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Original Article

Optimal foot-position of caregiver based on muscle activity of lower back and lower limb while providing sit-to-stand support

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Abstract. [Purpose] In caregivers, low load posture is necessary to prevent lower back pain during patient handling activities such as sit-to-stand support. This study focused on the foot-position of caregivers as an adjustable and useful parameter. A wide stance decreases the stress on the lumbar vertebra. However, this foot-position increases loading of the spinae erector muscles. The aim of this study was to investigate the relationship of anterior-posterior and lateral-medial distances between feet and activity of the spinae erector muscles to determine the optimal foot-position for reducing stress on the lumbar vertebra without increasing spinae erector muscle load. [Participants and Methods] Five young male participants were asked to provide sit-to-stand support 10 times using nine normalized foot-positions with different anterior-posterior and lateral-medial distances. Surface electromyograms of the erector spinae and lower limb muscles were measured during sit-to-stand support. [Results] The results showed that the optimal foot-position (anterior-posterior 55%, lateral-medial 20% of body height) increased muscle activity within the lower limb muscles compared with the lower back muscles and did not increase loads on the erector spinae muscle. [Conclusion] Optimizing foot-position can reduce stress on the lumbar vertebra without increasing load on the spinae erector muscles.

Key words: Foot-position, Patient handling, Lumbar load

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INTRODUCTION

Caregivers experience lower back pain associated with frequent patient handling motions such as providing standing-up support[1, 2)]. Patient handling motions are risk factors for lower back pain since they are strongly related to heavy lifting, bending, and twisting[2)]. Assistive equipment such as lifting devices and sliding sheets that support patient handling motions may prevent lower back pain, however, they are used infrequently because they are inefficient and limit workspace[3)]. Furthermore, caregivers experience lower back pain associated with unsuitable posture even when assistive equipment is used[3)]. Thus, it is necessary to consider suitable posture to reduce lower back load associated with patient handling motions done without assistive equipment.

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Body mechanics theory is considered a solution that might reduce lower back load without assistive equipment[4–6]. Body mechanics theory provides suitable posture to reduce body load during common activities such as lifting, pushing, and pulling, and helps to remedy and prevent lower back problems[4]. Previous studies found that body mechanics theory reduced lower back load by suppression of trunk bending and using lower limb muscles in patient handling motions[5]. However, body mechanics theory does not propose quantitative parameters of suitable posture to prevent lower back pain. It is hypothesized that caregivers could adjust their posture and prevent lower back pain more easily with quantitative and self-adjustment parameters for suitable postures. Therefore, we focused on caregiver foot-position as an adjustable parameter since caregivers can adjust their own foot-positions before providing patient handling motion support. Our previous study found that when the foot-distance of the caregiver increased, stress on the lumbar vertebra decreased while providing standing-up support[7]. In addition, body mechanics theory[5] and a previous study related to manual handling[8] also suggested the possibility that greater foot-distance could reduce lower back load by prompting usage of lower limb muscles instead of lower back muscles. Furthermore, the base of support achieved by greater foot-distance provides body stability while lifting a patient[9]. However, too long foot-distance requires flexion and extension of the hip joint, which may increase the load on erector spinae muscles[10], which is not recommended to prevent lower back pain because loads on erector spinae muscles negatively affect the stress and structure of lumbar vertebrae[11–13]. Therefore, it is necessary to quantitatively find the optimal foot-position that will reduce stress on the lumbar vertebra without increasing load on the spinae erector muscles. The aim of this study was to determine the relationship between foot-position and activity of the spinae erector muscles in order to find the optimal foot-position to realize smaller low- load posture in patient handling motions. In particular, we focused on standing-up motion support with larger lumbar loads than in other patient handling motions[14]. In this study, we also investigated the relationship between foot-position and muscle activity of the lower limb in order to verify whether the foot-position used while providing standing-up motion support could rely on the lower limb rather than the lower back.

PARTICIPANTS AND METHODS

The participants were 5 young healthy males (age, 25.4 ± 1.2 years; body height, 1.71 ± 0.03 m; body weight, 68.2 ± 6.9 kg) with no experience providing care. All participants received a description of this study and signed a written, informed consent form before participating. All experimental procedures were conducted in accordance with the Declaration of Helsinki. All experimental procedures were approved by the Ethics Committee for Human Research of Graduate School of Life Science and Systems Engineering, Kyushu Institute of Technology (approval number: 17-05).

Participants were asked to provide standing-up motion support for a doll with 9 different foot-positions, 10 times in the measurement session. Figure 1 shows the standing-up supporting motion and the doll for the experiment. The doll made of plastic bottles (volume of each bottle is 2,000 cm^3) was used instead of a patient for patient in order to remove the effects of patient's motion on the lower back load of caregivers. Weight of the doll was 10 kg because 5 plastic bottles of trunk are filled with water. This weight is lighter than an actual patient to prevent lower back load on the participants. Bottles of other parts excluding trunk were not filled with water because durable doll was necessary for safety in the experiment.

Table 1 and Fig. 2 show the 9 foot-positions. These 9 foot-positions were adjusted before the measurement session and fixed during the measurement session. These were adjusted as foot-positions that all participants could perform supporting

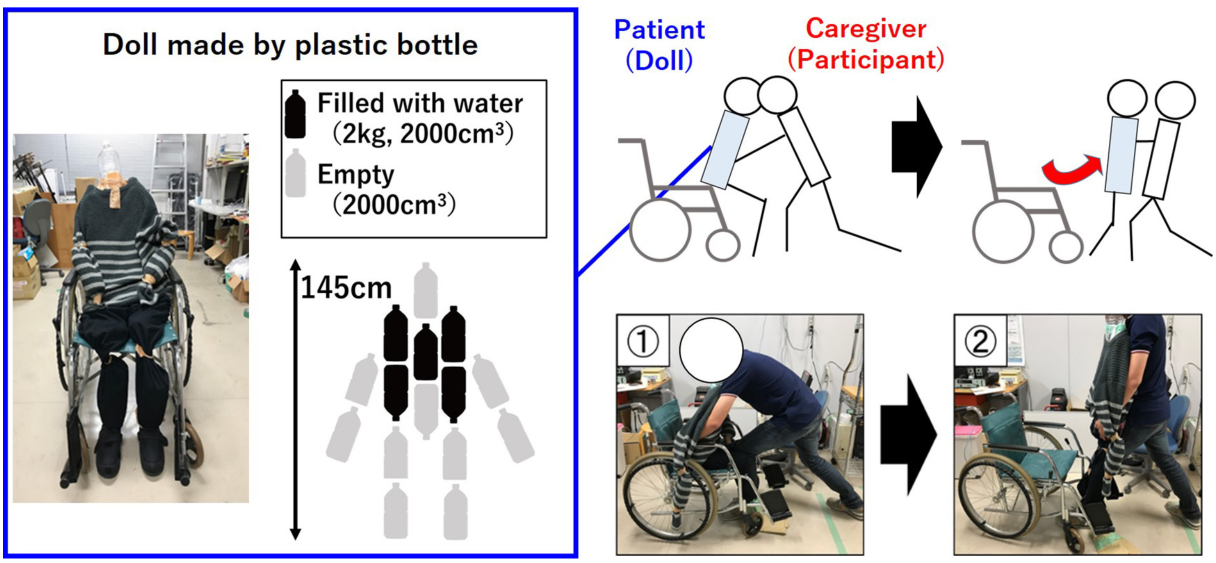

Fig. 1. Standing-up motion support using the doll as patient.

Table 1. Nine foot-positions with feet distance

Foot-Position	Distance (%height)	
	Anterior-posterior	Lateral-medial
#1	25	20
#2	25	30
#3	25	40
#4	40	20
#5	40	30
#6	40	40
#7	55	20
#8	55	30
#9	55	40

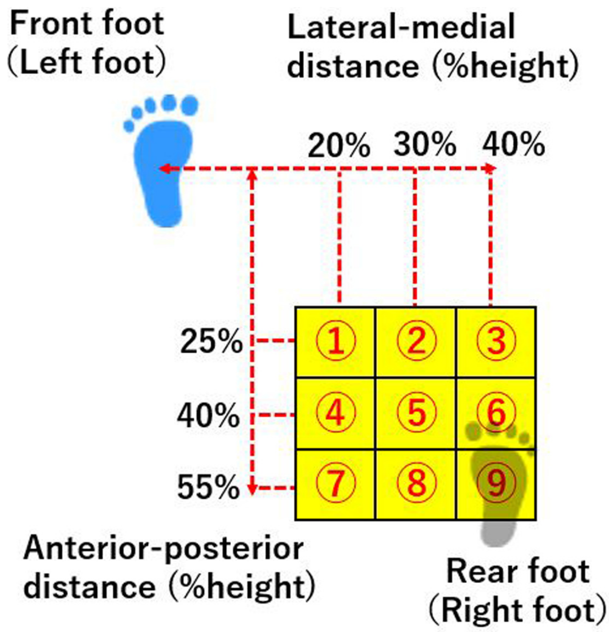

Fig. 2. Nine foot-positions.

standing-up motion. The left foot was considered as the front foot and fixed under the footrest of the wheelchair because body mechanics theory recommended decreasing the distance between the caregiver's center of gravity (COG) and that of the patient[6]. The right foot was considered as the rear foot and changed with each foot-position. Foot-distance between both heels for the 9 foot-positions was normalized by the body height of each participant. Therefore, the unit for foot-distance was determined to be "%height". The 9 foot-positions were modified by combining 3 anterior-posterior foot-distances (25%, 40%, and 55%height) and 3 lateral-medial foot-distances (20%, 30%, and 40%height). These distances were determined before the experiment so that all participants could provide standing-up motion support. Other parameters related to foot-position such as foot angle was not prescribed. These foot-positions were shown by plastic tape on the floor. The participants practiced providing standing-up motion support for 10 minutes prior to the measurement session. In the measurement session, each participant was asked to perform standing-up support motions for the 9 foot-positions in random order. The participant repeated this session 10 times with a 15-minute break between sessions. Surface electromyography (sEMG) was measured for each standing-up support motion. Ten sEMG data were measured for 1 foot-position of 1 subject, then, 50 sEMG data were measured for each foot-position.

sEMG of right and left erector spinae muscles was measured as lower back load while providing standing-up motion support. Furthermore, the sEMG of tibialis anterior muscles, rectus femoris muscles, and hamstring muscles for left and right sides were also measured as muscle activities of the lower limb. The sEMG was obtained by Blue Sensor P (Ambu, Ballerup, Denmark) and the EMG Logger LP-WS1402-W (Logical Product Inc., Fukuoka, Japan). Participant skin was shaved before attaching the electrodes. Electrode locations for the erector spinae muscles and lower limb were determined as per McGill[15] and Rainoldi et al.[16]. The cables were fixed with tape to ensure durability and to minimize the potential inconvenience for participants. The sampling frequencies of all devices were set to 1,000 Hz. Normalized sEMG (%MVC) during standing-up motion support and were calculated by dividing by mean values of 5-second maximal voluntary contractions (MVC) based on Daniels and Worthingham's muscle testing[17] for each muscle part. Integrated electromyographic (iEMG) values for analysis were calculated from the rectified signal of sEMG. iEMG values were normalized temporally by dividing by total motion time for each standing-up motion support. All calculations and signal processing were performed using MATLAB R2018 (Mathworks Inc., Natick, MA, USA).

The differences in iEMG values (sample size, N=50) between 9 foot-positions for each muscle part were evaluated using the Kruskal-Wallis test and Bonferroni method. Statistical analysis was performed using EZR[18] with $p<0.05$ considered significant.

RESULTS

Table 2 shows the relationship between the iEMG of erector spinae muscles and foot-position. iEMG values in Table 2 are shown by median and interquartile range (IQR). Although there was almost no difference in the iEMG of the left erector spinae muscles, the iEMG of the right erector spinae muscles tended to increase with increasing feet-distances. The iEMG of

Table 2. The iEMG values of erector spinae muscles

Foot-position	iEMG of erector spinae muscle (%MVC)					
	Left			Right		
	Median	IQR	Relationship with significant difference	Median	IQR	Relationship with significant difference
#1	6.93	6.64	< #9	4.99	20.56	> #7 and < #6, #8, #9
#2	7.26	5.40	< #9	5.75	22.57	> #7 and < #6, #8, #9
#3	7.65	6.66	None	5.89	30.85	< #9
#4	6.92	7.33	None	4.70	35.37	< #9
#5	7.34	7.23	None	6.77	21.72	< #9
#6	8.00	7.74	None	7.69	25.19	> #1, #2
#7	8.05	8.59	None	2.07	28.66	< #1, #2
#8	7.98	8.10	None	5.81	22.45	> #1, #2
#9	9.48	10.11	> #1, #2	8.72	26.69	> #1, #2, #3, #4, #5

The values are shown by median and interquartile range (IQR). Significant difference: $p<0.05$.

Table 3. The iEMG values of tibialis anterior muscles

Foot-position	iEMG of tibialis anterior muscle (%MVC)					
	Left			Right		
	Median	IQR	Relationship with significant difference	Median	IQR	Relationship with significant difference
#1	6.72	11.09	< #7, #8, #9	28.50	37.66	None
#2	9.79	11.01	< #9	39.28	27.22	None
#3	11.95	27.14	< #9	44.68	39.20	None
#4	7.48	10.58	< #7, #8, #9	39.70	31.47	None
#5	14.29	20.09	< #9	38.55	36.12	None
#6	12.46	16.33	< #9	36.20	33.32	None
#7	13.53	22.91	> #1, #4	39.06	33.72	None
#8	13.41	35.77	> #1, #4	38.64	45.82	None
#9	20.88	45.53	> #1, #2, #3, #4, #5, #6	37.15	41.82	None

The values are shown by median and interquartile range (IQR). Significant difference: $p<0.05$.

foot-position #9 was significantly larger than those of foot-position #1 and #2 only in the left erector spinae muscles, but the iEMG of foot-position #9 was significantly larger than more than half of the 9 foot-position (foot-positions #1, #2, #3, #4 and #5) in the right erector spinae muscles.

Tables 3, 4 and 5 show the relationship between the iEMG of lower limb muscles and foot-position. iEMG values in Tables 3, 4 and 5 are shown by median and IQR. The iEMG values of the left lower limb were dependent upon the feet-distance for 3 muscles. The iEMG values of foot-positions #7 and #9 were significantly larger than other foot-position such as #1, #4, and #6 in all muscles of the left lower limb (tibialis anterior muscle, rectus femoris muscle, and hamstring muscle). On the other hand, there were no significant difference between all foot-positions in all muscles of the right lower limb (tibialis anterior muscle, rectus femoris muscle, and hamstring muscle).

DISCUSSION

The iEMG of erector spinae muscles at foot-position #9 was largest because the flexion and extension of the hip joint activated the erector spinae muscles. Activation of erector spinae muscles by flexion and extension of hip joint is supported by a previous study[19)]. These results suggested that foot-position #9 with the longest feet-distance may cause greater load on erector spinae muscles than other foot-position. According to our previous study[7)], foot-position #9 with the longest feet-distance could reduce stress of lumber vertebral, but these results suggested that this placement was not optimum for low load motion to prevent lower back pain because it caused load on the erector spinae muscles. Because there were many significantly different iEMG values in only the right spinae muscles, it is hypothesized the that foot-position affected the load of the right erector muscles in the rear lower limb that was involved. In addition, these results suggested that lumbar load

Table 4. The iEMG values of rectus femoris muscles

Foot-position	iEMG of rectus femoris muscle (%MVC)					
	Left			Right		
	Median	IQR	Relationship with significant difference	Median	IQR	Relationship with significant difference
#1	19.30	28.01	< #5, #6, #7, #8, #9	13.96	16.46	None
#2	27.19	29.04	< #6, #8, #9	14.12	16.85	None
#3	32.91	43.74	None	11.97	13.04	None
#4	32.11	41.08	< #9	11.04	15.14	None
#5	36.27	42.25	> #1	11.59	12.90	None
#6	42.38	51.73	> #1, #2	10.71	11.43	None
#7	39.88	40.82	> #1	11.03	17.32	None
#8	48.10	55.95	> #1, #2	11.74	11.70	None
#9	47.87	48.30	> #1, #2, #4	13.38	11.93	None

The values are shown by median and interquartile range (IQR). Significant difference: $p<0.05$.

Table 5. The iEMG values of hamstring muscles

Foot-position	iEMG of hamstring muscle (%MVC)					
	Left			Right		
	Median	IQR	Relationship with significant difference	Median	IQR	Relationship with significant difference
#1	26.72	23.60	None	7.94	5.10	None
#2	30.51	21.07	None	7.34	5.31	None
#3	30.25	18.71	< #9	8.82	5.84	None
#4	32.12	16.43	None	8.71	6.87	None
#5	30.54	14.60	< #9	7.95	5.79	None
#6	31.27	10.34	< #7, #9	7.02	4.86	None
#7	35.23	11.13	> #6	8.48	7.81	None
#8	35.91	10.98	None	7.47	6.02	None
#9	37.92	9.84	> #3, #5, #6	10.03	6.21	None

The values are shown by median and interquartile range (IQR). Significant difference: $p<0.05$.

concentrated on erector muscles near the rear lower limb.

The results related to lower limb muscles stem from the fact that the foot-position with greater feet-distances required flexion of initial posture and extension of movement for ankle and knee joints in order to get close to the patient. The flexion and extension of the lower limb are hypothesized to reduce lumbar load. It was shown in the previous studies that activation of tibialis anterior muscle, rectus femoris muscle, and hamstring muscles affected flexion and extension of ankle or knee joints[20–22]. These results show that foot-position #7 (anterior-posterior 55%, lateral-medial 20% of body height) could use lower limb muscles instead of the lower back without increasing loads on erector spinae muscle. In addition, foot-position #7 uses longer feet-distance which is effective in reducing lumbar vertebral stress[7]. Furthermore, longer anteroposterior feet-distance is effective for moving COG of patient in supporting standing-up[23]. Therefore, foot-position #7 is considered to be the optimal foot-position for low load motion using the lower limb instead of the lower back when providing standing-up support. Foot-position #9 is not considered an optimal foot-position because of load on the erector spinae muscle as well as the lower limbs. There were no significant differences in iEMG values between foot-positions in all right lower limb muscles. These results suggest that foot-position failed to promote the use of rear lower limb (right lower limb in this study). The reason for these results is thought to be that the rear lower limb of the caregiver was not stable when the limb was placed that far from the COG and flexion/extension could not be performed. Optimal foot-position #7 could use front lower limb (left lower limb in this study) instead of the lower back, but load during motion would concentrate to front lower limb because these foot-positions could not use the rear lower limb. Foot angle is considered as a parameter which could prevent concentration of load on the front lower limb[24]. A previous study reported that adjusting foot angle of the caregiver can promote stability and alter the COG using extension and abduction of the lower limbs during patient handling motions such as standing-up motion support[24]. From this report, it is possible that the proposed foot-position and adjusting the foot angle could reduce load on both the lumbar vertebral and the erector spinae muscles while providing standing-up motion support by using both lower limbs. These results of muscle activity during lifting at the asymmetric foot-position may contribute to understanding not only patient handling motion but also occupational health and kinesiology related to other occupations.

One potential limitation was that this study and our previous study[7)] compared only EMG and lumbar vertebra for evaluation of lumbar load. These known factors are effective in and important to understanding lower back pain[11–14)], but there are other important factors related to lumbar load such as muscle cross-sectional areas of inner muscles[25, 26)]. In this study, the doll made of plastic bottles was used instead of a patient. When COG or weight of the doll is changed, there are possibilities that optimal foot-position of the caregiver also change. For example, when COG of the doll is higher, shorter feet-distance is necessary in order to elevate and close COG. Furthermore, when the weight of the doll is heavier, there is possibility that iEMG of erector spinae muscles at foot-position #7 is significantly higher than other foot-positions. In this case, shorter feet-distance is also necessary for the optimal foot-position. In addition, the participants of this study were only young males with no experience of providing care activities. The results of this study of inexperienced people suggest that the proposed optimal foot-position may contribute to outcomes for first-time caregivers. However, it is necessary to consider females, experts, and older caregivers, too, in actual environments because performance and lumbar load during manual handling may vary depending on experience, gender, or age[27–30)]. For example, the patient handling time of female caregivers may be longer than that of male caregivers[30)]. Moreover, number of participants was insufficient for further statistical analysis. Thus, further experiments with many participants are necessary in order to generalize optimal foot-position.

In future works, we will consider implementing low load patient handling motions with the proposed optimal foot-position for caregivers. Time efficiency and simplicity are importance factors for implementation. A previous study reported that some assistive equipment was not used by caregivers because of the required investment and complex processes[3)]. Therefore, we will propose simple and effective commands and coordinate them with proposed optimal foot-positions in future works.

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Conflicts of interest

None.

REFERENCES

1) Kai S: Consideration of low back pain in health and welfare workers. J Phys Ther Sci, 2001, 13: 149–152. [CrossRef]
2) Holtermann A, Clausen T, Jørgensen MB, et al.: Patient handling and risk for developing persistent low-back pain among female healthcare workers. Scand J Work Environ Health, 2013, 39: 164–169. [Medline] [CrossRef]
3) Iwakiri K, Takahashi M, Sotoyama M, et al.: Low back pain among workers in care facilities for the elderly after introducing welfare equipment. Sangyo Eiseigaku Zasshi, 2016, 58: 130–142 (in Japanese). [Medline] [CrossRef]
4) Karahan A, Bayraktar N: Determination of the usage of body mechanics in clinical settings and the occurrence of low back pain in nurses. Int J Nurs Stud, 2004, 41: 67–75. [Medline] [CrossRef]
5) Iitami K, Yasuda T, Otsuki Y, et al.: Development of a checking system for body mechanics focusing on the angle of forward leaning during bedmaking. Educ Technol Rev, 2010, 33: 63–71.
6) Reda AE, Omebrahiem AE: The effect of body mechanics training program for intensive care nurses in reducing low back pain. IOSR-JNHS, 2015, 4: 81–96.
7) Kitagawa K, Nishisako Y, Nagasaki T, et al.: Musculoskeletal simulation of the relationship between foot position and stress of the l4–l5 joint in supporting standing-up motion to prevent low back pain among caregivers. J Mech Med Biol, 2019, 19: 1940016. [CrossRef]
8) Zhou J, Dai B, Ning X: The assessment of material handling strategies in dealing with sudden loading: influences of foot placement on trunk biomechanics. Ergonomics, 2013, 56: 1569–1576. [Medline] [CrossRef]
9) Holbein MA, Chaffin DB: Stability limits in extreme postures: effects of load positioning, foot placement, and strength. Hum Factors, 1997, 39: 456–468. [Medline] [CrossRef]
10) Kitagawa K, Uezono T, Nagasaki T, et al.: Relationship between surface electromyography of the spinae erector muscles and subjectively adjusted step length in the supporting standing-up motion. J Phys Ther Sci, 2019, 31: 869–872. [Medline] [CrossRef]
11) McGill SM, Norman RW: Effects of an anatomically detailed erector spinae model on L4/L5 disc compression and shear. J Biomech, 1987, 20: 591–600. [Medline] [CrossRef]
12) Potvin JR, Norman RW, McGill SM: Mechanically corrected EMG for the continuous estimation of erector spinae muscle loading during repetitive lifting. Eur J Appl Physiol Occup Physiol, 1996, 74: 119–132. [Medline] [CrossRef]
13) Colloca CJ, Hinrichs RN: The biomechanical and clinical significance of the lumbar erector spinae flexion-relaxation phenomenon: a review of literature. J Manipulative Physiol Ther, 2005, 28: 623–631. [Medline] [CrossRef]
14) Schibye B, Hansen AF, Hye-Knudsen CT, et al.: Biomechanical analysis of the effect of changing patient-handling technique. Appl Ergon, 2003, 34: 115–123. [Medline] [CrossRef]
15) McGill SM: Electromyographic activity of the abdominal and low back musculature during the generation of isometric and dynamic axial trunk torque: implications for lumbar mechanics. J Orthop Res, 1991, 9: 91–103. [Medline] [CrossRef]
16) Rainoldi A, Melchiorri G, Caruso I: A method for positioning electrodes during surface EMG recordings in lower limb muscles. J Neurosci Methods, 2004,

134: 37–43. [Medline] [CrossRef]

17) Hislop H, Montgomery J: Daniels and Worthingham's, muscle testing. Techniques of manual examination, 8th ed. St Louis: Saunders Elsevier, 2004.

18) Kanda Y: Investigation of the freely available easy-to-use software 'EZR' for medical statistics. Bone Marrow Transplant, 2013, 48: 452–458. [Medline] [CrossRef]

19) Andersson EA, Oddsson LI, Grundström H, et al.: EMG activities of the quadratus lumborum and erector spinae muscles during flexion-relaxation and other motor tasks. Clin Biomech (Bristol, Avon), 1996, 11: 392–400. [Medline] [CrossRef]

20) Haxton HA: Absolute muscle force in the ankle flexors of man. J Physiol, 1944, 103: 267–273. [Medline] [CrossRef]

21) Alkner BA, Tesch PA, Berg HE: Quadriceps EMG/force relationship in knee extension and leg press. Med Sci Sports Exerc, 2000, 32: 459–463. [Medline] [CrossRef]

22) Onishi H, Yagi R, Oyama M, et al.: EMG-angle relationship of the hamstring muscles during maximum knee flexion. J Electromyogr Kinesiol, 2002, 12: 399–406. [Medline] [CrossRef]

23) Nakano S, Wada C, Kato H: Relationships between the foot placement of the care assistant and the force required to help a person who needs transfer assistance to stand. Rigakuryoho Kagaku, 2015, 30: 725–728 (in Japanese). [CrossRef]

24) Kaneko M: The Relationship between foot angle and postural stability in aided standing and sitting. Jpn J Nurs Art Sci, 2018, 17: 51–60 (in Japanese).

25) Huang Q, Zhang Y, Li D, et al.: The evaluation of chronic low back pain by determining the ratio of the lumbar multifidus muscle cross-sectional areas of the unaffected and affected sides. J Phys Ther Sci, 2014, 26: 1613–1614. [Medline] [CrossRef]

26) Huang Q, Li D, Zhang J, et al.: Comparison of the efficacy of different long-term interventions on chronic low back pain using the cross-sectional area of the multifidus muscle and the thickness of the transversus abdominis muscle as evaluation indicators. J Phys Ther Sci, 2014, 26: 1851–1854. [Medline] [CrossRef]

27) Gagnon M: The efficacy of training for three manual handling strategies based on the observation of expert and novice workers. Clin Biomech (Bristol, Avon), 2003, 18: 601–611. [Medline] [CrossRef]

28) Lindbeck L, Kjellberg K: Gender differences in lifting technique. Ergonomics, 2001, 44: 202–214. [Medline] [CrossRef]

29) Boocock MG, Mawston GA, Taylor S: Age-related differences do affect postural kinematics and joint kinetics during repetitive lifting. Clin Biomech (Bristol, Avon), 2015, 30: 136–143. [Medline] [CrossRef]

30) Miyasaka T, Matsumoto M, Kamoshida M, et al.: Study of evacuation techniques in the event of a night fire at a dementia group home—method of transferring evacuees from their beds to the floor. Int J N Technol Res, 2019, 5: 29–34.