey of Selected Service Industries in 2005 by the Ministry of Economy, Trade and Industry showed that the annual sales of fitness clubs with pools, aerobics areas, weight studios, etc., were concentrated in urban areas. The sales of the Tokyo metropolitan area accounted for 21.8% of the whole country, followed by the sales for Osaka (10.0%), Kanagawa (9.1%), Chiba (7.0%) and Saitama (6.7%).[7] The numbers of large cities included in the 2002 and 2005 analyses were 13 and 15, respectively.

## 2.2. Empirical model

The inequality in public sports facilities access can be measured using the concentration index, which is equal to twice the area between the line of equality and the concentration curve. The concentration curve plots the cumulative proportion of public sports facilities per population against the cumulative proportion of the population (from low income to high income). This concentration index is defined as twice the area between the concentration curve and the diagonal, and is bounded by -1 and 1. The larger the index is in terms of absolute size, the greater the degree of inequality. When it is negative, this indicates that the sports facilities variable in question is concentrated more among the poor (pro-poor inequality). When it is positive, this indicates a pro-rich inequality.

Both $h_i$ and $b_i$ in Equation (1) are variables that should be considered when we analyze the inequality in public sports facilities access. When $h_i$ is the degree of physical activity of the individual and $b_i$ is the ratio of the number of public sports facilities to population, the OLS estimate of $\beta$ in Equation (1) represents the extent of inequality in public sports facilities access:

$$2\sigma_R^2 [\frac{h_i}{h^*} - \frac{b_i}{b^*}] = \delta + \beta R_i + u_i \quad , \tag{1}$$

where $R_i$ is the fractional rank by the proportion of public sports facilities per population, $\sigma_R^2$ is its variance, $\delta$ is a constant term, $u_i$ is an error term, $h^*$ is the mean of $h_i$ and $b^*$ is the mean of $b_i$. The value of $\beta$ is Newey-West estimates which modified the serial correlation in Equation (1) (Wagstaff and Doorslaer, 2000).

## 3. Determinants of physical inactivity and economic intervention

### 3.1. Literature review

Mullahy and Robert (2008) examined the 2005 and 2006 American Time Use Study to explore factors associated with time spent in physical activity. They found that males with spouses have lower physical activity than those without and physical activity for females was reduced on weekends and holidays. Mclnnes and Shinogle (2009) argued that shocks to the time-use distributions of individuals, such as marriage, children, or a job change, affected physical activity. They revealed that individuals who report being married generally exhibited decreased participation in physical activity. Holding marital status constant, men were more likely to exercise than women across all income levels.[8]

Individuals were also more likely to defer health investments in response to temporary than lasting increases in work hours (Ruhm, 2005). Decreases in working hours are associated with reductions in smoking, severe obesity, physical inactivity and multiple health risks. Sokejima and Kagamimori (1998) found that a U-shaped relation existed between mean working hours and risk of acute myocardial infarction using 199 male patients who had been admitted to three university hospitals and one general hospital between November 1990 and November 1993.

Japan possesses specific characteristics relevant to these issues, such as an intense work environment (Kagamimori *et al.*, 2009). The number of hours of market work, which are likely to affect both income and health, is one of the components of SES. For regular workers, working for more than the prescribed 40 hours per week is a major constraint on leisure-time physical activity. The proportion of physical inactivity of female workers is larger than that of male workers because of the non-market work responsibilities. Kumagai (2012) could not confirm simultaneous relationships between physical inactivity and working hours. The estimation results may indicate that workers usually do not instantaneously change the time they spend on physical activity in response to a temporary decrease in working hours. Therefore, we consider that workers usually decide on the duration of their work before deciding on the time to be spent on

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[8] Mclnnes and Shinogle (2009) also found that education was associated with increased physical activity for both men and women.

physical activity. Income, education, occupational status, smoking, drinking and working hours are the determinants of leisure-time physical activity.[9]

### 3.2. Influences of happiness on self-assessed health or physical inactivity

Certain limitations of this study should be acknowledged. First, our analysis relied on self-reports and may therefore be subject to reporting biases. People with a worse objective health status may tend to overstate their subjective health. If poorer people responded that they were healthier than they really were, the effect of self-assessed health on income might be underestimated.

In addition, the self-assessed health (SAH) variable may be vulnerable to reporting bias because of anticipation and measurement heterogeneity (Hagan *et al*., 2008). There may be simultaneity between SAH or physical activity and perceived happiness, since happiness affects SAH or the participation in leisure-time physical activity directly.[10] In order to overcome the problems associated with the measurement errors, we created both a latent health stock variable and a latent physical activity variable. To correct for possible reporting heterogeneity, we applied a technique previously proposed by Disney *et al*. (2006).

The original SAH variable is a five-point scale variable. With respect to self-assessed health, the JGSS asked the respondents to choose from among 1 (=excellent), 2, 3, 4 and 5 (=poor) in response to the question, "How would you assess your health status?" Following Oshio and Kobayashi (2010), we reversed the order of choices so that "unhappy" and "poor" equaled 1 and "happy" and "excellent" equaled 5.[11]

Following the procedure of Disney *et al*. (2006), we estimated SAH as a function of perceived happiness ($d_{it}$) as well as a function of either gender or residential area ($w_{it}$). First, we wrote the unobservable health status ($Z_{it}$) as a function of *d*, *x* and unobserved variables ($\mu_{it}$):

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[9] If regular physical activity leads to improved health, then the estimated parameters on the education variables could be one mechanism by which individuals produce health. The Cabinet Office of Japan (2008) showed that working hours were in negative correlation with the degree of satisfaction with life in Japan. Based on their own analyses, they proposed that workers take long vacations to produce a more positive mindset. However, the Cabinet Office of Japan (2008) did not reveal the relationships between working hours, health and happiness.

[10] Previous studies also showed that age, health and marital status are strongly associated with happiness. The authors of many works have argued that there is evidence of a U-shape in the happiness level throughout the life cycle. There is thought to be a convex link between reported well-being and age (Clark and Oswald, 1994; Winkelmann and Winkelmann, 1998; Blanchflower, 2001; Frey and Stutzer, 2002; Di Tella *et al*., 2003; Blanchflower and Oswald, 2004).

[11] With respect to perceived happiness, the JGSS asked the respondents to choose from among 1 (= happy), 2, 3, 4 and 5(= unhappy) in response to the question, "How happy are you?"

$$Z_{it} = \delta' w_{it} + \gamma' d_{it} + \mu_{it}. \tag{2}$$

Instead of $Z_{it}$, the categorical variable SAH ($h_{it}$) was observed in our data set. This variable may be measured with a reporting error since the assessment of health may depend on health problems (Schneider and Schneider, 2012). The latent health status ($h_{it}^*$) as the counterpart of the observed $h_{it}$ is a function of $Z_{it}$ and the reporting error ($e_{it}$) as follows:

$$h_{it}^* = Z_{it} + e_{it}. \tag{3}$$

The latent health variable can be linked to the categorical variable $h_{it}$ using the mechanism below:

$$h_{it} = j, if\ \phi_{j-1} < h_{it}^* < \phi_{j-1}, j = 1,2,\ldots,6. \tag{4}$$

Equation (4) shows that our observable health variable takes the value $j$ if the latent health status lies between the two thresholds $\phi_{j-1}$ and $\phi_j$. Combining this observation mechanism with equation (2), the model can be estimated using an ordered probit model. Using the predicted values, we can normalize the health variable via a z-transformation. We used the health variable as a dummy variable, which took on the value of one if the latent health status was good. It was classified according to the median of the standardized variable (median = good). The latent physical inactivity variable was also calculated, which took on the value of one if the degree of physical activity was inactivity.

### 3.3. Economic intervention

Despite the fact that large portions of national taxes have been applied to the construction of public sports facilities, price discrimination exists between municipalities at almost all the public sport facilities. The user prices at the outside of residential municipalities are higher.[12] Since the population has been decreasing in

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[12] Almost every municipality has a sports center or a recreation facility. Shibuya Sports Center, for example, offers a training gym, volleyball courts, table tennis and a pool for 400 yen per day (100 yen for kids). Sarugaku Training Gym located at Shibuya Ward has a variety of training machines and is available to residents.

most municipalities with the exception of several large cities, in order to promote the cross-border use of public sport facilities, the price discrimination between municipalities should be abolished. A public policy which abolishes the price discrimination between municipalities would represent a big change in the impact of social environmental factors on physical inactivity.

Using a simple static model, Mclnnes and Shinogle (2009) showed that price changes affect an individual's level of physical activity. An economic intervention which changes the price in public sport facilities can alter individual preferences about physical activity. We used the ratio of population to the number of public sports facilities (the reciprocal of the ratio of the number of public sports facilities to population) as a proxy variable of the number of potential users of public sports facilities. Assuming that subjective well-being contributes to health, we analyzed the relationship between physical inactivity and self-assessed health using latent dichotomous variables that we calculated as described in the next section.

## 4. Estimation results

### 4.1. Data and variables

The original physical activity variable is a five-point scale variable. The data were drawn from the Japanese General Social Survey (JGSS), a questionnaire survey conducted by the Institute of Regional Studies at the Osaka University of Commerce in collaboration with the Institute of Social Science at the University of Tokyo. The data for physical activity were available from 2002. This survey was not conducted in 2004. Data were collected through a combination of interviews and self-administered questionnaires after two-stage stratified random sampling. The stratification of cities by population size in 2002 differed from that in 2005.[13] The JGSS asked each respondent about his/her occupational status. From these surveys, we obtained information about demographic variables, lifestyle and educational background.

The JGSS asked the respondents to indicate their annual pre-tax income for the previous year from nineteen categories. We took the median value of each category and transformed it into a natural log, considering the non-linear association between income and health. Annual income was deflated by the consumer price index. The consumer price index in Japan decreased from 2001 to 2005 as follows: it was 101.5 in 2001; 100.6 in 2002; 100.3 in 2003; 100.3 in 2004; and 100.0 in 2005.

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[13] Large cities in 2005 included Saitama, Shizuoka and 13 conventional large cities (Sapporo, Sendai, Chiba, Tokyo Metropolitan Area, Yokohama, Kawasaki, Nagoya, Kyoto, Osaka, Kobe, Hiroshima, Kitakyushu and Fukuoka).

It is well known that standard errors are large whenever large variations between individuals exist in repeated cross-sectional analysis, and the benefits of a longitudinal data (panel data) analysis over a repeated cross-sectional study include increased statistical power. However, in longitudinal surveys, the attrition rates are known to be higher among individuals with lower income than those with higher income. Consequently, we consider repeated cross-sectional analysis more effective for researchers when complete sets of new respondents are continually selected, ensuring a steady level of reliability for each successive sample.[14]

For lifestyle variables, we summarized the answers into dichotomous variables (yes=1) as follows: physical inactivity, drinking alcoholic beverages almost every day and smoking. We used physical inactivity as a dummy variable, which took on the value one if respondents hardly engaged in any sports (baseball, swimming, walking, etc.) per year during their leisure time, and zero otherwise. Both regular physical activity and irregular physical activity are in the same category. The following proportions of respondents were included in the respective levels of physical activity: regular physical activity, 0.29 (males, 0.31; females, 0.27); irregular physical activity, 0.15 (males, 0.18; females, 0.11) and physical inactivity, 0.56 (males, 0.51; females, 0.62). The JGSS did not ask the amount of time devoted to physical activity. The smoking rate of this data set was 0.35 (males, 0.50; females, 0.17).

The following proportions of respondents were included in the respective occupational status groups: regular employees, 0.55 (males, 0.68; females, 0.38); management executives, 0.06 (males, 0.09; females, 0.03); part-time and casual workers, 0.23 (males, 0.08; females, 0.42); self-employed, 0.10 (males, 0.13; females, 0.05); family workers, 0.05 (males, 0.01; females, 0.08) and dispatched workers, 0.02 (males, 0.01; females, 0.03). Homemakers, unemployed persons and retired people are not a part of the labor force and are not paid. Approximately 16% of workers spent less than 24 hours per week (mean=40.66, SD=15.80) performing market work. With respect to demographic variables, we considered age, gender, number of children and marital status (married, unmarried, divorced and widowed). The proportion of unmarried workers was about 0.38.

We divided the workplace groups into four classes: small (fewer than 30 employed), medium (30-999 employed), large (more than 1000 employed) and the remainder

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[14] In longitudinal data analysis, it is possible to focus on changes occurring within subjects and to make population inferences that are not as sensitive to variations between subjects. In studies comparing trends with time, longitudinal data have an advantage over repeated cross-sectional data because they facilitate the use of methodologies such as the Generalized Estimating Equations (GEE). The GEE approach accounts for the individual correlation and separates the nuisance variation due to population-wide behavior from variation related to trends with time.

(government official workers and "Don't know"). In addition to workplace size, we considered educational attainment. Half of the workers self-reported completing high school.

For the ratio of the number of public sports facilities to population, we obtained data on prefecture-level measures of physical activity resources in 2002 and 2005. These data consisted of multi-purpose playgrounds per 1 million persons (hereafter per 1M), gymnasiums per 1M, sports facilities per 1M and place of residence of each respondent. The number of sports facilities was from the Social Education Survey conducted by the Ministry of Education, Culture, Sports, Science and Technology. Population by prefecture was from the Statistics Bureau, Ministry of Internal Affairs and Communications.

**Table 1. Descriptive Statistics**

| | | | | | | | Male | Female |
|---|---|---|---|---|---|---|---|---|
| | Definition | N | Mean | S.D. | Min | Max | Mean | Mean |
| Dependent variables (original five-scale variable) | | | | | | | | |
| Physical activity | Regular=5, inactivity=1 | 4167 | 2.26 | 1.57 | 1 | 5 | 2.38 | 2.11 |
| Self-assessed health | Excellent=5, bad=1 | 4168 | 3.66 | 1.07 | 1 | 5 | 3.61 | 3.71 |
| Independent variables | | | | | | | | |
| (1) Subjective well-being and area | | | | | | | | |
| Perceived happiness | Happy=5, unhappy=1 | 4168 | 3.82 | 0.92 | 1 | 5 | 3.80 | 3.85 |
| Residential area | Large city=1 | 4168 | 0.19 | 0.39 | 0 | 1 | 0.19 | 0.19 |
| (2) Demographic variables | | | | | | | | |
| Age | | 4168 | 44.15 | 12.24 | 20 | 65 | 44.52 | 43.71 |
| Gender | Male=1 | 4168 | 0.54 | 0.50 | 0 | 1 | | |
| Marital status | Married=1 | 4168 | 0.57 | 0.50 | 0 | 1 | 0.57 | 0.56 |
| | Divorced=1 | 4168 | 0.04 | 0.20 | 0 | 1 | 0.02 | 0.07 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Widowed=1 | 4168 | 0.00 | 0.07 | 0 | 1 | | 0.00 | 0.01 |
| Children | Number of children | 4168 | 1.53 | 1.14 | 0 | 10 | | 1.49 | 1.57 |
| Educational Attainment | Junior high school | 4168 | 0.11 | 0.31 | 0 | 1 | | 0.12 | 0.10 |
| | High school (reference) | 4168 | 0.49 | 0.50 | 0 | 1 | | 0.46 | 0.52 |
| | College or University | 4168 | 0.32 | 0.47 | 0 | 1 | | 0.31 | 0.33 |
| | （ University | 4168 | 0.19 | 0.39 | 0 | 1 ） | | 0.24 | 0.13 |
| | （College | 4168 | 0.13 | 0.34 | 0 | 1 ） | | 0.07 | 0.20 |
| | Graduate school | 4168 | 0.07 | 0.26 | 0 | 1 | | 0.10 | 0.04 |
| **(3) Work** | | | | | | | | | |
| Working hours | | 4168 | 40.66 | 15.80 | 2 | 120 | | 46.43 | 33.82 |
| Occupational status | Management executive | 4168 | 0.06 | 0.24 | 0 | 1 | | 0.09 | 0.03 |
| | Part-time and casual worker | 4168 | 0.23 | 0.42 | 0 | 1 | | 0.08 | 0.42 |
| | Self-employed | 4168 | 0.10 | 0.30 | 0 | 1 | | 0.13 | 0.05 |
| Scale of workplace | Large | 4168 | 0.14 | 0.35 | 0 | 1 | | 0.17 | 0.10 |
| | Medium | 4168 | 0.26 | 0.44 | 0 | 1 | | 0.28 | 0.24 |
| | Small (reference) | 4168 | 0.27 | 0.45 | 0 | 1 | | 0.26 | 0.29 |
| **(4) Lifestyle** | | | | | | | | | |
| Drinking | Almost everyday=1 | 4168 | 0.27 | 0.44 | 0 | 1 | | 0.41 | 0.10 |
| Smoking | Smoker=1 | 4168 | 0.35 | 0.48 | 0 | 1 | | 0.50 | 0.17 |
| **(5) Other** | | | | | | | | | |
| Real income | Evaluated at 2005 prices, 10000 yen | 4168 | 372.72 | 327.23 | 0 | 3220 | | 513.76 | 205.66 |
| Sports facilities | Per 1 million persons (2002 | 2356 | 405.29 | 213.40 | 120 | 1003.1 | | 403.03 | 407.85 |

| | and 2005) | | | | | | | |
| Multi-purpose playgrounds | Per 1 million persons (2002 and 2005) | 2356 | 58.60 | 37.33 | 8 | 172 | 58.35 | 58.89 |
| Gymnasiums | Per 1 million persons (2002 and 2005) | 2356 | 56.24 | 36.33 | 15.5 | 204.3 | 55.97 | 56.53 |

Sources: Japanese General Social Survey 2002, 2003, 2005 and 2006

N=4167 (Male 2260, Female 1907; 1450 in 2002; 890 in 2003; 905 in 2005; 922 in 2006)

The number of sports facilities was from the Social Education Survey by the Ministry of Education, Culture, Sports, Science and Technology.

Population by prefecture was from the Statistics Bureau, Ministry of Internal Affairs and Communications.

## 4.2. Inequality in public sports facilities

The original physical activity variable (a five-point scale variable) and natural log of annual real income were used. Estimation results of the concentration index showed that workers in rural areas had better access to public sports facilities. Nevertheless, the estimation results of Equation (1) indicated that lower income workers did not tend to engage in leisure-time physical activity. Conversely, higher income workers did tend to engage in regular physical activity (see HIwv in Table 2). Therefore, we can consider that the accessibility to public sports facilities might not determine the participation in physical activity of lower income workers in rural areas. The user price might be an important barrier to physical inactivity for lower income workers. Reducing admission fees for public sport facilities for people outside the residential municipality could help to promote the cross-border use of the public sport facilities.[15]

**Table 2. Inequality in public sports facilities**

| Concentration index | | | | HIwv | |
|---|---|---|---|---|---|
| | Pooled | 2002 | 2005 | Pooled | t-value |
| Sports facilities | -0.0224 | -0.0225 | -0.0241 | 0.0518 | 4.31 |
| Multi-purpose playgrounds | -0.0275 | -0.0273 | -0.0304 | 0.0564 | 4.42 |
| Gymnasiums | -0.0308 | -0.0322 | -0.0327 | 0.0594 | 4.59 |
| N | 2352 | 1447 | 905 | 2351 | |

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[15] There is an exception necessitated by geography. In Hokkaido and Okinawa, it is not possible to promote the cross-border use of the sport facilities in adjoining prefectures.

| | | | |
|---|---|---|---|
| Physical activity | 0.0337 | 0.0318 | 0.0275 |
| N | 2351 | 1446 | 905 |

## 4.3. Latent variables

   Taking into account gender differences in SAH, we estimated a model of SAH using the procedure of Disney *et al*. (2006). We also estimated a model of physical inactivity by taking into account the regional differences in the participation in physical activity. Perceived happiness had positive effects for both SAH and physical activity at the 1% significance level. In contrast, residential area variables were not statistically significant at the 5% level for either equation.

**Table 3. Estimation results of ordered probit models**

| Dependent variables | Self-assessed health | Physical activity |
|---|---|---|
| Independent variables | | |
| Perceived happiness | 0.390*** | 0.109*** |
| | (0.0221) | (0.0221) |
| Gender | -0.077** | 0.244*** |
| | (0.0369) | (0.0404) |
| Large city (residential area) | -0.009 | -0.0005 |
| | (0.0466) | (0.0502) |
| Rural area (residential area) | 0.048 | -0.069 |
| | (0.0446) | (0.0500) |
| Cutpoint 1 | -0.661*** | 0.659 |
| | (0.0907) | (0.0937) |
| Cutpoint 2 | 0.300*** | 0.864*** |
| | (0.0875) | (0.0944) |
| Cutpoint 3 | 1.292*** | 1.094*** |
| | (0.0904) | (0.0952) |
| Cutpoint 4 | 2.095*** | 1.631*** |
| | (0.0943) | (0.0969) |
| N | 4163 | 4162 |
| Wald chi$^2$(4) (Prob > Chi$^2$) | 316.27 (0.00) | 57.93 (0.00) |
| Pseudo R-squared | 0.038 | 0.007 |

Robust standard errors in parentheses.

*** p<0.01, ** p<0.05, * p<0.1

4.4. Effects of changes in social environmental factors on physical inactivity

First, assuming that an increase in the number of potential users of public sports facilities would have positive effects on both physical activity and perceived happiness, we estimated a bivariate ordered probit model of physical activity and perceived happiness, because unobservable variables such as an individual's time preference may affect both variables. Correcting some unobserved heterogeneity that might give rise to the omitted variable bias is expected to increase the efficiency of estimation. The estimation result showed that the ratio of population to the number of public sports facilities (population-to-public sports facilities ratio) was statistically significant at the 1% level (see Appendix). The hypothesis above was supported, and thus we considered that the policy to promote the cross-border use of public sport facilities had positive effects on both physical activity and perceived happiness. On the other hand, the estimation result of the bivariate ordered probit model of physical activity and SAH showed that the ratio of population to the number of public sports facilities did not have a positive effect on SAH. This result appears to have arisen due to the characteristics of the original SAH, which did not take into account the positive effects of happiness on SAH.

Second, assuming that perceived happiness contributes to health, we analyzed the relationship between latent physical inactivity and latent health using a seemingly unrelated probit model shown as Equation (5).

$$
\begin{aligned}
y_{1i}^{*} &= \mathbf{x}_{1i}^{'}\boldsymbol{\beta}_1 + \varepsilon_{1i}, \\
y_{1i} &= \begin{cases} 1, if\ y_{1i}^{*} > 0 \\ 0, otherwise \end{cases} \\
y_{2i}^{*} &= \mathbf{x}_{2i}^{'}\boldsymbol{\beta}_2 + \varepsilon_{2i}, \\
y_{2i} &= \begin{cases} 1, if\ y_{2i}^{*} > 0 \\ 0, otherwise \end{cases}
\end{aligned}
\tag{5}
$$

where $y_{ji}, j = 1,2$ are latent physical inactivity and latent health, $y_{ji}^{*}, j = 1,2$ are their latent variables, $\mathbf{x}_{ji}, j = 1,2$ are the vectors of predictors, $\boldsymbol{\beta}_j, j = 1,2$ are the vectors of coefficients. These two equations are correlated and were jointly estimated on the assumption that two disturbances have the binomial standard normal distribution, as follows:

$$\begin{pmatrix} \varepsilon_{1i} \\ \varepsilon_{2i} \end{pmatrix} \sim N\left( \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & \rho \\ \rho & 1 \end{pmatrix} \right)$$

with $\rho$ being the covariance of disturbances.

Table 4 shows that the value of the arc-hyperbolic tangent (athrho) in the estimated function was significant at the 5% level, and we therefore rejected the alternative probit models. A negative relationship between SES and physical inactivity was found. Both lower income and low educational attainment had positive effects on physical inactivity. Smoking and longer working hours also had positive effects on physical inactivity. In contrast, management executive and the ratio of population to the number of public sports facilities (population-to-public sports facilities ratio) had negative effects on physical inactivity. The ratio of population to the number of public sports facilities had positive effects on latent health. The policy increasing the utilization of public sports facilities thus would contribute to both physical activity and health.

**Table 4. Estimation results of seemingly unrelated probit models**

| Dependent variables | Latent health | Latent physical inactivity |
|---|---|---|
| Independent variables | | |
| Logged real income: low | 0.0635 | 0.324*** |
| (Below 1.15 million yen) | (0.117) | (0.118) |
| Logged real income: middle | -0.0230 | 0.279*** |
| (1.15-3 million yen) | (0.0940) | (0.0945) |
| Logged real income: high | 0.00603 | 0.199** |
| (3-5.9 million yen) | (0.0831) | (0.0833) |
| Age | -0.0561*** | 0.0193 |
| | (0.0183) | (0.0184) |
| Age squared | 0.0550*** | -0.0224 |
| | (0.0207) | (0.0209) |
| Gender | -0.102 | -0.245*** |
| | (0.0736) | (0.0741) |
| Working hours | -0.00206 | 0.00593*** |
| | (0.00210) | (0.00214) |
| Married | 0.204** | 0.179* |
| | (0.0975) | (0.0975) |
| Divorced | 0.227 | 0.327** |
| | (0.147) | (0.152) |

| | | |
|---|---|---|
| Widowed | 0.162 | 0.0793 |
| | (0.307) | (0.305) |
| Number of children | -0.0112 | 0.00224 |
| | (0.0331) | (0.0336) |
| Drinking | 0.117* | -0.0374 |
| | (0.0665) | (0.0671) |
| Smoking | -0.104* | 0.201*** |
| | (0.0601) | (0.0610) |
| Junior high school | -0.0258 | 0.277*** |
| | (0.0899) | (0.0943) |
| College or University | 0.0995 | -0.152** |
| | (0.0605) | (0.0605) |
| Graduate school | 0.0192 | 0.0653 |
| | (0.186) | (0.186) |
| Medium | -0.0302 | 0.0645 |
| | (0.0675) | (0.0682) |
| Large | -0.0759 | -0.000475 |
| | (0.0823) | (0.0826) |
| Management executive | 0.162 | -0.349*** |
| | (0.117) | (0.118) |
| Part-time and casual worker | -0.113 | 0.0124 |
| | (0.0886) | (0.0899) |
| Self-employed | -0.00562 | 0.0790 |
| | (0.100) | (0.102) |
| Family worker | -0.0654 | 0.0673 |
| | (0.139) | (0.142) |
| Year | 0.0825*** | -0.0269 |
| | (0.0185) | (0.0186) |
| Large city | -0.0456 | 0.0446 |
| | (0.0758) | (0.0762) |
| Rural area | 0.0410 | -0.0184 |
| | (0.0685) | (0.0697) |
| Population-to-public sports facilities ratio | 0.332** | -0.373** |
| | (0.153) | (0.153) |
| Constant | -163.9*** | 53.30 |
| | (37.03) | (37.19) |

| Arc-hyperbolic tangent (athrho) | -0.136*** |
| --- | --- |
| | (0.0337) |

Likelihood-ratio test of $\rho = 0$: $Chi^2(1) = 16.423$, $Prob > Chi^2 = 0.0001$

N=2356, Log likelihood = -3117.3507, Wald $chi^2(52) = 187.75$

Robust standard errors in parentheses.

*** p<0.01, ** p<0.05, * p<0.1

The seemingly unrelated probit model with endogeneity draws upon a reduced form equation for the potentially endogenous dichotomous variable (latent physical inactivity) and a structural form equation for the existence of latent health. As a result of the estimation, the hypothesis that the correlation between the unobserved explanatory variables of both equations was zero was not rejected because the value of the arc-hyperbolic tangent in the estimated function was not significant. We concluded that physical inactivity was exogenous for the self-assessed health equation. The seemingly unrelated bivariate probit model of latent physical inactivity and latent health provided the best specification.

## 5. Conclusions

There exists price discrimination between municipalities at almost all the public sports facilities. That is, the user fees at regions outside the residential municipalities are higher. Such differences in the access to sports facilities, along with other environmental factors, can affect individual participation in sports and, ultimately, individual health. Therefore, an economic intervention to change the price of public sports facilities could encourage individuals to use them more frequently.

In regard to the results of estimation of the concentration index, we found that workers in rural areas had better access to public sports facilities, but that lower income workers still did not tend to engage in leisure-time physical activity. Using micro-data from nationwide surveys, we examined the potential effects of a policy to promote the cross-border use of public sports facilities by workers in Japan, taking into account the endogeneity problem among physical activity, self-assessed health and happiness.

We analyzed the relationship between physical inactivity and health, using two latent dichotomous variables. As a proxy variable of the number of the potential users of public sports facilities, the ratio of population to the number of public sports facilities was used. The seemingly unrelated bivariate probit model of latent physical inactivity and latent health provided the best specification. Both lower income and low educational attainment had greater positive effects on physical inactivity. Smoking and

longer working hours had positive effects on physical inactivity. The ratio of population to the number of public sports facilities had two opposite effects. One was a negative effect on physical inactivity and the other was a positive effect on latent health.

We concluded that abolishing the price discrimination between municipalities to promote the cross-border use of public sports facilities would increase the health of individuals. Since population has been decreasing in most municipalities in Japan, with the exception of several large cities, a policy which abolishes the price discrimination between municipalities would seem to be a good health policy.

## Appendix

**Table A. Estimation results of bivariate ordered probit models**

| Dependent variables | Perceived happiness | Physical activity |
|---|---|---|
| Independent variables | | |
| Logged real income: low | -0.378*** | -0.193* |
| | (0.0990) | (0.1080) |
| Logged real income: middle | -0.212*** | -0.165* |
| | (0.0797) | (0.0857) |
| Logged real income: high | -0.078 | (-0.136)* |
| | (0.0706) | (0.0747) |
| Working hours | -0.001 | -0.007*** |
| | (0.0017) | (0.0019) |
| Population-to-public sports facilities ratio | 0.381*** | 0.357*** |
| | (0.1299) | (0.1385) |
| Arc-hyperbolic tangent (athrho) | 0.089*** | |
| | (0.0264) | |
| N=2356, Log likelihood = -5784.7666, Wald chi$^2$(26) = 2891253.41 | | |

Robust standard errors in parentheses.

*** p<0.01, ** p<0.05, * p<0.1

The other independent variables were the same as in Table 4.

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