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Associations of physical activity in rural life with happiness and *ikigai*: a cross-sectional study

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Physical activity is associated with subjective well-being. In rural communities, however, physical activity may be affected by environmental factors (e.g., nature and socioecological factors). We examined the association of two physical activities in rural life (farming activity and snow removal) with subjective well-being in terms of happiness and *ikigai* (a Japanese word meaning purpose in life). In this cross-sectional study, we analysed data collected from community-dwelling adults aged ≥ 40 years in the 2012–2014 survey of the Uonuma cohort study, Niigata, Japan. Happiness ($n = 31{,}848$) and *ikigai* ($n = 31{,}785$) were evaluated with respect to farming activity from May through November and snow removal from December through April by using an ordinal logistic regression model with adjustments for potential confounders. The analyses were conducted in 2019. Among the participants who reported some farming or snow-removal time, median farming and snow-removal time (minutes per day) was 90.0 and 64.3 for men and 85.7 and 51.4 for women, respectively. Ordinal logistic regression analysis showed that longer time farming was associated with greater happiness and *ikigai* in men (adjusted odds ratio for first vs. fourth quartile: happiness = 1.17, 95% confidence interval [CI] = 1.01, 1.35; *ikigai* = 1.29, 95% CI = 1.10, 1.50), and also in women (adjusted odds ratio for first vs. fourth quartile: happiness = 1.17, 95% CI = 1.001, 1.36; *ikigai* = 1.42, 95% CI = 1.20, 1.67). More snow-removal time was inversely associated with happiness and with *ikigai* in women only (adjusted odds ratio for first vs. fourth quartile: happiness = 0.75, 95% CI = 0.67, 0.85; *ikigai* = 0.78, 95% CI = 0.69, 0.88). Our findings showed that physical activity in rural life was associated with happiness and with *ikigai*, and gender differences were observed in their associations with more snow-removal time. These results may be useful in helping to identify people in rural communities who are vulnerable in terms of psychological well-being.

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Introduction

"Happy people live longer" is a longstanding idea in public health (Diener and Chan, 2011; Frey, 2011). Happiness, or more broadly subjective well-being, has been shown to be positively associated with longevity and physical health (Diener and Chan, 2011; Frey, 2011; Howell, 2009; Veenhoven, 2008). In general, happiness can be described as a pleasant feeling or positive emotion and is influenced by interpersonal relationships in daily life.

Factors associated with subjective well-being

A wide array of factors is known to contribute to subjective well-being including happiness, such as genetics, personality, and socioeconomic status (Johnson and Acabchuk, 2018; Steptoe, 2019), and various potential determinants of subjective well-being have been investigated in countries worldwide (Steptoe et al., 2015; Adesanya et al., 2017).

Subjective well-being can be conceptualised as culturally unique and shaped by cultural values and beliefs (Fulmer et al., 2010; Karasawa et al., 2011; Miyamoto et al., 2019). Diener and Diener (1995) found a stronger correlation between subjective well-being and self-esteem in individualistic nations, such as the United States and Canada, than in collectivistic nations, such as Asian countries including Japan, in a study of cross-cultural differences in predictors of subjective well-being. The predictors of subjective well-being in the United States, an independent culture, were disengaging emotions (e.g., pride), whereas those in Japan, an interdependent culture, were engaging emotions (e.g., friendly feelings) (Kitayama et al., 2006). In Asia, a Chinese study ($n = 301$) of individuals aged 60 years or older living in rural and urban areas and a Japanese study ($n = 2730$) of adults aged 40–75 years living in the community found that social relationships and social capital had a greater impact on happiness (Yu et al., 2019; Tsuruta et al., 2019).

The concept of *Ikigai* in Japan

In Japan, the culturally specific term *ikigai* is believed to be the most common indicator of well-being (Nakanishi, 1999). It is the policy of the Japanese government to create a society in which each individual can fulfil their *ikigai* (Prime Minister's Office of Japan, 2019). Although the English language cannot precisely capture the nuance of *ikigai*, it basically means having a purpose in life or the sense that life is worth living (Lomas, 2016). *Ikigai* can be used to describe specific experiences that include future-oriented actions and confer a sense of worth and happiness, as well as the sense of fulfilment and joy that is derived from the cognitive evaluation of such experiences (Maeda et al., 1979). The well-being of Japanese people can be understood as encompassing both happiness and *ikigai*. When the subjective well-being of Japanese people is divided into hedonic and eudaimonic well-being, feelings of happiness are categorised as hedonic well-being, whereas feelings of *ikigai* are categorised as eudaimonic well-being (Kumano, 2018).

Ikigai has been considered to be an important factor in longevity (Alimujiang et al., 2019; Seki, 2001) and has been documented in Japanese studies to be associated with functional disability in the elderly as well as all-cause, external-cause, and cardiovascular mortality (Koizumi et al., 2008; Mori et al., 2017; Tanno et al., 2009). In addition, *ikigai* has been associated with family relationships, perception of good health, and social role fulfilment among older residents in rural communities (Hasegawa et al., 2003). *Ikigai* may also be applicable to non-Japanese cultures (Martela and Steger, 2016). As previous studies have clarified structural aspects of well-being from a cultural perspective, clarifying the concept of *ikigai* could have significance for understanding how psychological well-being can be maintained, regardless of cultural differences.

Physical activity as a predictor of subjective well-being

Rural and urban regional variations in physical activity. Previous studies have found evidence that physical activity is associated with better health and psychological well-being (Ekelund et al., 2016; Steven et al., 2006; Warburton and Bredin, 2019). Meanwhile, physical activity varies between urban and rural areas due to environmental factors, such as the built environment, weather, and the community (Chan et al., 2006; Hermosillo-Gallardo et al., 2017; Lee et al., 2009). According to a study using data from the population-based International Collaborative Study of Cardiovascular Disease in Asia, which assessed physical activity as vigorous activity, moderate activity, light activity, watching television, other sedentary activities, and inactivity/sleeping in 15,540 representative samples (aged 35 to 74 years) from urban and rural areas, rural residents in China were more likely to be physically active compared with urban residents (Muntner et al., 2005). A US study based on data from 178,161 respondents to the 2000 Behavioural Risk Factor Surveillance System found that achieving a recommended physical activity level was associated with degree of urbanisation and that higher non-leisure-time activity levels were observed in rural areas than in urban areas (Martin et al., 2005). These differences may reflect the built environment of neighbourhoods and regional differences in physical activity infrastructure and recreational opportunities (Carlson et al., 2018). In addition, related cost and safety concerns may be barriers to physical activity (Moore et al., 2010).

Significance of non-leisure-time physical activity for daily life and health. Regular physical activity is distinguished from leisure-time and non-leisure-time physical activity. Leisure-time physical activity includes physical activities such as exercise and recreation that are performed in any context other than those associated with one's job, housework, and transportation, whereas non-leisure-time physical activity includes physical activities associated with one's occupations, housework, and transportation. Although many related studies have focused exclusively on leisure-time physical activity, the majority of physical activity in middle-aged and older adults consists of non-leisure-time physical activity (Dong et al., 2004; Phongsavan et al., 2004). Data from the National Human Activity Pattern Survey in the US found that leisure-time physical activity accounted for only about 5% of the population's total energy expenditure ($n = 7515$, aged 18 years or older) (Dong et al., 2004). In addition, previous studies found that non-leisure-time physical activity consistently reduced substantial mortality risk in the US adult population, but leisure-time physical activity did not (Arrieta and Russell, 2008; Davis et al., 1994). Similarly, an independent positive association was found between non-leisure-time physical activity and longevity among older Taiwanese living in Tainan City (876 community-dwelling individuals aged 65 or older) (Lin et al., 2011).

The present study: physical activity in rural life and subjective well-being

Farming activity is affected by agricultural cycles and neighbourhood greenspace, and snow removal requires snow accumulation. Neighbourhood greenspace could contribute to the development of neighbourhood social cohesion, which has been proven to benefit people's health (Twohig-Bennett and Jones, 2018) and lead to a general sense of well-being due to the attractiveness of the living environment (Brown et al., 2013).

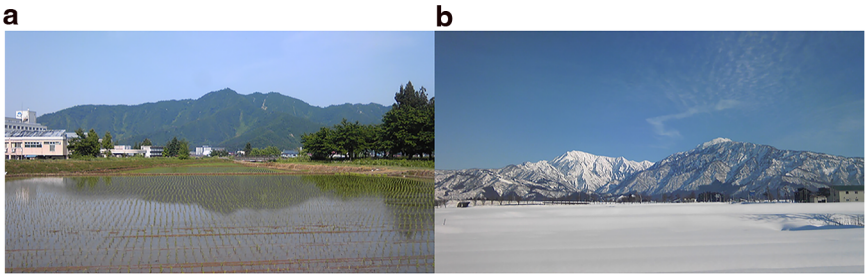

Fig. 1 Seasonal landscapes of the Uonuma area of Niigata Prefecture, Japan. Uonuma area in **a** the green season and **b** the snow season.

However, no study has investigated the relationship between snow removal and well-being, and little is known about the relationship between these daily physical activities and *ikigai*. To reveal the relationship between physical activity and subjective well-being in a community, culture-specific terms for well-being such as *ikigai* should be considered, as should important contributors to daily living activities such as farming activity and snow removal.

Farming activities and snow removal in Uonuma, Japan. In this study, we focused on the area in and around the city of Uonuma, in Niigata Prefecture, Japan, which we took to be representative of areas with abundant greenspace and snow accumulation in the corresponding seasons. Uonuma is located in a rural area in the south-central part of Niigata Prefecture, in north-eastern Japan. Although detailed characteristics of this area are described in the "Methods" section, its topography and climate result in abundant snow accumulation and subsequently abundant water from snowmelt, making the area a leading producer of rice in Japan. To our knowledge, no other part of Japan has such an even balance between farming and snowfall, so the Uonuma area is valuable because both farming activity and snow removal can be studied as daily physical activities.

Purpose of the present study. Against this backdrop, this study aimed to examine the relationship between physical activity and subjective well-being in terms of happiness and *ikigai*, focusing on farming activity and snow removal carried out by Uonuma residents. The study is based on data from the Uonuma cohort study, a large cross-sectional questionnaire survey conducted in the Uonuma area. Using these data, this paper explores the characteristics of farming activity and snow removal and tests the hypothesis that physical activity in rural life, particularly, farming activity and snow removal, would affect subjective well-being in terms of happiness and *ikigai* in community-dwelling Japanese adults.

Methods

Study setting. This study was based on cross-sectional data from the Uonuma cohort study, which was a population-based prospective cohort study that started in 2012 to 2014 in the Uonuma area of Niigata Prefecture, Japan. The methods of the Uonuma cohort study have been described in detail previously (Kabasawa et al., 2020). In the present study, we focused on Minamiuonuma City and Uonuma City in Niigata, Japan. Baseline surveys of residents (aged ≥ 40 years) living in Minamiuonuma City were conducted in fiscal years 2012 (Muikamachi area) and 2013 (Shiozawa-Yamato area); a baseline survey of residents living in Uonuma City was conducted in fiscal year 2014. At baseline, the Uonuma cohort study invited all 61,762 Minamiuonuma City and Uonuma City residents aged ≥40 years to complete a questionnaire and ultimately received consent from 39,761 (64.4%).

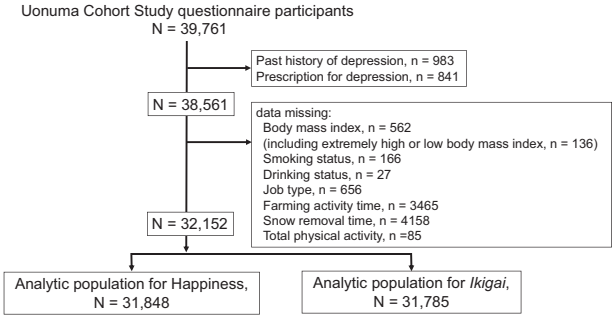

Fig. 2 Inclusion flowchart for study participants.

Between October and November of the baseline survey year, self-administered questionnaires in sealed envelopes were distributed to the residents and collected by hand in cooperation with the administrative district manager of each city. Some questionnaires were mailed subsequently. Informed consent was received from all participants. The study protocol was approved by the Research Ethics Committee of Niigata University (approval numbers 2012–1403 and 2013–1640).

Briefly, the characteristics of this area are as follows. Minamiuonuma City and Uonuma City are located in the Uonuma Basin (lat. 37° N and long. 139° E) and the annual average temperature was 10–11 °C at the time of the study. This area is the leading producer of rice in Japan and its landscape is usually green from spring to fall (Fig. 1a) but turns white in the winter with approximately 3–5 m of snow accumulation (one winter saw approximately 10 m of snow accumulation) (Fig. 1b). The Uonuma Basin has arable land and forests, which account for ~10% and 60% of Minamiuonuma City, and ~4% and 80% of Uonuma City, respectively (Ministry of Agriculture, Forestry and Fisheries, 2017). The area has abundant snow accumulation almost every year due to seasonal winds from Siberia that blow over the warm waters of the Sea of Japan and then hit the Echigo mountains, thereby bringing abundant snow to the area. Snowmelt leads to a stable supply of water and a favourable soil temperature during the summer, making the area ideal for. Minamiuonuma City and Uonuma City had a population of 58,568 (population density, 101.2 people/km^2) and 37,352 (39.5 people/km^2) as of 2015, respectively, compared with 810,157 (1115.3 people/km^2) in Niigata City, the prefectural capital. The proportion of elderly residents (aged ≥ 65 years) was 32.9% in Minamiuonuma City and 29.2% in Uonuma City, compared with 27.0% in Niigata City and 26.7% in Japan nationwide. Approximately 10.3% of the residents living in the area work as farmers, which is more than the Japanese national average of 3.4% (Statistics Bureau of Japan, 2015).

A flowchart of the study enrolment process is shown in Fig. 2. Participants were excluded from the study if they reported a history of depression, had a prescription for an antidepressant, or

had incomplete questionnaire data. Finally, the total number of analysed subjects was 31,848 for happiness and 31,785 for *ikigai*.

Measures. All participants were given self-administered questionnaires covering demographic characteristics, height, weight, smoking status, alcohol intake, and history of diseases. Sociodemographic characteristics included living status (alone or living with others), employment status (unemployed or employed), and education level. Occupation was classified as "farmer or fisher" or other. A summary of smoking status and alcohol intake was also obtained. Body mass index (BMI) was calculated by dividing self-reported body weight (kg) by self-reported height squared (m^2). Participants with extremely high or low BMI (three standard deviations [SD] from the mean BMI for each sex) were excluded. History of chronic conditions (self-reported malignancy of any type, cardiovascular disease, stroke, hypertension, diabetes, asthma, etc.) was summarised as whether a participant had any chronic disease or not. Total physical activity was assessed as the sum of metabolic equivalent of task (MET) × hours per day performing each daily and leisure activity. MET intensities were 4.5 given for vigorous physical work or strenuous exercise, 2.0 for walking or standing, 1.5 for sedentary activities, and 1.0 for sleeping. This index has been validated previously (Kikuchi et al., 2018).

Physical activity in rural life. The average time per week performing farming activity from May through November (green season) and performing snow removal from December through April (snow season) were assessed. In the questionnaire, the participants were asked the following, with no restriction on the type of farming activity or snow removal: "How many minutes per week do you spend on farming activity?" and "How many minutes per week do you spend on snow removal?" The total time spent on each activity type per week was calculated and then converted to time spent per day. Then, participants who responded with farming activity or snow-removal times that were excessive (more than 7 days a week or more than 1440 min per day including sleeping time) were excluded.

To validate the correlation between time spent on each activity type and intensity, participants in fiscal year 2014 were also asked about activity intensity (vigorous, moderate, or light). Responses from 5305 participants (3108 men and 2197 women) were obtained for farming activity and 7527 participants (4563 men and 2964 women) for snow removal. The total amount of activity was estimated as METs × hours per day by calculating time spent on each activity type per day multiplied by its MET intensity (for farming and snow removal, respectively): vigorous (6.0, 7.5), moderate (4.3, 5.3), and light (2.8, 2.5). Spearman's correlation coefficients for total time spent performing farming activity vs. total MET score (METs h/day), vigorous activity time, moderate activity time, and light activity time were 0.71, 0.54, 0.50, and 0.52 for men and 0.64, 0.45, 0.53, and 0.30 for women, respectively. Those for snow removal were 0.78, 0.58, 0.41, and 0.24 for men and 0.72, 0.54, 0.36, and 0.10 for women, respectively.

Happiness and *Ikigai*. Separate questions addressing happiness and *ikigai* were asked in the questionnaire. Participants were asked to subjectively respond to the questions, "To what degree do you feel happy?" and "To what degree do you have *ikigai*?" Responses were given on a 4-point scale. Responses for happiness were coded as very happy (1), happy (2), neither happy nor unhappy (3), and unhappy (4). Responses for *ikigai* were coded as have a lot of *ikigai* (1), have some *ikigai* (2), have a little *ikigai* (3), and have no *ikigai* (4) (Table 1).

Statistical analysis. Data were analysed between April and November 2019 using SAS statistical software (version 9.4, SAS Institute Inc., Cary, NC).

Characteristics of the participants according to quartile of time for farming activity and snow removal by sex are presented as means ± SD, medians (interquartile range), or numbers (percentage) (Tables S1 and S2). Physical activity for farming activity and snow

Table 1 Variables used in the analysis.

Variables	Unit	Description or coding
Dependent variables		
Happiness	4 ordinal scale	1 = very happy, 2 = happy, 3 = neither happy nor unhappy, 4 = unhappy
Ikigai	4 ordinal scale	1 = have a lot of *ikigai*, 2 = have some *ikigai*, 3 = have a little *ikigai*, 4 = have no *ikigai*
Independent variables		
Farming activity, min/day	None and Quartile	Quartile 1 refers to short and quartile 4 refers to long time spent on relevant activity
Snow removal, min/day	None and Quartile	Quartile 1 refers to short and quartile 4 refers to long time spent on relevant activity
Adjustment		
Age, years	10-year increments	1 = 40–49 years, 2 = 50–59 years, 3 = 60–69 years, 4 = 70–79 years, 5 = 80–89 years, and 6 = 90 years or older
Body mass index, kg/m^2	4 ordinal scale	1 = 18.5 kg/m^2 or lower, 2 = 18.5–24.9 kg/m^2, 3 = 25–29.9 kg/m^2, 4 = 30 kg/m^2 or higher
Survey year	2 dummy variable	Dummy 1 = survey in 2012(Muikamachi area), Dummy 2 = survey in 2013 (Shiozawa-Yamato area)
Total physical activity, METs·h/day	Quartile	Quartile of total time spent on physical activity
Smoking status	3 ordinal scale	1 = never smoker, 2 = past smoker, 3 = current smoker
Alcohol intake, g ethanol/week	4 ordinal scale	1 = none or rarely, 2 = 1–149 g ethanol/week, 3 = 150–299 g ethanol/week, 4 = 300–449 g ethanol/week, 5 = ≥ 450 g ethanol/week
Living alone	Yes or no	Yes = 1
Farmer or fisher	Yes or no	Yes = 1
Have any chronic diseases	Yes or no	Yes = 1. If yes, the subject provided responses on chronic diseases, such as history of malignancy of any type, cardiovascular disease of any type, stroke, hypertension, diabetes, asthma, chronic obstructive pulmonary diseases, chronic renal insufficiency, cataract, glaucoma, gastrointestinal polyp, gastroduodenal ulcer, chronic hepatitis, gall stone, urinary tract stone, sleep apnoea syndrome, and any type of fracture, etc.
Unemployed	Yes or no	Yes = 1
Educational level	4 ordinal scale	1 = junior high school, 2 = high school, 3 = junior college, 4 = university or higher

Table 2 Odds ratios (95% CI) of happiness according to farming activity (a) and snow removal (b), by sex.

(a) Farming activity, min/day						
Men	**None**	**Q1 (1–33)**	**Q2 (34–89)**	**Q3 (90–205)**	**Q4 (≥ 206)**	**[a]P for trend**
n	6970	2171	2077	1974	2325	
Crude	0.86 [0.78, 0.95]	1 (Ref)	0.97 [0.86, 1.09]	1.14 [1.01, 1.28]	1.26 [1.12, 1.41]	<0.001
Age-adjusted	0.86 [0.78, 0.94]	1 (Ref)	0.93 [0.83, 1.05]	1.04 [0.92, 1.18]	1.11 [0.99, 1.25]	0.048
[b]Multivariable	0.93 [0.84, 1.02]	1 (Ref)	0.95 [0.84, 1.07]	1.08 [0.95, 1.23]	1.17 [1.01, 1.35]	0.064
Women	**None**	**Q1 (1–33)**	**Q2 (34–85)**	**Q3 (86–179)**	**Q4 (≥ 180)**	**[a]P for trend**
n	10,107	1701	1286	1613	1624	
Crude	0.88 [0.79, 0.97]	1 (Ref)	1.06 [0.92, 1.22]	0.99 [0.87, 1.14]	1.13 [0.99, 1.29]	0.148
Age-adjusted	0.88 [0.79, 0.97]	1 (Ref)	1.04 [0.90, 1.20]	0.97 [0.84, 1.11]	1.09 [0.95, 1.25]	0.888
[b]Multivariable	0.91 [0.82, 1.01]	1 (Ref)	1.10 [0.95, 1.28]	1.04 [0.90, 1.20]	1.17 [1.001, 1.36]	0.714
(b) Snow removal, min/day						
Men	**None**	**Q1 (1–33)**	**Q2 (34–63)**	**Q3 (64–119)**	**Q4 (≥ 120)**	**[a]P for trend**
n	1586	3840	3211	2632	4248	
Crude	0.92 [0.82, 1.03]	1 (Ref)	0.98 [0.89, 1.07]	1.07 [0.97, 1.18]	1.01 [0.93, 1.10]	0.5204
Age-adjusted	0.79 [0.70, 0.88]	1 (Ref)	0.95 [0.87, 1.04]	0.99 [0.90, 1.09]	0.92 [0.84, 0.998]	0.070
[b]Multivariable	0.92 [0.81, 1.05]	1 (Ref)	0.95 [0.86, 1.04]	1.00 [0.90, 1.11]	0.93 [0.84, 1.02]	0.175
Women	**None**	**Q1 (1–20)**	**Q2 (21–50)**	**Q3 (51–102)**	**Q4 (≥ 103)**	**[a]P for trend**
n	6158	2363	2672	2852	2286	
Crude	0.99 [0.91, 1.09]	1 (Ref)	0.98 [0.88, 1.09]	0.83 [0.75, 0.93]	0.73 [0.65, 0.81]	<0.001
Age-adjusted	0.94 [0.86, 1.04]	1 (Ref)	0.97 [0.87, 1.08]	0.81 [0.73, 0.91]	0.70 [0.62, 0.78]	<0.001
[b]Multivariable	0.996 [0.90, 1.10]	1 (Ref)	0.999 [0.89, 1.12]	0.85 [0.76, 0.95]	0.75 [0.67, 0.85]	<0.001

Odds ratios and 95% CI were calculated using an ordinal logistic regression model.
[a]Trend analysis was performed by quartile of each physical activity, except the "none" category.
[b]In the multivariable model, the number of participants analysed was reduced to 768 men and 1144 women due to missing values.

removal was classified either as none or according to quartile of total time spent for each activity per day. Differences across quartiles were assessed by one-way analysis of variance for continuous variables and the chi-square test for categorical variables.

The association between each physical activity and degree of happiness or *ikigai* was assessed using an ordinal logistic regression model (McCullagh, 1980; Stewart et al., 2019). This model is similar to conventional logistic regression approaches except that an ordered categorical variable is treated as a dependent variable. Although the interpretation of the estimated regression slope is different and more complicated than that of conventional regression approaches, the assumption of intervals between scoring categories is no longer needed. Odds ratios (ORs) were estimated as crude, age-adjusted, and multivariable-adjusted values (Tables 2, 3, S3, and S4). The details of adjustment variables are shown in Table 1. Trend analysis was performed according to quartile of each physical activity except the "none" category. To ensure the robustness of the relationship with farming activity for those who were not farmers or fishers by occupation, similar ordinal logistic regression analysis calculating ORs of happiness and *ikigai* for farming activity was performed in the subpopulation excluding participants who were working as a farmer or fisher.

Results

The entire population that was analysed comprised men with a mean age of 62.5 (SD, 12.2) years and women with a mean age of 62.9 (SD, 12.8) years. After excluding participants who spent no time on farming activity or snow removal, the median time for farming activity and snow removal was 90.0 min/day ($n = 8631$) and 64.3 min/day ($n = 14{,}054$) for men and 85.7 min/day ($n = 6277$) and 51.4 min/day ($n = 10{,}242$) for women, respectively. The distribution of happiness and *ikigai* according to quartile of time spent on farming activity and snow removal by sex are shown in Fig. 3. The percentage of participants who answered very happy or happy was higher among those who reported spending a long time on farming activity than among those who reported spending a short or no time on farming activity in both sexes. A higher percentage of women who answered neither unhappy nor happy or unhappy was observed among those who reported no time spent on farming activity and those in the longest quartile of time spent on snow removal than among those in the shortest quartile (Fig. 3a). As for *ikigai*, the percentage of participants who answered that they had some or a lot of *ikigai* was higher among those who reported spending a long time on farming activity than among those who reported a short or no time spent on farming activity in both sexes. The highest percentage of participants who answered that they had little or no *ikigai* was observed among those who reported spending no time on snow removal in men (Fig. 3b).

Men who spent more time on farming activity were likely to be older, be married, have higher total physical activity, have a chronic disease, have a lower education level, be unlikely to be unhappy, be a current smoker, have no *ikigai*, and live alone. Women who spent more time on farming activity were likely to be older, be non-drinkers, have higher total physical activity, have a lower education level, and be unlikely to be a current smoker (Table S1; all $P < 0.05$). For snow removal characteristics, men who spent no time on snow removal were likely to be older, be thinner, be unhappy, be a non-drinker, be unemployed, have lower total physical activity, have a chronic disease, live alone, have no *ikigai*, be unlikely to be a current smoker, be a farmer or fisher, and be married. Women who spent no time on snow removal were likely to be older, be a non-drinker, be very happy, be unemployed, have lower total physical activity, have a chronic disease, not be a current smoker, and not be a farmer or fisher (Table S2; all $P < 0.05$). Men who reported spending more time on snow removal than those who reported a shorter time spent on snow removal were likely to be older, be a farmer or fisher, be unemployed, be married, have higher total physical activity, have a chronic disease, and have a lower education level. Women who reported spending more time on snow removal than those who reported a shorter time spent on snow removal were more likely to be older, be unhappy, be a non-smoker, be a non-drinker, be a farmer or fisher, be unemployed, have higher total physical

Table 3 Odds ratios (95% CI) of *ikigai* according to farming activity (a) and snow removal (b), by sex.

(a) Farming activity, min/day

Men	**None**	**Q1 (1–33)**	**Q2 (34–89)**	**Q3 (90–205)**	**Q4 (≥206)**	**[a]P for trend**
n	6970	2171	2075	1974	2320	
Crude	0.86 [0.78 to 0.95]	1 (Ref)	1.06 [0.94 to 1.20]	1.27 [1.12 to 1.44]	1.57 [1.39 to 1.77]	<0.001
Age-adjusted	0.86 [0.78 to 0.95]	1 (Ref)	1.03 [0.91 to 1.17]	1.19 [1.05 to 1.36]	1.44 [1.27 to 1.63]	<0.001
[b]Multivariable	0.92 [0.83 to 1.02]	1 (Ref)	1.03 [0.91 to 1.17]	1.17 [1.02 to 1.34]	1.29 [1.11 to 1.50]	0.003
Women	**None**	**Q1 (1–33)**	**Q2 (34–85)**	**Q3 (86–179)**	**Q4 (≥180)**	**[a]P for trend**
n	10,084	1689	1280	1606	1616	
Crude	0.83 [0.75 to 0.93]	1 (Ref)	1.13 [0.97 to 1.31]	1.11 [0.96 to 1.28]	1.41 [1.22 to 1.62]	<0.001
Age-adjusted	0.83 [0.75 to 0.92]	1 (Ref)	1.13 [0.97 to 1.32]	1.12 [0.97 to 1.29]	1.42 [1.22 to 1.64]	0.005
[b]Multivariable	0.90 [0.80 to 1.00]	1 (Ref)	1.14 [0.98 to 1.34]	1.09 [0.94 to 1.27]	1.42 [1.20 to 1.67]	0.114

(b) Snow removal, min/day

Men	**None**	**Q1 (1–33)**	**Q2 (34–63)**	**Q3 (64–119)**	**Q4 (≥120)**	**[a]P for trend**
n	1586	3838	3209	2630	4247	
Crude	0.69 [0.61 to 0.78]	1 (Ref)	1.02 [0.93 to 1.13]	1.12 [1.01 to 1.24]	1.12 [1.03 to 1.23]	0.004
Age-adjusted	0.59 [0.53 to 0.67]	1 (Ref)	1.00 [0.90 to 1.10]	1.04 [0.94 to 1.16]	1.02 [0.93 to 1.12]	0.821
[b]Multivariable	0.74 [0.65 to 0.84]	1 (Ref)	0.97 [0.88 to 1.07]	1.01 [0.91 to 1.13]	0.96 [0.87 to 1.06]	0.465
Women	**None**	**Q1 (1–20)**	**Q2 (21–50)**	**Q3 (51–102)**	**Q4 (≥103)**	**[a]P for trend**
n	6138	2353	2662	2842	2280	
Crude	0.84 [0.76 to 0.93]	1 (Ref)	0.97 [0.87 to 1.09]	0.91 [0.81 to 1.02]	0.83 [0.74 to 0.94]	0.001
Age-adjusted	0.80 [0.72 to 0.89]	1 (Ref)	0.96 [0.86 to 1.08]	0.89 [0.80 to 1.00]	0.80 [0.71 to 0.91]	<0.001
[b]Multivariable	0.85 [0.77 to 0.95]	1 (Ref)	0.94 [0.84 to 1.06]	0.87 [0.77 to 0.98]	0.78 [0.69 to 0.88]	<0.001

Odds ratios and 95% CI were calculated using an ordinal logistic regression model.
[a]Trend analysis was performed by quartile of each physical activity, except the "none" category.
[b]In the multivariable model, the number of participants analysed was reduced to 764 men and 1135 women due to missing values.

activity, have a chronic disease, live alone, and have a lower education level, and were less likely to be married (Table S2).

The association between each physical activity and happiness is shown in Tables 2 and S3. In the multivariable ordinal logistic regression analysis, the fourth quartile of farming activity was associated with happiness in men and women (adjusted odds ratio for the first vs. fourth quartile of time spent on farming activity for men = 1.17, 95% confidence interval [CI] = 1.01, 1.35; women = 1.17, 95% CI = 1.001, 1.36) (Fig. 4a). However, more time spent on snow removal was inversely associated with happiness in women only (P-trend < 0.001).

The association between each physical activity and *ikigai* is shown in Tables 3 and S4. The fourth quartile of farming activity was associated with *ikigai* in men and women (adjusted odds ratio for the first vs. fourth quartile of farming activity for men = 1.29, 95% CI = 1.10, 1.50; women = 1.42, 95% CI = 1.20, 1.67) (Fig. 4b). Compared with participants who reported snow removal, those who reported no snow removal exhibited a negative association with *ikigai* in men and women (adjusted odds ratio for the first quartile of time spent on farming activity vs. no time spent on farming activity for men = 0.74, 95% CI = 0.65, 0.84; women = 0.85, 95% CI = 0.77, 0.95) (Fig. 4b). Similar to the association with happiness, more time spent on snow removal was inversely associated with having *ikigai* in women only (P-trend < 0.001).

Similar ordinal logistic regression analysis was performed for the participants who did not work as farmers or fishers. In this multivariable model, the population that was analysed comprised 12,724 men and 14,752 women for happiness; 12,725 men and 14,704 women for *ikigai*. Adjusted ORs of happiness for the first vs. fourth quartiles of farming activity were 1.06 (95% confidence interval [CI] = 0.91, 1.24, P-trend = 0.432) in men and 1.17 (95% CI = 1.01, 1.35, P-trend = 0.678) in women. Those of having *ikigai* for the first vs. fourth quartile of farming activity were 1.16 (95% CI 0.98, 1.37, P-trend = 0.123) in men, and 1.34 (95% CI = 1.14, 1.57, P-trend = 0.171) in women.

Discussion

This study identified not only positive associations of more time farming with happiness and *ikigai* in both men and women but also inverse associations of more snow-removal time with happiness and *ikigai* in women only. Furthermore, not engaging in snow removal was demonstrated to be negatively associated with *ikigai* in men and women. This study provides a unique perspective on gender differences in the association between rural physical activity and subjective well-being.

Associations between farming activity and subjective well-being. Farming activity generally refers to plant-based activities such as growing fruits, vegetables, or other crops. In rural areas, farming activity is considered a type of community practice that can provide an opportunity for constructing social relationships. In the mental healthcare field, plant-based activities are used in horticultural therapy to promote social skills, self-esteem, and time spent on leisure activities (Smith, 1998). Among Japanese studies, Machida (2019) reported a positive association of home gardening with happiness and reason for living, which could be interpreted as *ikigai*, in Japanese elderly. Also, some studies have indicated a positive relationship between plant-based activities and mental health, such as psychological well-being, cognitive protection, and decreased sadness and anxiety (Infantino, 2004; Shiue, 2016; Tournier and Postal, 2014). Considering these findings together with the present results, plant-based activities including farming activity could have beneficial effects on subjective well-being, particularly happiness and *ikigai*, in both men and women.

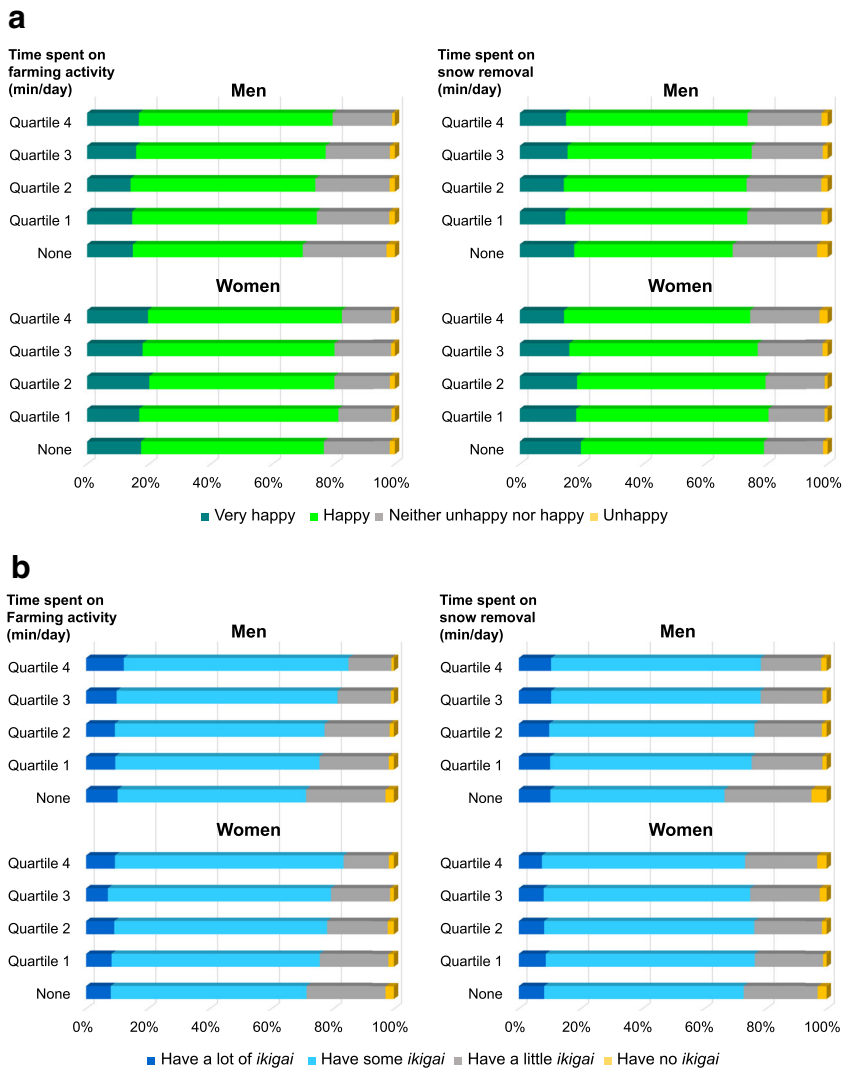

Fig. 3 Distribution of happiness and *ikigai* according to quartile of each physical activity in rural life. Distribution of happiness (**a**) and *ikigai* (**b**) according to quartile of time spent on farming activity and snow removal, by sex.

Associations between snow removal and subjective well-being. Snow removal and farming activity are similar in terms of providing an opportunity to engage in social relationships and physical activity; however, their effects were opposite for happiness and *ikigai* in this study. The difference between characteristics of farming activity and snow removal might have caused this result; that is, snow removal is considered an additional but necessary task for maintaining daily life, whereas farming activity is considered a vocation for farmers but a freely selectable activity for non-farmers. The varied relationship between farming activity and snow removal with subjective well-being could be positively influenced by economic benefits. In other words, farming activity such as growing vegetables and fruits could provide economic incentives for both sexes. Meanwhile, snow removal in the Uonuma area can provide part-time work in winter to supplement wages but such an opportunity would not traditionally be applied to women.

Gender differences in associations between snow removal and subjective well-being. This study observed clear gender differences in the relationship between snow removal and subjective well-being; namely, inverse associations were observed only in women. The traditional Japanese norm is "men at work and women at home", which may negatively affect women's subjective well-being if women feel trapped by gender role fulfilment. Moreover, societal expectations could worsen women's feelings of daily pressure due to gender role fulfilment in traditionally male-dominated societies (Batz-Barbarich et al., 2018). In terms of biological factors, it is to be expected that men and women have different stamina and patience to remove snow. Although physical activity plays an important role in subjective well-being, it is known to vary according to content and intensity level (Brajša-Žganec et al., 2011; Zhang et al., 2017). Zhang et al. (2015) found that men tended to engage in more diverse types of leisure activities than women; in other words, men had greater freedom in selecting and participating in various activities than women due to their differing degrees of expected fulfilment of family duties. Taken together, when snow removal is added to women's family duties, gender role fulfilment may become a stressful experience because it takes away from women's freedom, leading to reduced happiness (Segar et al. 2017).

Other differences in associations between physical activity and subjective well-being. Interestingly, this study found that not engaging in snow removal was inversely associated with *ikigai*, and a marginal negative association of no time spent engaged in farming activities with happiness as well as *ikigai*. This may relate to differences in background characteristics between participants

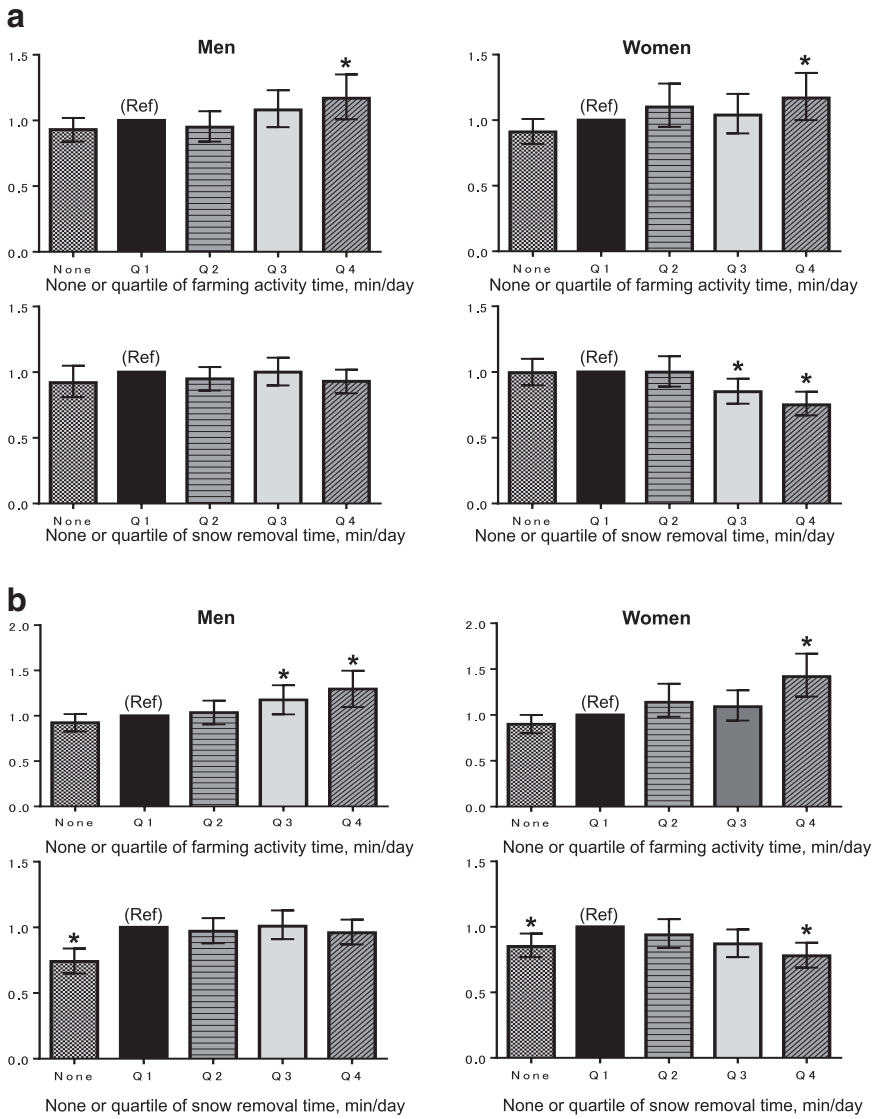

Fig. 4 The adjusted odds ratio of happiness and *ikigai* according to quartile of time spent on farming activity and snow removal. The adjusted odds ratio (95% CI) of happiness (a) and ikigai (b) are calculated by multivariable ordinal logistic regression analysis, by sex. The reference group is quartile 1, which the shortest amount of time on each physical activity. *95% confidence intervals (CI) of odds ratios do not include 1.00.

who do and do not engage in snow removal and farming activities. For example, those who did not engage in snow removal were likely to be older, have a chronic disease, be unemployed, live alone, be never smokers, and be non-drinkers; those who reported no time spent on farming activity were likely to be current smokers, be unmarried, and have a higher education level. Moreover, men feeling less subjective well-being when they do not or cannot perform snow removal may reflect that men feel economic incentives are insufficient and that they are not sufficiently fulfilling their expected gender role in the community. Not engaging in snow removal seems to be affected by physical limitations and low motivation for that activity, whereas no time spent on farming activities may relate to other activities such as one's job. In addition, one's drive and adaptability may affect this difference because low-intensity activity and the interchangeability of moderate and vigorous activity are important for improving life satisfaction (Wicker and Frick, 2017).

Difference between happiness and *Ikigai* in the relationship with physical activity. In this study, differences between happiness and *ikigai* were observed only in the absence of snow removal. This might mean that snow removal contributes to *ikigai* in the Uonuma area, but it might lead to less *ikigai* for women if it takes up more time than they can bear for their well-being. In a previous study that assessed factors associated with *ikigai* among older public temporary employees, physical condition and socioeconomic factors were significant factors for men, and family relations and life satisfaction were significant for women (Shirai et al., 2006). Given that snow removal might relate to socioeconomic factor for men and family duties for women, not removing snow could lead to compromised *ikigai* in the Uonuma area, where abundant snowfall is a part of life. Whether or not to farm is a decision that can be decided by the individual, but most people have no choice but to remove snow. Therefore, not removing snow may lead to less *ikigai* but not less happiness, because happiness is considered from a hedonic perspective whereas *ikigai* is considered from a eudaimonic perspective.

Future implication of the study. The results of the present study hold implications for future research because the study design could be applied to other places where physical activity is essential for people's lives. Although snow removal is specific to

the study area, similarly vigorous physical activity essential for living such as hunting and travelling long distances in the scorching heat to get water. Thus, our finding of a clear negative association between longer time spent removing snow and subjective well-being could be applied to these hard physical activities, especially for women. Our results also suggest the need to consider those who do not or cannot perform such physical activities as psychologically vulnerable populations who might be in need of assistance from the community. Vuong (2018) argued that modern society faces challenges in terms of the balance between the cost and benefit of science's contribution to society, but also stated that "the real value of science is in improving quality of life". To achieve psychological well-being in the community, performing chores and engaging in other physical activities that benefit the community, as well as practising gratitude and volunteering one's time can all be beneficial (Jackowska et al., 2016; Borgonovi, 2008). From the perspective of policy efforts to maintain or improve subjective well-being in the community, it may be useful to address environmental factors, such as providing opportunities for farming activity and support so that people can perform snow removal within the amount of time they would like to spend.

Thus, future work may involve a longitudinal evaluation of the association found in this study, as well as the specific forms or theories of measures such as social support frameworks that are culturally appropriate and effective for improving happiness and *ikigai* in rural communities. Many more studies are needed to determine effective approaches for achieving subjective well-being in rural communities along with understanding relevant environmental factors and traditional social norms. The factors identified in this study might provide anchors for interventions or other ideas for achieving subjective well-being in rural communities.

Limitations. A strength of the present study is that it is the first report to assess the relationship of physical activity in rural life (farming activity and snow removal) with happiness and *ikigai* separately in a large-scale population. However, the study also has some limitations. First, data were all self-reported, meaning that misclassification bias may have occurred. Second, this study was conducted in a Japanese rural area. Therefore, there is potential sociocultural bias due to the selection of the study area. Within the study area, even though there was adjustment for the survey area by year, farming activity and snow removal depend on weather, which differs from one year to the next, and other environmental factors. Also, our results may be affected by uncertainty in the impacts of climate change. Third, although there was adjustment for major confounding factors of happiness and *ikigai*, we could not control for unmeasured potential confounders, such as personality and disability. Finally, the study design was cross-sectional, so causal relationships could not be determined.

Conclusion

This study revealed the association of physical activity in rural life with subjective well-being in terms of happiness and *ikigai* in community-dwelling adults. Notably, a gender difference was found, with men and women exhibiting different associations of more snow-removal time with happiness and *ikigai*. Considering our findings together with previous studies, farming activity could be protective for psychological health in rural life. Meanwhile, this study suggests that physical activity in rural life induced by environmental stress such as snow removal may negatively affect subjective well-being. This may provide indicators for who in the rural community should be considered vulnerable in terms of psychological well-being.

Data availability

All data generated or analysed during this study are included in this published article.

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Competing interests

The authors declare no competing interests.

Additional information

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