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Community Gardens as Health Promoters: Effects on Mental and Physical Stress Levels in Adults with and without Mental Disabilities

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Abstract: The study focuses on psychological and physical effects of stress while performing community garden activities of various intensity levels. The aim of this study was to determine the psychological and physical effects in adults with (case group) and without (control group) mental disabilities. Salivary α-amylase (sAA) levels and the stress response scale (SRS-18) were used for the psychological analysis (n = 42). For physical assessment (n = 13), electrocardiogram (ECG), surface electromyogram (sEMG), and respiration rate were continuously measured while performing the activities using a multichannel telemetry system. The results showed that following the activities, the case group exhibited decreasing sAA levels while control group exhibited increasing sAA levels. However, both groups exhibited lower SRS-18 results following the activities. Compared with the control group, the case group had a significantly lower increase in the ratio of the heart rate (IRHR) (5.5%) during low-intensity work (filling pots with soil), but a significantly higher IRHR (16.7%) during high-intensity work (turning over soil). The case group experienced significantly higher levels of fatigue during high-intensity work (digging) than during the rest condition. These findings indicate that appropriate workload allocation, according to health, is necessary in the community garden setting because reducing the intensity of work assignments for people with mental disabilities will reduce their physical stress.

Keywords: community gardens; mental disabilities; psychological stress; physical stress; salivary α-amylase; SRS-18; ECG; sEMG; breathing rate

1. Introduction

Health and well-being are important aspects of the cultural domain of urban sustainability [1]. One of the goals of urban sustainability is to improve the quality of life; therefore, policy-makers use a set of urban quality of life principles to address environmental, physical, mobility, social, psychological, economic, and political interests [2]. One aspect of the environmental, social, and psychological urban quality of life goals is the ability to enjoy natural landscapes and green areas, providing public gathering places to promote good relationships and interactions between people, along with the opportunity for people to have a place of their own by providing the ability to personalize the space [2]. These aspirations can be provided by community gardens.

As health promoters, community gardens provide many types of health and well-being benefits. The provision of food security for the community, a therapeutic landscape, and increased social activity are often discussed as key benefits. Community gardens can also help overcome food desert problems for mature and inner-suburban neighborhoods [3] by giving participants access to fresh foods [3–6] and increasing fruit and vegetable consumption [7,8]. Food deserts have been associated with an increase in obesity [9], which increases the risk of many physical and mental diseases. Community gardens also enhance social relationships between members by giving a sense of belonging [10] and improving healthy behaviors [7,11,12]. In addition, community gardens may provide therapeutic experiences, with volunteers recommending this activity to reduce stress [6,12]. However, although previous studies have investigated the impact of gardens, orchards, and forests on stress levels [13–15] and several studies have considered gardening as a physical activity promoter, but not among adults with mental disabilities.

Working in a community garden brings benefits not only in terms of mental restoration, but also for physical health. According to the exercise and physical activity guide for health promotion that was provided by the Ministry of Health, Labor and Welfare of Japan in 2006, gardening can be considered a moderate to high-intensity non-exercise activity that burns approximately three metabolic equivalents (METs) or more [16]. Gardening tasks that use both the upper and lower body have been shown to burn 3–4.5 METs in older adults [17]; therefore, these tasks can meet the physical activity recommendations from the Centers for Disease Control and Prevention, American College of Sport Medicine, for moderate-intensity physical activity for older adults (3.8 ± 1.4 METs) [18,19]. Even gardening tasks that only use the upper body burn 1.7–2.9 METs in older adults [17]. Furthermore, results from the Short-Form 36 health survey (SF-36) showed that gardening can promote hand strength, pinch force, and overall physical health [19].

The benefits of community gardens have already been proven for people without disabilities[3–8,10–12]. However, fewer studies have considered those with mental disabilities. In 2014, there were 3,175,000 patients with mental and behavioral disorders in Japan; 773,000 of whom were suffering from schizophrenia, schizotypal, and delusional disorders [20]. Males represented a significantly greater proportion of this group than females [21]. Pharmacological or medicinal treatments are still the main therapies for schizophrenia [22,23], but some patients still experience symptoms. Many studies have indicated that psychosocial intervention can reduce psychotic symptoms [22], and it has been shown that horticultural therapy leads to a greater reduction in the depression anxiety stress scale (DASS21) in schizophrenia patients than the standard treatment for schizophrenia [23,24]. However, there is still insufficient evidence for this effect, so it requires further exploration.

The majority of the general public in Japan keeps a greater social distance from individuals with mental illness [25]. Schizophrenia is more stigmatized than depression, and the severity of the illness increases the negative attitude towards it [25]. To overcome this problem, direct social contact with people with mental illness is needed for both people with and without disabilities [25]. In addition, to reduce premature mortality and prevent physical health problems, increasing physical activity of people with schizophrenia is important [26,27]. Overweight and obese adults with schizophrenia or schizoaffective disorders engaged in unstructured intermittent low physical activity and were significantly less active [28].

Community gardens represent a promising approach for promoting physical activity. The aim of this study was to determine psychological and physical effects of stress in adults with and without disabilities while performing community garden activities. This evidence can promote the development of mental and physical intervention for people with mental disabilities.

2. Materials and Methods

2.1. Research Design

This study on community garden activities was conducted at the Center for Field Science Research and Education (FSC), Ibaraki University, Japan, with support from the College of Agriculture, Ibaraki University, and Ibaraki Prefectural University of Health Sciences. Community garden activities have been held since 2014 and still continue.

A case-control quasi-experimental design was used in this study [29,30]. The independent variables are the various garden activities and the dependent variables are the specific objective and health outcomes. All subjects volunteered to participate, and the study was approved by the human research ethics committees of Ibaraki University. Stressors, stress responses, and individual characteristics (personal resources, behavior patterns, and coping styles) are all important factors that should be considered when measuring stress [31]. A stressor can be defined as a perceived threat to an organism, and the response to this perceived threat is called the stress response [32]. Stressors can be psychological or physical, and the stress response includes sympathetic arousal, which is an increase in physical factors such as the heart rate, blood pressure, and muscle activity [31]. To determine the psychological stress response, we conducted a sympathetic arousal test using salivary α-amylase (sAA) analysis and carried out a self-assessment questionnaire of the psychological state (SRS-18). To determine the physical stress response, we measured heart rate, respiration rate, and muscle activity.

2.2. Participants

The study participants ranged in age, gender, occupation, and disability status. They included local volunteers and students from the Ibaraki University College of Agriculture as the control group and outpatient psychiatric day care patients of Ibaraki Prefectural University of Health Sciences Hospital as the case group. In this study, the case group suffered from schizophrenia and organic mental disorders [33] with severity levels from mild to moderate [34]. They have been suffering from mental disability for 6–29 years. The control group is defined as people without mental disabilities. For psychological assessment in 2014, the total number of participants for the case and control groups was 28 people, including males and females. There was a 3:1 ratio for male and female participants. The case group consisted of 11 adults (mean age, 37 $\pm$ 10 years) with mental disabilities and the control group included 17 adults (mean age, 32 $\pm$ 19 years) without disabilities (four volunteers and 13 students). Participant numbers varied for psychological and physical assessment because of lower participation in 2016 data, particularly on the control group in community garden activity. However, some participants in 2014 also participated in the 2016 activity. For physical assessment in 2016, data of male participants in the 2014 activity was used as the number of male participants was higher. The total number of participant was 13 males, the case group consisted of six adult males (mean age, 37 $\pm$ 12 years old), while the control group included seven adult males without disabilities (mean age, 29 $\pm$ 10 years old). All participants were right-handed.

2.3. Psychological Assessment

2.3.1. Procedure

Garden activities were conducted every Wednesday from 10 a.m. to 12 p.m. Each individual played a role in establishing the garden, and they grew vegetables and maintained some fruit orchards and greenhouses at FSC. The participant engaged in this activity for seven months (May–December 2014). The participants were required to take part in community garden activities including crop cultivation, seedling preparation, transplanting, planting, weeding, inter-tillage, top-dressing, pillar standing, pest control, harvesting, and cleaning up. These activities were carried out throughout the year depending on weather conditions. The average temperature throughout the study period was 22.3 °C (minimum, 3.6 °C on 24 December; maximum, 33.2 °C on 20 August). Psychological assessment procedure is described in Figure 1. Salivary amylase test and SRS-18 evaluation were performed six times (28 May, 11 June, 9 July, 6 August, 3 September, and 1 October) from May to October 2014. There was a procedure explanation before activity. First, the participant answered the SRS-18 questionnaire and then took a salivary test before the activity. After the activity, the participant took the salivary test and then answered the SRS-18 questionnaire.

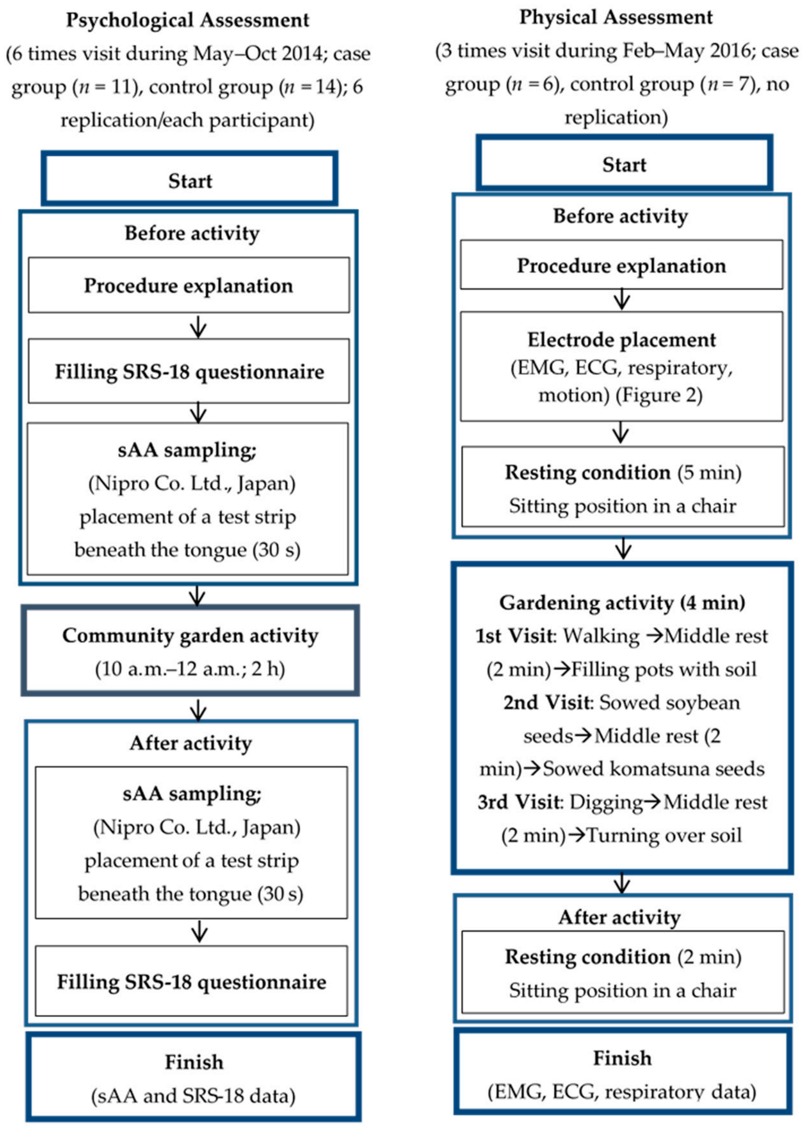

Figure 1. Psychological and physical assessment procedure.

2.3.2. Constructs and Measures

A portable salivary amylase monitor (Nipro Co. Ltd., Osaka, Japan) was used to analyze α-amylase (sAA) levels in the saliva before and after each activity. This equipment can automatically measure sAA with high accuracy within 1 min [35–37] via placement of a test strip beneath the tonguefor 30 s.

The self-assessment questionnaire of psychological state (SRS-18) developed by Suzuki et al., 1997 [38] was conducted to observe the emotional and behavioral status of each participant before and after the activity. This questionnaire has been used in previous studies to investigate the stress management behavior of Japanese university students [39], and to examine cultural differences in interpersonal stress experiences in students from Japan and the United States [40]. This questionnaire consists of 18 questions, for each of which the participants are asked to score their level of agreement with particular statements. These are then used to obtain depression-anxiety, irritability-anger, helplessness, and total scores.

2.3.3. Data Analysis

We compared with each result of sAA and SRS-18 in participants before and after community garden activities. One-way analysis of variance (ANOVA) was performed using SPSS 16.0 (SPSS Inc., Chicago, IL, USA). The Bonferroni correction was applied for monthly sampling data by dividing p-value (p = 0.05) by the number of sampling times (six times) to avoid a type-I error. $p < 0.008$ was considered to be statistically significant.

2.4. Physical Assessment

2.4.1. Procedure

Electrocardiogram (ECG), surface electromyogram (sEMG), and respiration rate measurements were monitored and recorded simultaneously and continuously while performing the gardening activities using a multi-channel telemetry system (WEB-7000®; Nihon Kohden, Tokyo, Japan; Figure 2). This unit includes four telemetry pickers (transmitters); one for muscle (sEMG); one ECG; one breathing wave; and one motion transmitter. The telemetry pickers were 25 mm wide, 34.5 mm high, and 12 mm deep, and weighed 10 g. They transmitted the signal to a bio-repeater (ZB-700H) mounted on the waist. The receiver (ZR-700H) received a waveform of the data from the bio-repeater, which was directly measured, monitored, and recorded by the QP-700H® software (Nihon Kohden, Tokyo, Japan), which was derived from spectral analysis and has previously been used to address questions related to fatigue [41]. This measurement system is completely cordless, allowing the participants to perform the tasks in a more natural and comfortable way, and preventing any noise from occurring due to shaking of the cord. The transmitters were attached to the body surface around the chest area (ECG), on specific muscles (sEMG), and in the nostril area (breathing transmitter). The motion transmitter was attached to the surface of the bio-repeater, which was mounted on the waist. The transmitters were attached using double-sided tape to obtain stable data without the need for skin pretreatment, which is usually required when using an active electrode system. Four specific muscles that have a dominant role in upper limb motion were analyzed in this study. The upper trapezius muscles on each side, which were shown to have higher activity in a previous horticultural activity motion study [42], and the deltoid muscles on each side were analyzed to provide an understanding of how the musculoskeletal loads were distributed [30].

Figure 1 describes physical assessment procedure. Participant age, height, and weight were obtained from the medical history and lifestyle management questionnaire which includes general health, medical history, and lifestyle (smoking, alcohol consumption, sleep duration, exercise rate, and horticulture activity) information. After reading the activity procedure, each participant began with a 5-min rest to obtain resting heart rate and breathing rate. The rest period occurred while sitting in a chair. Then, the gardening activity (Table 1) was performed for 4 min. The participant performed the 4-min work task naturally without any intervention. There was a 2-min rest period between each activity and a final rest period of 2 min. The 5-min initial rest period and 2-min rest between activities were found to be sufficient for the heart rate and muscles to return to their resting values. In total, participants performed six frequent gardening activities. These were separated into three groups of activities, each of which was performed on a different visit during February–May 2016: during the first visit, they performed the walking and filling pots with soil activities. During the second visit, they sowed soybean (*Glycine max*) seeds and komatsuna (*Brassica rapa* var. *perviridis*; also known as Japanese mustard spinach) seeds; and during the third visit, they performed the digging and turning over the soil activities. These measurements are not replicated. The first and second groups of activities were performed inside a building at a room temperature of 25 °C, while the third was performed outside the building at a mean temperature of 22 °C.

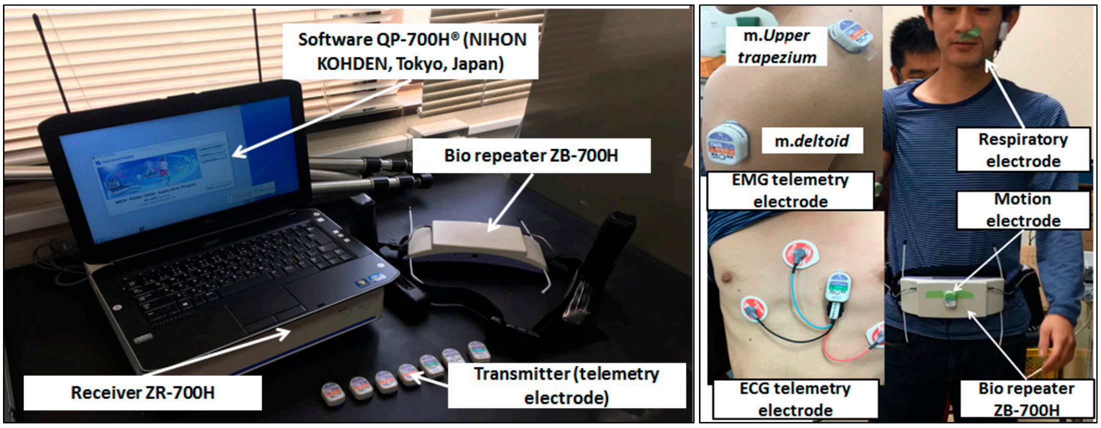

Figure 2. Multi-channel telemetry system and placement of each telemetry electrode.

Table 1. Description of the gardening activities performed in this study.

No.	Gardening Activity	Description
1	Walking	Walking while carrying a load (1 kg) in the right hand.
2	Filling pots with soil	Placing soil into pots (upper diameter: 10 cm; bottom diameter: 7 cm; height: 15 cm) using a trowel (squatting position).
3	Sowing big seed	Sowing soybean (glycine max) seeds in a 128-hole tray (3 cm × 3 cm) filled with soil by hand (standing position).
4	Sowing small seed	Sowing komatsuna (*Brassica rapa* var. *perviridis*) seeds in a 128-hole tray (3 cm × 3 cm) filled with soil by tweezers (standing position).
5	Digging soil	Digging soil using a shovel with both hands.
6	Turning over soil	Turning over soil with a shovel after digging with both hands.

2.4.2. Data Analysis

All of the signal data were sampled at a frequency of 1 kHz, and filtered with a pass band range of 15–500 Hz (sEMG data) [43], 30 Hz (ECG data), and 10 Hz (breathing data) by the QP-700H® software (Nihon Kohden, Tokyo, Japan). ECG data were analyzed using a self-developed program, Enthought Canopy 1.5.5 (Enthought, Inc., Austin, TX, USA) to determine the R-R interval. The increase in the ratio of the heart rate (IRHR) was used to compare the heart at rest and during the activities [44,45]. To analyze breathing rate, the breathing wave pattern that occurred while performing the activities was calculated. Previous studies have used the median frequency to analyze sEMG data [30,46]. Therefore, in this study, we used the QP-700H® software (Nihon Kohden, Tokyo, Japan) for median frequency analysis. To compare the physical parameters of the case group to the control group participants before and after the activities, one-way analysis of variance (ANOVA) was performed using SPSS 16.0 (SPSS Inc., Chicago, IL, USA). $p < 0.05$ was considered to be statistically significant.

3. Results

3.1. Psychological Assessment

The sAA values for the case group and control group before and after the community garden activities are shown in Figure 3. There was no significant difference in the sAA values before and after the activities for case group ($p < 0.8$) and control group ($p < 0.2$). Before the activities, the control group exhibited a lower sAA value than the case group (71.2 vs. 85.0 kIU/L), whereas alternating results were found among each group after the activities. Furthermore, while the sAA value of the control group increased after the activities, that of the case group decreased.

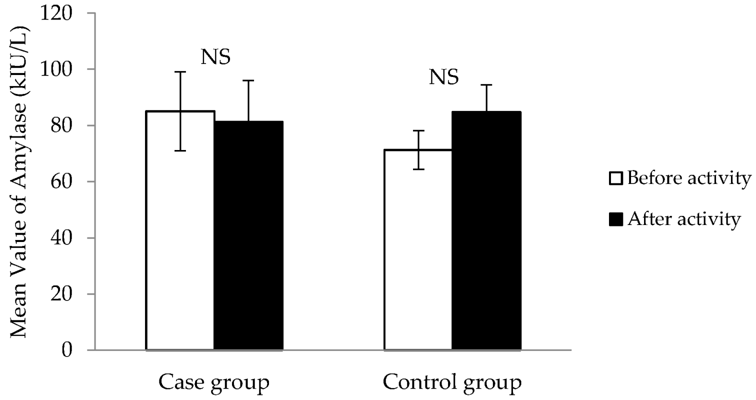

Figure 3. Salivary α-amylase (sAA) levels in each group before and after the activities.

Figure 4 compares the SRS-18 results before and after the activities for each group. For the case group, there was no significant difference in the helplessness before and after the activities, whereas these were significantly different for the control group, with significantly lower scores being obtained after the activities. There was no significant difference in the depression-anxiety and irritability-anger scores for each group before and after the activities, but this also decreased slightly following the activities. The total SRS-18 score, which combined the depression-anxiety, irritability-anger, and helplessness scores, was significantly lower after the activities in the control group. The total score for the case group also exhibited a slight decrease following the activities, but this was not significant.

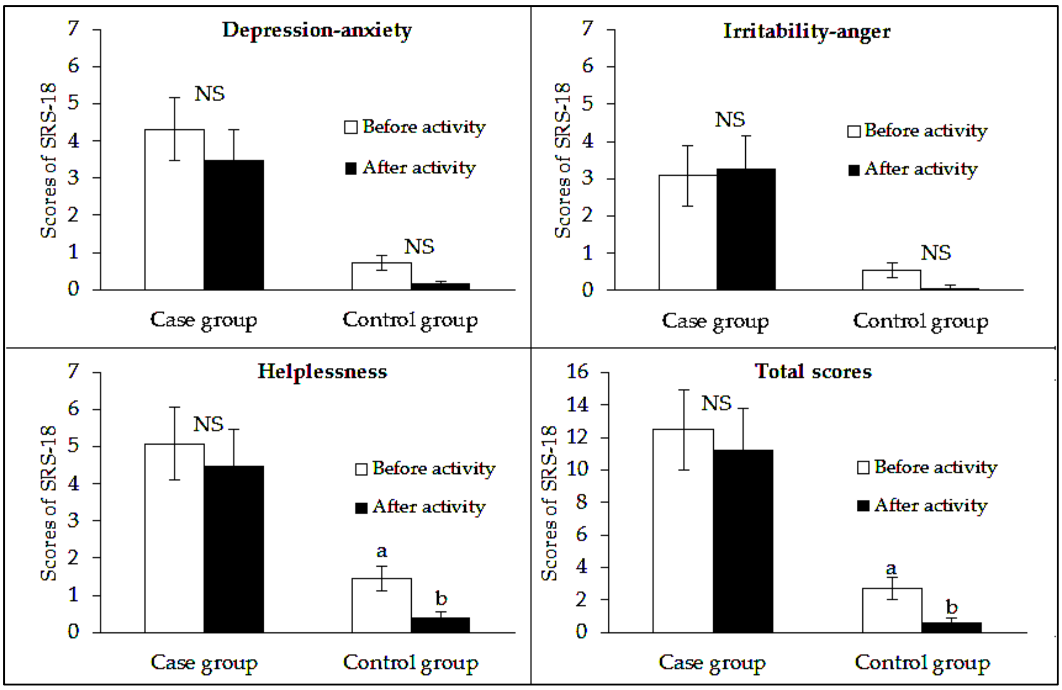

Figure 4. The stress response scale (SRS-18) results for the control group and case group before and after the activities. Bars with different lower-case letters are significantly different (ANOVA, $p < 0.008$).

3.2. Physical Assessment

There were no significant differences between the case group and control group in any of the baseline parameters, including age, height, body weight, body mass index (BMI), resting heart rate, and breathing rate (Table 2). Based on BMI, participants in both groups were not considered as obese [47].

Table 2. Descriptive characteristic of the subjects.

Variable *	Case Group (n = 6)		Control Group (n = 7)	
	Mean	SD	Mean	SD
Age (years)	37	14.2	29	10.3
Height (cm)	165.7	5.3	169.0	6.3
Body weight (kg)	67.3	10.2	71.3	9.9
Body mass index (kg·m^{-2})	24.6	4.2	25.0	3.3
Resting heart rate (beats/min)	75	9.7	72	14.7
Resting breathing rate (breaths/min)	16	1.7	16	1.6
Age-adjusted HR max (beats/min)	183	14.2	190	10.3

* There were no significant differences between the case and control groups for any of these parameters (ANOVA, $p > 0.05$); body mass index (BMI) = weight (kg)/(height (m))^2; age-adjusted maximum heart rate (HRmax) = 220−age (years).

Table 3 displays the achieved results after participants performed each of the six community garden activities (4 min work/activity). During the activity, sEMG, ECG, and breathing rate were simultaneously measured. There was no significant differences in the walking rate between groups, which included moderate-intensity walking [48], or in the rate of sowing komatsuna seeds ($p > 0.05$). There were, however, significant differences between the groups in the rate of filling pots with soil ($p < 0.001$), sowing soybean seeds ($p < 0.001$), digging ($p < 0.01$), and turning over the soil ($p < 0.01$), with the control group having significantly higher activity achievement rates than the case group.

Table 3. Activity achievements of the case group (n = 6) and control group (n = 7) in completing community garden activities.

Activity Achievement	Case Group (n = 6)		Control Group (n = 7)	
	Mean	SD	Mean	SD
Walking (steps/min)	94	16.4	122	30.4
Filling pots with soil (pots/min) **	3	0.6	5	0.5
Sowing soybean seeds (seeds/min) **	20	2.9	29	1.2
Sowing komatsuna seeds (seeds/min)	13	2.4	16	0.6
Shoveling (m/min) *	3.9	1	6.1	1.2
Turning soil (m/min) *	2.3	0.5	3.9	1.3

* $p < 0.05$; ** $p < 0.01$ (one-way ANOVA).

3.2.1. Increase in the Ratio of the Heart Rate (IRHR)

There was an increase in heart rate during all activities compared with the rest condition, with the largest increases being observed during the turning over the soil activity and the smallest occurring during the filling pots with soil activity. There were significant differences in IRHR between the control and case groups for all activities except walking (Figure 5). With respect to low-intensity activities, the IRHR of the case group was 5.5% lower during filling pots with soil, 2.9% lower during sowing komatsuna seeds, and 2.71% lower during sowing soybean seeds, compared with the control group. However, during high-intensity activities, the IRHR of the case group was significantly higher than that of the control group, increasing by 5.3% during digging and 16.7% during turning over the soil. Across all six activities, the highest IRHR occurred during turning over the soil, followed by digging, while the lowest occurred during filling pots with soil.

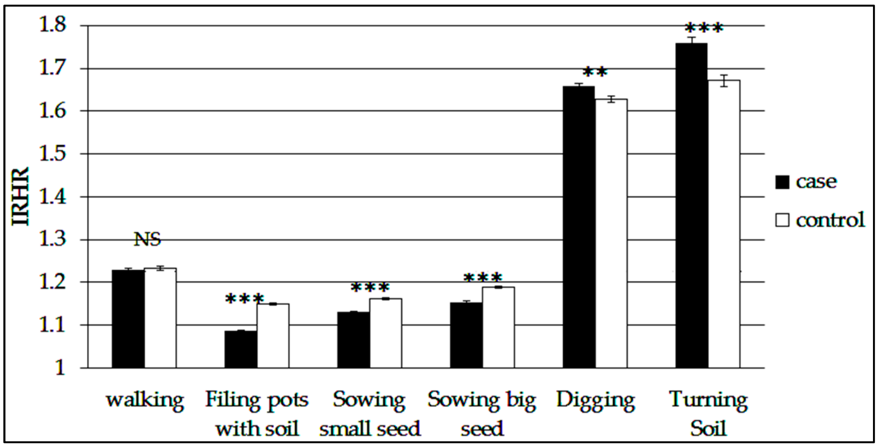

Figure 5. Increase in the ratio of the heart rate (IRHR) in the case and control groups during community garden activities. ** Significant at $p < 0.01$; *** significant at $p < 0.001$; NS: not significant (one-way ANOVA).

3.2.2. Correlation between the Increase in the Ratio of the Heart Rate (IRHR) and the Increase in the Ratio of the Breathing Rate (IRBR)

There was a significant correlation between the IRHR and IRBR during community garden activities for both groups ($p < 0.05$; Figure 6). The IRBR of the control group was consistently higher than that of the case group. High-intensity activities such as digging and turning over the soil led to higher values of both IRBR and IRHR compared with low-intensity activities, such as filling pots with soil, sowing seeds, and walking.

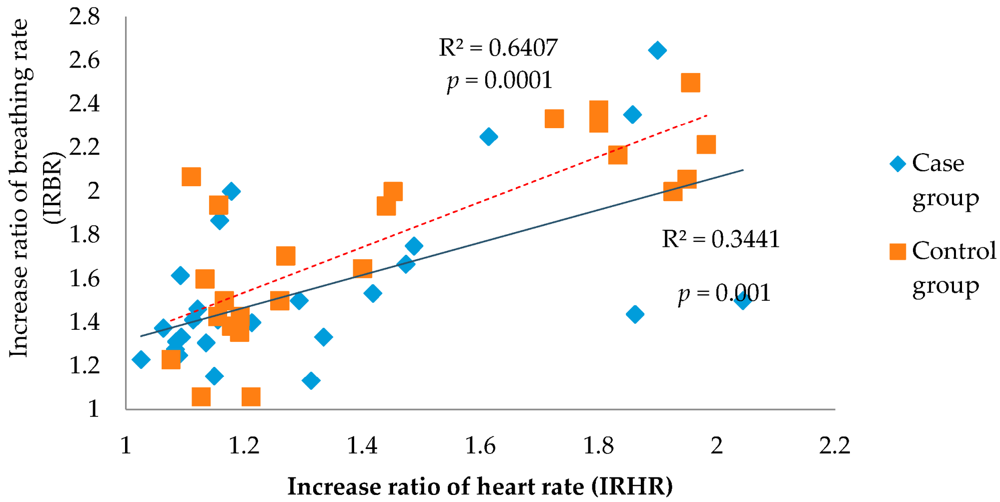

Figure 6. Correlation between the increase in the ratio of the heart rate (IRHR) and the increase in the ratio of the breathing rate (IRBR) during various community garden activities.

3.2.3. Muscle Activity

Figure 7 shows that persistent discharge patterns corresponding with little motion occurred while sowing seeds and filling pots with soil, whereas periodic discharge patterns corresponding with motion occurred while walking, digging, and turning soil.

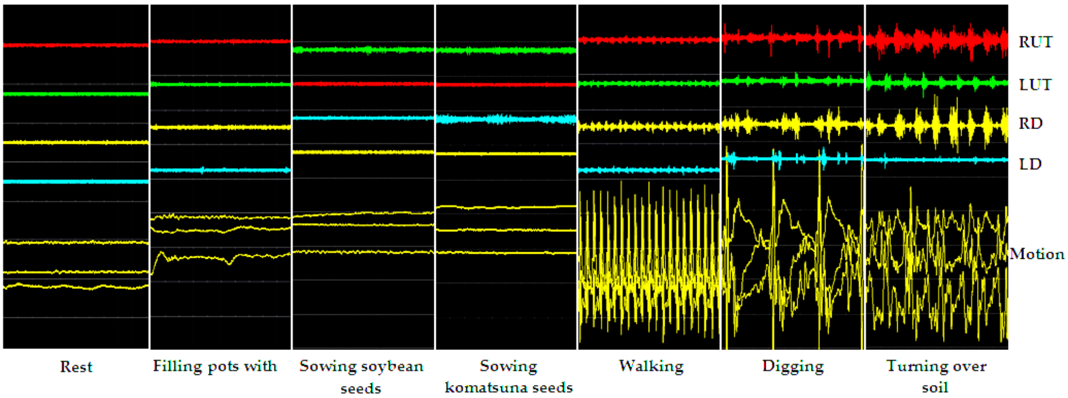

Figure 7. Electromyogram (EMG) discharge pattern during activity in the right m. upper trapezius (RUT), left m. upper trapezius (LUT), right m. deltoid (RD), and left m. deltoid (LD).

According to Figure 8, there were no significant differences between groups in the median frequency of the muscles during each activity. However, the case group experienced significantly higher levels of fatigue than the rest condition when performing high-intensity activities, such as digging and turning over the soil, whereas the control group exhibited significantly higher levels of fatigue compared with the rest condition during all activities except sowing seeds. There were no significant differences between the right- and left-hand sides in any of the activities, but the right muscles did tend to become more fatigued than the left. The one exception to this was for filling pots with soil, where the left upper trapezius muscle became more fatigued than the right muscle.

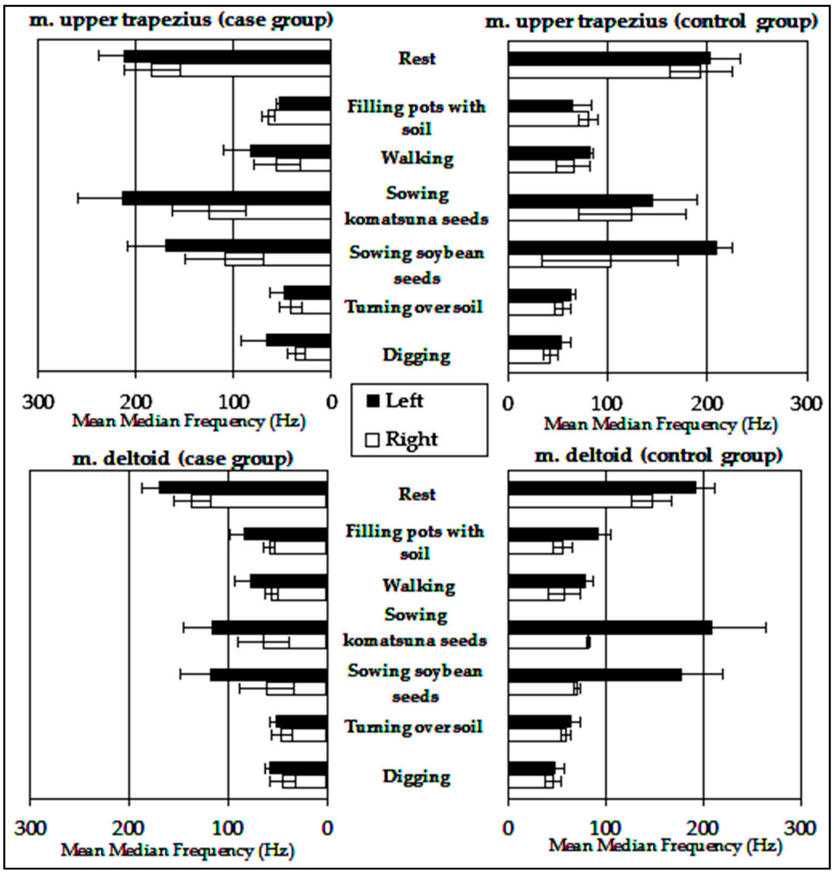

Figure 8. Mean median frequency (MF) of the m. upper trapezius and m. deltoid in the case and control groups.

4. Discussion

4.1. Psychological Assessment

Stress triggers the autonomic nervous system (ANS) to stimulate the sympathetic adrenal medullary (SAM) axis and hypothalamic pituitary adrenal axis (HPA) [49]. The HPA releases cortisol as a long-term reaction to stress [50,51], whereas the SAM releases α-amylase [49] as a short-term reaction to the types of stressors experienced in experimental situations [52]. Saliva sampling is a noninvasive, easy, and stress-free procedure [53], so levels of salivary cortisol have previously been used to assess endocrine activity [54,55]. However, since α-amylase responds more quickly and sensitively to psychological stress than cortisol [56], it has been widely used to quantify this [35,53,56–61].

Previous studies have indicated that the sAA levels of people who developed post-traumatic stress disorder (PTSD) following the East Japan earthquake decreased after taking care of plants (15 min/day) [55] and increased following exercise [62]. Similarly, in our current study, we found that the case group had reduced sAA levels after carrying out community garden activities despite no significant differences. Furthermore, the total SRS-18 scores also indicated that the community garden acted as a stress reducer for the case and control group. However, the control group experienced increased sAA levels, although there was no significant differences following the community garden activities. Yamaguchi et al. found that sAA increased with increasing levels of mental and physical fatigue [53], due to mental and physical stimuli activating the sympathetic nervous system [63–65].

4.2. Physical Assessment

All six of the community garden activities resulted in increased heart rates in adults with and without mental disabilities, supporting previous findings for gardening activities in adults and older adults [17–19]. Among these six activities, turning over the soil involved the most physical work, followed by digging, while filling pots with soil was the least strenuous. In terms of metabolic cost, Park et al. [17,66] explained that digging was a high- to moderate-intensity physical activity (6.6 ± 1.6 METs), while sowing seeds and filling pots with soil were low-intensity physical activities (1.7–2.9 METs) in children, adults, and older adults. Turning over the soil, digging, and sowing seeds were performed in a standing position, while filling pots with soil was carried out in a squatting position. Thus, body position affects heart rate [67], with a significant increase occurring when the posture changes from horizontal to vertical, as the highest rate occurred while standing ($p < 0.001$) [68].

The breathing rate and muscle activity also increased after the activities, as indicated by the respiration and EMG results. The breathing rate was significantly higher in both groups during digging and turning over the soil, which was similar to the observed IRHR result. The higher the breathing rate, the smaller the R-R interval and systolic blood pressure (SBP) [69], i.e., increases in the breathing rate are associated with an increase in heart rate. An intense periodic discharge pattern that was associated with higher levels of muscle activity was observed during high-intensity activities such as digging and turning over the soil, whereas a persistent discharge pattern that corresponded with lower muscle activity was observed during low-intensity activities such as sowing seeds and filling pots with soil. Low-frequency fatigue is characterized by a relative loss of force at low frequencies of stimulation and a slow recovery over the course of hours or days [70]. In the power density spectrum of the EMG (spectral analysis), the energy content is expressed as a function of frequency. Thus, the lower the median frequency value, the higher the level of fatigue. The lowest median frequency was observed during digging and turning soil, while the highest was observed while sowing seeds. During sustained contraction, the median frequency decreases more quickly in the non-dominant hand of right-handed individuals [71]. However, here, there was no significant difference in fatigue levels of the dominant (right arm) and non-dominant (left arm) muscles, indicating that both arms have an equal musculoskeletal load during community garden activities. Thus, these activities encourage muscle activity in both arms.

Walking is the most frequently reported physical activity among adults and meets the recommendations for regular physical activity [72]. It was also included in the list of recommended moderate-intensity physical activities produced by the Ministry of Health, Labor and Welfare of Japan [16]. However, based on the physical assessment in this study, the activities that are performed in a community garden can also provide a range of low- to high-intensity physical activities. Thus, community gardens provide the full range of physical activities compared with walking.

4.3. Comparison among Case and Control Groups through Community Garden Activities

The performance of the case group in filling pots with soil, sowing soybean seeds, shoveling, and turning over the soil differed from that of the control group in terms of the amount of work achieved. This difference was also reflected in the IRHR of the case and control groups, and was affected by the physical workload and levels of mental stress [44,45]. The findings showed that the case group experienced a significantly higher physical workload than the control group during high-intensity activities, such as digging and turning over the soil, but had a lower physical workload during low-intensity activities, such as filling pots with soil and sowing seeds. Previous studies showed that people with mental disabilities, such as schizophrenia, have lower physical activity levels than people without disabilities [26,73,74], and this was reflected in the findings of our current study. Although no significant difference was observed, the control group experienced increased sAA levels, while the case group experienced decreased levels. Similar findings were observed by Koibuchi and Suzuki that exercise up-regulates salivary amylase levels. In this case, community garden activities act as an exercise for the control group. Furthermore, although there were no significant differences between the two groups, the case group had significantly higher levels of fatigue than the rest condition after digging and turning the soil, while the control group had significantly higher levels of fatigue following nearly all of the activities in all of the muscles measured.

4.4. Implications for Task Allocation in Community Gardens

Community gardens have the potential to help people with and without mental disabilities to work collaboratively, enabling people without disabilities to gain a better understanding of those with disabilities and reduce the negative stigma attached to their conditions. In addition, they allow people with mental disabilities to increase their self-esteem and promote physical activity. In terms of physical health, the types of physical activity that can be provided by community gardens can prevent health problems, such as overweight and obesity [28] for people with mental disabilities. However, appropriate task allocation is important to reduce physical stress and prevent overload or unbalanced work in each group.

To improve the task allocation in community gardens, workload should be assigned according to the health characteristics of the participant. Specifically, high-intensity activities may create additional stress for people with mental disabilities. Based on 2008 Physical Activity Guidelines for America, adults with disabilities should be concerned about the amounts and types of physical activity they obtain and they should adapt their physical activity program to match their abilities [75]. Despite the study's sample sizes are small, the findings of the present study suggest that a reduction in high-intensity work assignments may have larger effects on reducing physical stress in people with mental disabilities than in those without (Figure 9). This result will help us to better manage community garden tasks to facilitate collaboration between those with and without mental disabilities.

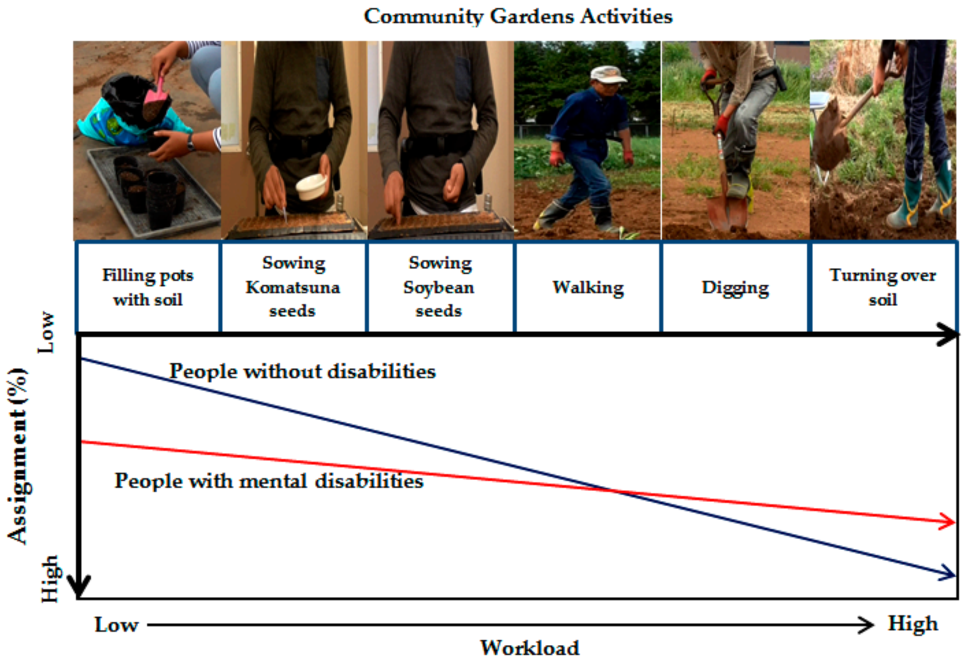

Figure 9. An approach to improving the task allocation in community gardens for people with and without mental disabilities.

5. Conclusions

This study showed that people with mental disabilities tended to experience higher levels of physical stress following community garden activities compared with those without mental disabilities. However, although the IRHR of this group was significantly higher during high-intensity work, it was significantly lower during low-intensity activities. Thus, appropriate workload assignment with a reduction in high-intensity activities is crucial to decreasing the physical stress of people with mental disabilities.

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References

1. James, P. Urban Sustainability in Theory and Practice. Circles of Sustainability, 2015. Available online: http://www.circlesofsustainability.org/wp-content/uploads/2014/10/Ch-08-Circles-Questionnaire-2015.pdp (accessed on 18 September 2016).
2. El Din, H.S.; Shalaby, A.; Farouh, H.E.; Elariane, S.A. Principles of urban quality of life for a neighborhood. *HBRC J.* **2013**, *9*, 86–92. [CrossRef]
3. Chen, D.; Jaenicke, E.C.; Volpe, R.J. Food environments and obesity: Household diet expenditure versus food deserts. *Am. J. Public Health* **2016**, *106*, 881–888. [CrossRef] [PubMed]
4. Amstrong, D. A survey of community gardens in upstate New York: Implications for health promotion and community development. *Health Place* **2000**, *6*, 319–327. [CrossRef]
5. Blair, D.; Giesecke, C.; Sherman, S. A dietary, social and economic evaluation of the Philadelphia Urban Gardening Project. *J. Nutr. Educ.* **1991**, *23*, 161–167. [CrossRef]

6. Pitt, H. Therapeutic experience of community gardens: Putting flow in its place. *Health Place* **2014**, *27*, 84–91. [CrossRef] [PubMed]
7. Twiss, J.; Dickinson, J.; Duma, S.; Kleinman, T.; Paulsen, H.; Rilveria, L. Community gardens: Lessons learned from California Healthy Cities and Communities. *Am. J. Public Health* **2003**, *93*, 1435–1438. [CrossRef] [PubMed]
8. Castro, D.C.; Samuels, M.; Harman, A.E. Growing healthy kids: A community garden-based obesity prevention program. *Am. J. Prev. Med.* **2013**, *44*, 193–199. [CrossRef] [PubMed]
9. Wang, H.; Qiu, F.; Swallow, B. Can community gardens and farmers' markets relieve food dessert problems? A study of Edmonton, Canada. *Appl. Geogr.* **2014**, *55*, 127–137.
10. Agustina, I.; Beilin, R. Community gardens: Space for interactions and adaptations. *Procedia Soc. Behav. Sci.* **2012**, *36*, 439–448. [CrossRef]
11. Teig, E.; Amulya, J.; Bardwell, L.; Buchenau, M.; Marshall, J.A.; Litt, J.S. Collective efficacy in Denver, Colorado: Strengthening neighborhoods and health through community gardens. *Health. Plc.* **2009**, *15*, 1115–1122. [CrossRef] [PubMed]
12. Hale, J.; Knapp, C.; Bardwell, L.; Buchenau, M.; Marshall, J.; Sancar, F.; Litt, J.S. Connecting food environments and health through the relational nature of aesthetics: Gaining insight through the community gardening experience. *J. Soc. Sci. Med.* **2011**, *72*, 1853–1863. [CrossRef] [PubMed]
13. Rodiek, S. Influence of an outdoor garden on mood and stress in older adults. *J. Ther. Hortic.* **2002**, *18*, 13–21.
14. Igarashi, M.; Miwa, M.; Ikei, H.; Song, C.; Takagaki, M.; Miyazaki, Y. Physiological and Psychological Effects of Viewing a Kiwifruit (*Actinidia deliciosa* 'Hayward') Orchard Landscape in Summer in Japan. *Int. J. Environ. Res. Public Health* **2015**, *12*, 6657–6668. [CrossRef] [PubMed]
15. Lee, J.; Park, B.J.; Tsunetsugu, Y.; Ohira, T.; Kagawa, T.; Miyazaki, Y. Effect of forest bathing on physiological and psychological responses in young Japanese male subjects. *Public Health* **2011**, *125*, 93–100. [CrossRef] [PubMed]
16. Ministry of Health, Labor and Welfare of Japan. Exercise and Physical Activity Guide for Health Promotion. 2006. Available online: http://www0.nih.go.jp/eiken/programs/pdf/exercise_guide.pdf (accessed on 3 June 2016).
17. Park, S.A.; Lee, K.S.; Son, K.C. Determining Exercise intensities of gardening task as a physical activity using metabolic equivalents in older adults. *HortScience* **2011**, *46*, 1706–1710.
18. Park, S.A.; Shoemaker, C.; Haub, M. Can older gardeners meet the physical activity recommendation through gardening? *HortTechnology* **2008**, *18*, 639–643.
19. Park, S.A.; Shoemaker, C.; Haub, M. Physical and psychological health conditions of older adults classified as gardeners or nongardeners. *HortScience* **2009**, *44*, 206–210.
20. Ministry of Health, Labor and Welfare of Japan. Handbook of Health and Welfare Statistic 2015: Total Number of Patients by Sex and Classification of Diseases. 2015. Available online: http://www.mhlw.go.jp/english/database/db-hh/xls/2-66.xls (accessed on 1 October 2016).
21. McGrath, J.; Saha, S.; Welham, J.; El Saadi, O.; MacCauley, C.; Chant, D. A systematic review of the incidence of schizophrenia. *BMC Med.* **2004**, *2*, 1–22. [CrossRef] [PubMed]
22. Chien, W.T.; Leung, S.F.; Yeung, F.K.K.; Wong, W.K. Current approaches to treatments for schizophrenia spectrum disorders, part II: Psychosocial interventions and patient-focused perspectives in psychiatric care. *Neuropsychiatr. Dis. Treat.* **2013**, *9*, 1463–1481. [CrossRef] [PubMed]
23. Liu, Y.; Bo, L.; Sampson, S.; Roberts, S.; Zhang, G.; Wu, W. Horticultural therapy for schizophrenia (review). *Cochrane Database Syst. Rev.* **2014**, *5*, 1–31.
24. Kam, M.C.Y.; Siu, A.M.H. Evaluation of a horticultural activity program for persons with psychiatric illness. *J. Occup. Ther.* **2010**, *20*, 80–86.
25. Ando, S.; Yamaguchi, S.; Aoki, Y.; Thornicroft, G. Review of mental-health-related stigma in Japan. *Psychiatry Clin. Neurosci.* **2013**, *67*, 471–482. [CrossRef] [PubMed]
26. McNamee, L.; mead, G.; MacGilivray, S.; lawrie, S.M. Schizoprenia, poor physical health and physical activity: Evidence-based interventions are required to reduce major health inequalities. *Br. J. Psychiatry* **2013**, *203*, 239–241. [CrossRef] [PubMed]
27. Richardson, C.R.; Faulkner, G.; McDevitt, J.; Skrinar, G.S.; Hutchinson, D.S.; Piette, J.D. Integrating physical activity into mental health services for persons with serious mental illness. *Psychiatr. Serv.* **2005**, *56*, 324–331. [CrossRef] [PubMed]

28. Janney, C.A.; Ganguli, R.; Tang, G.; Cauley, J.A.; Holleman, R.G.; Richardson, C.R.; Kriska, A.M. Physical activity and sedentary behavior measured objectively and subjectively in overweight and obese adults with schizophrenia or schizoaffective disorders. *J. Clin. Psychiatry* **2015**, *76*, 1277–1284. [CrossRef] [PubMed]
29. Harris, A.D.; McGregor, J.C.; Perencevich, E.N.; Furuno, J.P.; Zhu, J.; Peterson, D.E.; Finkelstein, J. The use and interpretation of quasi experimental studies in medical informatics. *J. Am. Med. Inform. Assoc.* **2006**, *13*, 16–23. [CrossRef] [PubMed]
30. Szeto, G.P.Y.; Straker, L.M.; O'Sullivan, P.B. EMG median frequency changes in the neck-shoulder stabilizers of symptomatic office workers when challenged by different physical stressors. *J. Electromyogr. Kinesiol.* **2005**, *15*, 544–555. [CrossRef] [PubMed]
31. Koh, K.B.; Park, J.K.; Cho, S. Development of the somatic stress response scale and its application in clinical practice. *Yonsei Med. J.* **2005**, *46*, 614–624. [CrossRef] [PubMed]
32. Schneiderman, N.; Ironson, G.; Siegel, S.D. Stress and health: Psychological, behavioral and biological determinats. *Annu. Rev. Clin. Psychol.* **2005**, *1*, 607–628. [CrossRef] [PubMed]
33. World Health Organization. *The ICD-10 Classification of Mental and Behavioural Disorders: Clinical Descriptions and Diagnostic Guidelines*; World Health Organ: Genewa, Switzerland, 1992; Available online: http://apps.who.int/iris/bitstream/10665/37958/8/9241544228_eng.pdf (accessed on 1 October 2016).
34. American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders (DSM-5)*; American Psychiatric Publish: Arlington, VA, USA, 2013.
35. Yamaguchi, M. Salivary sensors in point-of-care testing. *J. Sens. Mater.* **2010**, *22*, 143–153.
36. Minowa, C.; Koitabashi, K. Salivary alpha-amylase activity—An indicator of relaxation response in perioperative patients. *J. Nurs.* **2012**, *2*, 208–214. [CrossRef]
37. Fukusaki, M.; Miura, K.; Okada, M.; Araki, H.; Terao, Y.; Sumikawa, K. Objective assessment with salivary α-amylase activity of the effect of stellate ganglion block in the patients with cervical radiculopathy: 14AP7-1. *Eur. J. Anaesthesiol.* **2012**, *29*, 207–208. [CrossRef]
38. Suzuki, S.; Shimada, H.; Miura, M.; Katayanagi, K.; Umamo, R.; Sakano, Y. Development of a new psychological stress response scale (SRS-18) and investigation of the reliability and validity. *Jpn. J. Behav. Med.* **1997**, *4*, 22–29.
39. Nakamura, N. The relationships among stages of change for stress management, stress responses, self-efficacy, and frequency of stress-management behavior in Japanese university student. *J. Sch. Health* **2009**, *5*, 24–30.
40. Hashimoto, T.; Mojaverian, T.; Kim, H.S. Culture, interpersonal stress and psychological distress. *J. Cross-Cult. Psychol.* **2012**, *43*, 527–532. [CrossRef]
41. Soderberg, G.L.; Knutson, L.M. A guide for use and interpretation of kinesiologic electromyographic data. *J. Am. Phys. Ther. Assoc.* **2000**, *80*, 485–498.
42. Park, S.A.; Oh, S.R.; Lee, K.S.; Son, K.C. Electromyographic analysis of upper limb and hand muscles during horticultural activity motions. *HortTechnology* **2013**, *23*, 51–56.
43. Balasubramanian, V.; Adalarasu, K. EMG-based analysis of change in muscle activity during simulated driving. *J. Bodyw. Mov. Ther.* **2007**, *11*, 151–158. [CrossRef]
44. Syuaib, M.F.; Moriizumi, S.; Shimizu, H. Ergonomic study on the process of mastering reversible plow operation using ride-on tractor. *Jpn. J. Farm Work Res.* **2007**, *42*, 91–103. [CrossRef]
45. Syuaib, M.F.; Moriizumi, S.; Shimizu, H. Ergonomic study on the process of mastering tractor operation-rotary tillage operation using walking type tractor. *Jpn. J. Farm Work Res.* **2002**, *64*, 61–67.
46. Hermens, H.J.; Bruggen, T.A.M.V.; Baten, C.T.M.; Rutten, W.I.C.; Boom, H.B.K. The median frequency of the surface EMG power spectrum in relation to motor unit firing and action potential properties. *J. Electromyogr. Kinesiol.* **1992**, *2*, 15–25. [CrossRef]
47. World Health Organization. Obesity and Overweight. 2016. Available online: http://www.who.int/mediacentre/factsheets/fs311/en/ (accessed on 27 November 2016).
48. Rowe, D.A.; Welk, G.J.; Heil, D.P.; Mahar, M.T.; Kemble, C.D.; Calabro, M.A. Stride rate recommendations for moderate intensity walking. *Med. Sci. Sports Exerc.* **2011**, *43*, 312–318. [CrossRef] [PubMed]
49. Nater, U.M.; Rohleder, N. Salivary alpha-amylase as a non-invasive biomarker for the sympathetic nervous system: Current state of research. *Psychoneuroendocrinology* **2009**, *34*, 486–496. [CrossRef] [PubMed]
50. Ali, N.; Pruessner, J.C. The salivary alpha amylase over cortisol ratio as a marker to assess dysregulations of the stress systems. *Physiol. Behav.* **2012**, *106*, 65–72. [CrossRef] [PubMed]

51. Chrousos, G.P. Stress and disorders of the stress system. *Nat. Rev. Endocrinol.* **2009**, *5*, 374–381. [CrossRef] [PubMed]
52. Skoluda, N.; Strahler, J.; Schlotz, W.; Niederberger, L.; Marques, S.; Fischer, S.; Thoma, M.V.; Spoerri, C.; Ehlert, U.; Nater, U.M. Intra-individual psychological and physiological responses to acute laboratory stressors of different intensity. *Psychoneuroendocrinology* **2015**, *51*, 227–236. [CrossRef] [PubMed]
53. Yamaguchi, M.; Deguchi, M.; Wakasugi, J.; Ono, S.; Takai, N.; Higashi, T.; Mizuno, Y. Hand-held monitor of sympathetic nervous system using salivary amylase activity and its validation by driver fatigue assessment. *Biosens. Bioelectron.* **2006**, *21*, 1007–1014. [CrossRef] [PubMed]
54. Ng, V.; Koh, D.; Mok, B.Y.Y.; Chia, S.E.; Lim, L.P. Salivary biomarkers associated with academic assessment stress among dental undergraduateds. *J. Dent. Educ.* **2003**, *67*, 1091–1094. [PubMed]
55. Kotozaki, Y.; Takeuchi, H.; Sekiguchi, H.; Araki, T.; Takahashi, K.; Yamamoto, Y.; Nozawa, T.; Taki, Y.; Kawashima, R. Positive effects of the victim by the growing of plants after great east Japan earthquake. *Int. J. Recent Sci. Res.* **2015**, *6*, 2850–2858.
56. Yamaguchi, M.; Kanemori, T.; Kanemaru, M.; Takai, N.; Mizuno, Y.; Yoshida, H. Performance evaluation of salivary amylase activity monitor. *Biosens. Bioelectron.* **2004**, *20*, 491–497. [CrossRef] [PubMed]
57. Yamamoto, M.; Tokushige, A. Using salivary amylase to measure stress caused by urinating in diapres. *Aino J.* **2010**, *9*, 11–13.
58. Vineetha, R.; Pai, K.M.; Vengal, M.; Gopalakrishna, K.; Narayanakurup, D. Usefulness of salivary alpha amylase as a biomarker of chronic stress and strees related oral mucosal changes-a pilot study. *J. Clin. Exp. Dent.* **2014**, *6*, 132–137. [CrossRef] [PubMed]
59. Yamaguchi, M.; Kanemori, T.; Kanemaru, M.; Mizuno, Y.; Yoshida, H. Correlation of stress and salivary amylase activity. *J. Med. Electron. Biol. Eng.* **2001**, *39*, 234–239.
60. Yamaguchi, M.; Kanemaru, M.; Kanemori, T.; Mizuno, Y. Flow-injection-type biosensor system for salivary amylase activity. *Biosen. Bioelectron.* **2003**, *18*, 835–840. [CrossRef]
61. Yamaguchi, M.; Kanemori, T.; Kanemaru, M.; Mizuno, Y.; Takai, N. The Influence of Physical Stress on Amylase Activity in Human Saliva. *Life Support* **2003**, *15*, 4–11. [CrossRef]
62. Koibuchi, E.; Suzuki, Y. Exercise upregulates salivary amylase in humans (Review). *Exp. Ther. Med.* **2014**, *7*, 773–777. [PubMed]
63. Appenzeller, O. The autonomic nervous system and fatigue. *Funct. Neurol.* **1987**, *2*, 473–485. [PubMed]
64. Chrousos, G.P.; Gold, P.W. The concepts of stress and stress system disorders. *JAMA* **1992**, *267*, 1244–1252. [CrossRef] [PubMed]
65. Elenkov, I.J.; Wilder, R.L.; Chrousos, G.P.; Vizi, E.S. The sympathetic nerve—An integrative interface between two supersystems: The brain and the immune system. *Pharmacol. Rev.* **2000**, *52*, 595–638. [PubMed]
66. Park, S.A.; Lee, H.S.; Lee, K.S.; Son, K.C.; Shoemaker, C.A. The metabolic cost of gardening tasks in children. *HortTechnology* **2013**, *23*, 589–594.
67. Watanabe, N.; Reece, J.; Polus, B.I. Effect of body position on autonomic regulation of cardiovascular function in young, healthy adults. *Chiropr. Osteopat.* **2007**, *15*, 1–8. [CrossRef] [PubMed]
68. Jones, A.Y.M.; Kam, C.; Lai, K.W.; Lee, H.Y.; Chow, H.T.; Lau, S.F.; Wong, L.M.; He, J. Changes in heart rate and r-wave amplitude with posture. *Chin. J. Physiol.* **2003**, *46*, 63–69. [PubMed]
69. Pitzalis, M.V.; Mastropasqua, F.; Massari, F.; Passantino, A.; Colombo, R.; Mannarini, A.; Forleo, C.; Rizzon, P. Effect of respiratory rate on the relationships between RR interval and systolic blood pressure fluctuations: A frequency-dependent phenomenon. *Cardiovasc. Res.* **1998**, *38*, 332–339. [CrossRef]
70. Jones, D.A. High and low frequency fatigue revisited. *Acta Physiol. Scand.* **1996**, *156*, 265–270. [CrossRef] [PubMed]
71. De Luca, C.J.; Sabbahi, M.A.; Roy, S.H. Median frequency of the myoelectric signal: Effects of hand dominance. *Eur. J. Appl. Physiol.* **1986**, *55*, 457–464. [CrossRef]
72. Simpson, M.E.; Serdula, M.; Galuska, D.A.; Gillespie, C.; Donehoo, R.; Macera, C.; Mack, K. Walking trends among U.S. adults: The behavioral risk factor surveillance system, 1987–2000. *Am. J. Prev. Med.* **2003**, *25*, 95–100. [CrossRef]
73. Vancampfort, D.; Knapen, J.; Probst, M.; Scheewe, T.; Remans, S.; De Hert, M. A systematic review of correlates of physical activity in patients with schizophrenia. *Acta Psychiatr. Scand.* **2012**, *125*, 352–362. [CrossRef] [PubMed]

74. Zschucke, E.; Gaudlitz, K.; Strohle, A. Exercise and physical activity in mental disorders: Clinical and experimental evidence. *J. Prev. Med. Public Health* **2013**, *46*, 12–21. [CrossRef] [PubMed]
75. U.S. Departement of Health and Human Services. 2008 Physical Activity Guidelines for America. 2008. Available online: www.health.gov/paguidelines (accessed on 1 December 2016).