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Age, Stature and Trellis Height as Primary Risk Factors Interrelated with Musculoskeletal Symptoms of Vineyard Farmers

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ブドウ農家の筋骨格症状と相互に関係する主なリスク因子としての
年齢, 身長およびブドウ棚の高さ

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The association of age, stature, and trellis height (TH) with the upper body musculoskeletal symptoms (MSS) in Japanese vineyard farmers was investigated to provide basic information for MSS health improvement and the creation of new version of mechanical wearable supports, such as the agri-robot suits. A total of 151 vineyard farmers responded to the questionnaire-based survey about workload and MSS with age, stature, and TH. Logistic regression, linear regression, and correlation analysis was used to test the association of MSS with age, stature, and TH in shoulder, upper back, and low back regions. Different significant risk factors for the upper back, shoulder, and lower back were noted. Older age, high TH, and small height difference (HD) between the stature and TH significantly increased the risk of shoulder, upper back, and lower back MSS, respectively. MSS were higher in the upper body than the lower body. These risk factors vary depending on the specific body region. High incidence rate (100%) was reported in the study population. Among farmers who desired to buy the robot suit (58%), asked for support of the whole body (42%), upper body (46%), and lower body (12%). The risks of MSS in vineyard farmers are high. Intervention measures such as relaxing postural stress by taking a regular break every hour might be beneficial. Lightening the muscle strain of the high risk body parts by reducing considerable exertion with mechanical support is also a great option. The wearable agri-robot suit should be improved, mainly focusing on the specific risk factors of the shoulder, upper back, and lower back regions to reduce physical strain. It is also worth to develop the suit in detachable design which can support whole body, upper part only, and lower part only.

Key Words : lower back MSS, mechanical supports, posture, shoulder MSS.

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1. Introduction

In the course of adapting a wearable robot suit (Toyama and Yonetake, 2007; Toyama and Yamamoto, 2009; Ogiwara *et al.*, 2010) in agriculture, a pilot questionnaire-based survey and direct observational analysis were conducted by Ovako Working Posture Analysis System (OWAS) among vineyard farmers in the Yamanashi Prefecture, Japan (Akagawa *et al.*, 2010; Nwe *et al.*, 2012). The results showed that the awkward postures of farmers including elevated arms for 73% of the total working time during berry thinning and bending and twisting of the back for 31% of the total time during pruning (Nwe *et al.*, 2012). When questioned regarding the provision of mechanical support to reduce the workload, 58% of the farmers wanted to buy the robot suit (Nwe *et al.*, 2012). The musculoskeletal health of aged vineyard farmers should be investigated to improve the quality of wearable robot suits. Several previous studies have reported associations between development of musculoskeletal symptoms (MSS) and the non-neutral postures (Bernard, 1997; Gamperiene and Stigum, 1999; Sood *et al.*, 2007). The confined height of the horizontal trellis system has been reported as a workplace risk factor leading to awkward postures of vineyard farmers in Japan (Nwe *et al.*, 2012). Stature and trellis height (TH) have been reported as potentially important risk factors for the musculoskeletal health of vineyard farmers (Nwe *et al.*, 2012). Various studies also reported age as a potential risk factor for musculoskeletal problems (de Zwart *et al.*, 1997; Holmstrom and Engholm, 2003). Although table grape production involves intensive manual labor by the aged farmer population, their musculoskeletal health has not been extensively studied in association with potential risk factors, such as age, stature, and TH. Therefore, this study investigated the incidence of MSS associated with age, stature, and TH for vineyard farmers in Japan, specifically in the Yamanashi Prefecture, to identify the risk factors of MSS in the vineyards. In addition, to reduce physical exertion of farmers, active exoskeleton type- the wearable agri-robot suit is developing and creating a robot suit with

Fig. 1 Improved version of wearable agri-robot suit, agricultural power assist suit, PAS: (Araie *et al.* 2017).

stability that does not fall over and can bend the ankle for overhead work in stoop posture (Toyama and Yamamoto, 2009). The results of this study are expected to be used for the improvement of a new version of a recently developed mechanical support, wearable agri-robot suit or power assist suit, PAS (Araie *et al.*, 2017; Fig. 1).

2. Methods

1) Questionnaire development

The structured questionnaire in this study was designed based on the pilot questionnaire survey and direct observations conducted by OWAS on the workload assessment of vineyard farmers. The questionnaire was prepared in Japanese language and included the following sections: (1) demographics (age, sex, stature), (2) workload and working conditions (work hours, years of professional experiences, break interval, TH, the person who originally established the trellis, cultivar, workload after cultivar change from seeded to seedless), (3) MSS incidence based on body map technique (neck, shoulder, upper back, lower back, forearm, upper arm, wrist, hip, thigh, knee, lower leg, ankle, and (4) requirements for the mechanical support. The questionnaire defined MSS as pain and fatigue in any body part investigated and accompanied by a mannequin diagram to define the affected region.

Table 1 Characteristics and working hours in the vineyard farmers (n=151).

Numerical variable	Mean $\pm$ SD	Range (minimum-maximum)
Age (years)	55 $\pm$ 11.6	24–85
Stature (cm)	169 $\pm$ 6.7	147–183
Working hour per work day (during busy season)	9 $\pm$ 2	13–4
Trellis height (TH) (cm)	170 $\pm$ 9	140–200
Height difference (HD) between stature and trellis (cm)	1.3 $\pm$ 11.8	–38–40
Categorical variable	Category	Rate (%)
Age of person who established the trellis (year)	21–40	0
	41–50	11
	51–60	30
	61–70	44
	71–85	66
Stature of person who adjusted trellis height	Current owner	44
	Others	56
HD between stature and trellis (cm)	–(1–10)	34
	–(11–20)	14
	–(21–40)	3
	0–10	34
	10–20	11
	21–40	3
TH (cm)	140–150	3
	151–160	13
	161–170	50
	171–180	29
	181–190	3
	191–200	1
Working experience (year)	<5	9
	5–10	11
	10–15	9
	16–20	12
	21–25	13
Break intervals (h)	25<	46
	> 2	86
Grape variety	< 2	14
	Seedless	79
	Seeded	1
	Both	20

2) Questionnaire administration and sampling

Japan Agriculture Co-operatives (JA) Fruits division, Yamanashi prefectural branch, distributed and collected the questionnaires in Enzan and

Katsunuma townships from 2011 to 2012. Among the 200 questionnaires distributed, 167 were collected with the response rate of 83.5%. Among them, 151 questionnaires (14 women and 137 men)

with complete answers on age, stature, TH, and MSS were considered in this study.

3) Statistics

All statistical analyses were done by using SPSS version 23 (Armonk, NY: IBM Corp). Logistic regression analysis was performed to evaluate the association between each exposure variable and MSS. To investigate the TH condition in the workplace among vineyard farmers, the height difference (HD) between the farmers' stature and TH was calculated by deducting the former from the latter. Logistic regression analysis was performed by individually assigning stature, TH, and HD in addition to age as risk factors of MSS on the right and left sides of the body for neck, shoulder, upper back, and lower back regions, so that the potential bias effect of age can be controlled during the risk factor analysis (Widanarko *et al.*, 2011). Linear regression and correlation was also done as necessary. The effect of risk factors was considered significant when p -value was less than 0.05.

3. Results

1) Effect of age, stature, and trellis height on MSS

Table 1 shows the data on age, stature, working hours per work day (during busy season), HD, working experience (year), variety grown (seeded, seedless, both), age of person who established the trellis, stature of person who adjusted trellis height, and working experience of the study participants. The average age, stature, and working hours per day during the busy season of berry thinning and cluster shaping, and TH of the study participants were 55 years, 169 cm, 9 h, and 170 cm, respectively. The HD ranged from -38 to 40 cm, which means that the trellis was located below the stature for over half of the farmers, 51% (Table 1).

Table 2 presents the association of MSS with age, stature, TH, and HD in the study group. The HD was the significant risk factor for MSS in the right ($p = 0.001$) and left ($p = 0.042$) lower back, whereas lower TH ($p = 0.011$) and higher stature ($p = 0.013$) were the significant risk factors for the MSS in the right lower back only. The greater TH

was also a significant risk factor for right upper back MSS ($p = 0.031$). The higher age was the significant risk factor for the right shoulder MSS ($p = 0.002$) with no significant effect of stature, TH or HD. For the left shoulder MSS also, the higher age was a significant risk factor only when either stature or HD is considered simultaneously. The neck MSS was not significantly related with any of the factors.

In the study population, MSS in the upper body were higher than in the lower body (Table 3). MSS on the right side was the highest in the lower back (61%), followed by the shoulder (58%), upper back (49%), neck (31%), and lower body (1–9%). The MSS on the left side was highest in the lower back (59%), followed by the upper back (46%), shoulder (25%), neck (22%), lower leg (14%), fore arm (6%), knee (6%), thigh (4%), upper arm (3%), ankle (2%), wrist (2%), and hip (1%) (Table 3). Although this study focused on detailed analysis on the risks of MSS with high incidence rate ($> 20\%$), MSS with low incidence rate ($< 20\%$) are also important. The overall incidence rate of MSS was 100% and number of pain site ranged from 1 to 12 (Table 4). Figure 2 presents significant relationship between stature and HD ($R^2 = 0.453$, $p < 0.0001$). TH and stature with the MSS of the right lower back could be a result of the positive association between HD and TH ($R^2 = 0.679$, $p = 0.0001$) or high negative correlation with stature ($r = -0.673$, $p = 0.0001$). Moderate positive relationship between stature and age ($r = 0.323$, $p < 0.0001$), and moderate positive relationship between age and HD ($r = 0.302$, $p < 0.0001$) were also observed.

Although age had a significant association with work experience ($R^2 = 0.58$ and $p < 0.001$), work experience was not related with MSS in any of the body parts studied. HD ($p = 0.011$) and stature ($p = 0.011$) become significant risk factors in upper back right region (data not shown). Significant association was not observed between age and number of pain sites reported either (Table 4).

2) The requirement of mechanical assistance (the wearable agri-robot suit)

In the questionnaire survey, 58% of farmers

Table 2 Results of logistic regression of musculoskeletal symptoms (MSS) in the left and right sides of the shoulder, upper back, and lower back among vineyard farmers on age, stature, trellis height (TH), and height difference (HD) between the stature and TH.

Left/ right side MSS	Body parts	Risk factor	Age		Additional factor	
			Odds ratio	<i>p</i>	Odds ratio	<i>p</i>
Left	Shoulder	Age	1.028	0.105	–	–
		Age, stature	1.041	0.036	1.057	0.089
		Age, TH	1.029	0.085	0.982	0.401
		Age, HD	1.037	0.042	0.987	0.304
	Lower back	Age	0.978	0.137	–	–
		Age, stature	0.984	0.292	1.031	0.256
		Age, TH	0.982	0.222	0.964	0.072
		Age, HD	0.987	0.402	0.969	0.042
	Upper back	Age	0.982	0.204	–	–
		Age, stature	0.981	0.198	0.993	0.793
		Age, TH	0.979	0.154	1.021	0.281
		Age, HD	0.977	0.133	1.015	0.326
	Neck	Age	0.982	0.283	–	–
		Age, stature	0.990	0.589	1.049	0.143
		Age, TH	0.984	0.357	0.981	0.419
		Age, HD	0.990	0.574	0.974	0.147
Right	Shoulder	Age	1.049	0.002	–	–
		Age, stature	1.048	0.004	0.998	0.926
		Age, TH	1.049	0.003	1.001	0.963
		Age, HD	1.048	0.004	1.001	0.929
	Lower back	Age	0.976	0.099	–	–
		Age, stature	0.988	0.431	1.072	0.013
		Age, TH	0.980	0.196	0.947	0.011
		Age, HD	0.990	0.539	0.943	0.001
	Upper back	Age	0.985	0.293	–	–
		Age, stature	0.993	0.639	1.044	0.102
		Age, TH	0.980	0.162	1.045	0.031
		Age, HD	0.977	0.133	1.015	0.326
	Neck	Age	0.998	0.911	–	–
		Age, stature	1.006	0.737	1.039	0.190
		Age, TH	1.001	0.961	0.979	0.309
		Age, HD	1.006	0.710	0.975	0.127

wanted to buy the wearable agri-robot suit (Nwe *et al.*, 2012), which should be effective in giving them assistances, light weight, easy to wear, and available at a reasonable price as their common requests for wearable agri-robot suit in table grape production. The fraction of farmers mentioned the need for

mechanical assistance amounted to 42% in the whole body, 46% in upper body, and 12% in lower body (Fig. 3). Among them, 72% asked for minor improvements in tape wrapper (35%), scissors (20%), shears (20%), radio (10%), stapler (3%), tape (2%), harvest container (2%), saw (2%), waist bag

Table 3 Rate of MSS incidence (%) in the upper and lower body of the vineyard farmers (n=151).

Body part	Left (rate %)	Right (rate %)
Upper body		
Neck	22	31
Shoulder	25	58
Upper back	46	49
Lower back	59	61
Upper arm	3	6
Forearm	6	8
Wrist	2	6
Lower body		
Hip	1	1
Thigh	4	3
Lower leg	14	7
Knee	6	9
Ankle	2	6

Fig. 2 Relationship between the stature and height difference (HD) between the stature of the farmers (circles) and trellis height. The regression line of HD on stature is also shown (n=151).

Table 4 Pain site number reported and frequency (%) in the vineyard farmers (n=151).

Pain site number	Frequency (person)	Percent (%)
1	6	4.0
2	13	8.6
3	32	21.2
4	26	17.2
5	13	8.6
6	33	21.9
7	7	4.6
8	13	8.6
9	2	1.3
10	3	2.0
11	2	1.3
12	1	0.7
Total	151	100.0
Mean	4.83	
Std. Deviation	2.26	
Range	1-12

Fig. 3 Requirement of support by the robot suit in various body parts of vineyard farmers (n=67).

(2%), drinking water (2%), and apron (2%) (Fig. 4).

4. Discussion

The results of this study showed that the

significant risk factors in MSS were different among the lower back, shoulder, and upper back regions (Table 2). TH is the major risk factor for MSS in right lower back, right upper back, and left lower back. Age is the major risk factor in the left and right shoulder MSS. The significant association of TH and stature with the MSS of the right lower back could be a result of the positive association between HD and TH or the high negative correlation with stature. Negative association between stature and

Fig. 4 Requirement of minor improvement in the robot suit requested by vineyard farmers (n=48).

Fig. 5 Work of vineyard farmers. From left to right; Awkward hand, shoulder, and back posture in gibberellin treatment, berry thinning, pruning, and back bending and twisting posture under the trellis in pruning.

HD showed a probability that a taller person has greater risk of MSS than a shorter person due to low HD (Fig. 2). Positive association trend between Age and HD indicates possibility of greater risk of MSS for younger people than older people by small HD. Therefore, taller and younger people may have greater risk of MSS due to small HD by low TH.

The hardest crop management task was reported as berry thinning and cluster shaping in which more than 70% of the hand is above the shoulder level

(Nwe *et al.*, 2012). Vineyard farmers work with one or both hands above the shoulder level (Fig. 5) in shoot thinning, Gibberellin treatment for seedless cultivars, berry thinning, cluster shaping, bagging, harvesting and pruning subsequently long term repetitive and excessive use of shoulder muscle supposedly lead to the shoulder MSS (personal communication). In crop management tasks, excessive exertion of shoulder muscle fatigue deposited over time to shoulder MSS with age and supposed to be there was a dose

response relationship (da Costa and Vieira, 2010). The greater incidences of MSS in right shoulder (58%) than left shoulder (25%) should be related to the high proportion of right handed persons in the study population. The incidence of individuals who always use left hand for writing and eating in Japan was only 0.7% and 1.7%, respectively (Shimizu and Endo, 1983).

The result of age-dependent shoulder MSS is consistent with that of other studies (Hughes *et al.*, 1997; Meroni *et al.*, 2014). Moreover, it was also consistent with the hypothesis that elevated arm postures reduce the blood flow to the rotator cuff tendons, thereby facilitating tendon degeneration (Hughes *et al.*, 1997). In addition, it is noteworthy that higher TH is associated with higher incidence of MSS in the right upper back, although the association is barely significant ($p = 0.031$). Physical risk factors at work have also been reported to lead to pain worsening in specific regions, rather than just any regional pain (Andersen *et al.*, 2007). One solution for reducing age-dependent shoulder MSS could be using active exoskeleton to reduce the physical exertion because the TH is difficult to be altered (Fathallah, 2010; Looze *et al.*, 2015; Bosch *et al.*, 2016). By using active exoskeletons (classical robots, full-automation systems or humanoid robots with actuators), lower body, trunk, and upper body regions could benefit from them by reductions up to 80% of muscle activities. They have the potential to considerably reduce the underlying factors associated with work-related MSS (de Looze *et al.*, 2015). The wearable agri-robot suit should make improvements to reduce physical load on the shoulder and arms for a wide range of overhead tasks in the vineyard.

Although stature has been reported as one of the strong predictors of MSS among farmers in India (Patil *et al.*, 2018), this study identified HD as the main contributing risk factor for low back MSS in vineyard farmers indicating that the risk factors might change depending on the specific population in relation to the nature of work. Small HD could be due to the TH not being adjusted to the stature of the relatively large proportion of current farmers.

The trellises have been constructed with the TH adjusted to the stature of the owner of the vineyards in 44% of the cases, while this adjustment was not made for the remaining cases (56%) (Table 1). If the grape trellis is low, back and neck postural stress of bending the neck down to avoid interference of the head and bending over the hands to see the fruit might occur (Fig. 5). There is a mismatch in shelf height due to other work circumstances and height differences between workers. Another possibility of low HD is the shelf has weakened and become lowered due to deterioration over time and weight of the vine. The results of the question who originally established the trellis were grouped depending on age categories showed declined trend from the eldest farmers (71–85 yr –92%), to the youngest farmers (21–40 yr –0%) showing that a large number of the trellis was built by the elders (Table 1). Therefore, it is assumed that the lower back MSS is increasing. In addition, majority of farmers (78.2%) were producing seedless grapes, followed by those producing both seedless and seeded (21%), and seeded only (1.4%) (Table 1). The variety changed from seeded to seedless grapes (such as Delaware to Kyoho and Pione), which should have exacerbated the stress on shoulder and back MSS by demanding more working time in berry thinning and cluster shaping tasks due to excessive fruit setting per cluster after Gibberellin treatment. Reducing workload in berry thinning and cluster shaping tasks by using grape varieties with fewer fruit per cluster is also worth to consider.

We found that TH serves as a risk factor in opposite directions between the upper and lower back MSS; high TH increased the risk of upper back MSS, whereas low TH increased the risk of lower back MSS via smaller HD. Postural stress of reaching/stretching to high TH increased the risk of upper back MSS and bending and twisting of the trunk under low TH increased the risk of lower back MSS. In vineyard work, the high risk of back injury is mainly due to the iterative forces imposed to the upper body and trunk in combination with awkward stooping, twisting movements, and repetitive lifting of excessive loads (Benos *et al.*, 2020). These

findings are consistent with those of the previous study based on direct observations by OWAS, in which stature and TH are reported as potential risk factors for the musculoskeletal health of vineyard farmers (Nwe *et al.*, 2012). Other studies have also reported awkward posture as a contributing factor to back problems (Gamperiene and Stigum, 1999; Pinzke, 2003; Fathallah, 2010; de Looze *et al.*, 2015; Bosch *et al.*, 2016). Heavy physical work and non-neutral postures contributed to the shoulder, low back, neck, and upper body problems (Myers *et al.*, 1999; Ueno *et al.*, 1999; Ariens *et al.*, 2000; Svendsen *et al.*, 2004; Ebaugh *et al.*, 2006; da Costa and Vieira, 2010; Osborne *et al.*, 2010; Nourollahia *et al.*, 2018). Our results showed that having optimum TH in relation to the stature of farmer is important to reduce the risk of MSS in the upper and lower back regions although both issues were hardly modifiable. The wearable agri-robot suit is a full-body exoskeleton type which can potentially reduce back physical exertion considerably (Toyama and Yamamoto, 2009). Passive exoskeletons developed without actuator reported to reduce 10–40% back muscle activities and have potential in reducing low back MSS (de Looze *et al.*, 2015; Bosch *et al.*, 2016). Although only 12% of vineyard farmers among who wanted to buy the suit requested for lower body support, 46% requested for upper body and 42% requested for the whole body support (Fig. 3). It indicated that active exoskeleton might benefit for the vineyard farmers. On the other hand, the number of pain sites reported in farmers was highest in 6 sites (33%), followed by 3 sites (32%), 4 sites (26%), and 13% for 2, 5, and 8 pain sites (Table 4) indicating that many farmers have MSS in several places. Upper body showed high incidence rates and lower body showed relatively low incidence rates (maximum 14% in the left lower leg) (Table 3). Therefore the robot suit should give priorities to support in the order of upper body, whole body, and lower body.

One of the solutions worth to consider is taking active rest break which is already using as successful intervention in the US (Faucett *et al.*, 2007). Among the study group, 86% of farmers took breaks at >2

h intervals (Table 1). Therefore, more active rest breaks combined with mechanical supports might be practical to solve MSS problems in the vineyard farmer population having the overall incidence rate of 100% (Table 4).

The wearable agri-robot suit could provide supports to reduce postural stress in shoulder, upper back, and low back regions as priorities. The suit should be improved to be detachable to provide selective support to upper body, the whole body, and lower body. The leg support might hinder working in slope land vineyard due to the balance issue (personal communication). Comfortable support with natural and safety movement are necessary to adapt the wearable agri-robot suit for vineyard farmers (de Looze *et al.*, 2015; Bosch *et al.*, 2016).

The strength of this study was its representativeness to vineyard farmers in Yamanashi Prefecture that producing approximately 24% of total grapes in Japan because of its high response rate (87%). The results are also complementary with those of previous studies (Toyama and Yamamoto, 2009; Akagawa *et al.*, 2010; Ogiwara *et al.*, 2010; Nwe *et al.*, 2012). Although the common table grape varieties and production techniques tend to vary by region in Japan, results presented here should represent some commonalities in other regions. While longitudinal studies are required to provide a better estimation of MSS risk (Holmstrom and Engholm, 2003; da Costa and Vieira, 2010), cross-sectional studies still provide representative information if combined with pilot survey and direct observation.

Working under horizontal trellis system with a specific posture continuously for a long time seemed to induce musculoskeletal pain which lead to diseases among farmers. Some tall men farmer had back pain and some short woman farmer had cervical spine pain and went to an osteopathic clinic (personal communication) during winter season. Some farmers already retired because of chronic low back pain issue and some were using electronic scissor in pruning task because of chronic shoulder pain (personal communication).

The robot suit is potentially very effective for work with overhead posture and the hands are

raised for a long time such as berry thinning, cluster shaping, and harvesting fruits by climbing the tree with a ladder (Araie *et al.*, 2017). On the other hand, when farmers necessarily become to work in a stoop posture by twisting the trunk while pruning and fertilizer or compost application tasks because the height of the trellis is not constant, make not suitable for the robot suits. Therefore, to develop the robot suit that can safely handle from a short time light work to a long time heavy work, improvement measures such as installation of a fall warning foot sensor are in progress by pooling together the results of research on work posture analysis and the risk factors for MSS. Since there are peculiar movements in agricultural work, the agri-robot suit should be improved in the future by evaluating the work posture in this research or incorporating the opinions of farmers trying on the improved agri-robot suit.

5. Conclusion

The risk factors for MSS identified in this study; age, TH, and HD are hardly modifiable. To reduce postural stress, taking a regular short break interval in every hour combining with physical exercise is considered important. To reduce the physical strain of vineyard farmers, the workload reduction using mechanical supports might be a proper solution by supporting mainly the shoulder, upper back, and lower back regions. Hence, the wearable agri-robot suit should be improved to reduce physical exertion depending on the specific risk factors on these regions. Because crop management tasks are labor intensive, physically stressful and involve every part of the body, the MSS incidence among vineyard farmers should be consistently identified through long-term follow-up studies in this study population.

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要旨

本研究は、日本のブドウ園農家における年齢、身長、ブドウ棚の高さ（TH）と上肢の筋骨格症状（MSS）との関連を調査し、MSS の改善とアグリロボットスーツのようなウェアラブルサポー

トの製造に関する基本資料を得る目的で行った。151 のブドウ園農家に対して、年齢、身長、TH を含む作業負荷、MSS などに関するアンケートによる調査を行った。ロジスティック回帰、線形回帰および相関分析を使用して、MSS と年齢、身長および肩、背中上部、背中下部の TH との関連を解析した。その結果、背中上部、肩、背中下部のさまざまな重大なリスク因子が認められた。高齢、TH が高く、身長とブドウ棚との高さの差（HD）が小さいと、それぞれ肩、背中上部、背中下部の MSS のリスクが大幅に増加した。MSS は下肢より上肢で高かった。これらのリスク因子は、体の部位によって異なった。ロボットスーツの購入を希望する農家（58%）は、全身（42%）、上半身（46%）、下半身（12%）のサポートが必要であると回答した。

キーワード

肩の筋骨格症状、サポート機器、姿勢、腰の筋骨格症状