Range of Motion and Walking Status in Adults with Long-Term Disabilities Attending a Disability Welfare Facility: A Cross-Sectional Study

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Abstract

Aim: To describe routinely measured joint range of motion (ROM) in adults with long-term disabilities attending a disability welfare facility, evaluate measurement completion, and explore associations between ROM and physical therapist-defined walking status. Evidence from heterogeneous populations receiving long-term disability support remains limited.
Methods: This exploratory retrospective cross-sectional observational study included 47 facility users. Passive ROM was assessed bilaterally for shoulder flexion, elbow flexion and extension, knee flexion and extension, and ankle dorsiflexion in routine care. Participants were classified as walking-capable or walking-difficulty based on clinical observation independently of ROM. Completion rates were calculated for each movement. Between-group differences were examined using Mann–Whitney U tests, and age associations using Spearman correlations. Twelve group comparisons were assessed using a Bonferroni sensitivity threshold of $p < 0.0042$.
Results: Measurement completion varied between movements and was lowest for knee flexion. The walking-capable group showed less bilateral knee extension limitation at nominal significance (left: $p = 0.005$, $r = 0.43$; right: $p = 0.009$, $r = 0.40$), but neither comparison met the Bonferroni-adjusted threshold. No other joint movement showed a nominally significant between-group difference. No statistically significant association between age and ROM was detected.
Conclusion: Bilateral knee extension ROM differed between clinical walking-status groups at nominal significance but not after adjustment for multiple comparisons. Routinely collected knee extension ROM may complement mobility-related physical impairment assessment in disability welfare settings. The small, heterogeneous sample, missing measurements, and unadjusted cross-sectional analyses require cautious interpretation; these findings are exploratory rather than confirmatory.

Keywords: Knee Joint, Physical Functional Performance, Long-Term Care, Rehabilitation

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1. Introduction

Range of motion (ROM) is a fundamental measure used to assess physical function. Restricted ROM may affect postural control, bed mobility, transfers, walking, and activities of daily living; therefore, continued assessment is important in rehabilitation practice, including physical and occupational therapy (Gates et al., 2016; Hyodo et al., 2017; Skalsky & McDonald, 2012). In long-term rehabilitation and disability support settings, ROM assessment is also relevant to the prevention of functional decline, maintenance of mobility, and planning of individualised support across daily activities.

Users of disability welfare facilities have diverse diseases and disabilities, including cerebral palsy, cerebrovascular disease, neuromuscular disorders, intellectual disabilities, and neurodevelopmental disorders. Many facility users live for long periods with childhood-onset or acquired disabilities and may require ongoing rehabilitation support as they age. In these individuals, ROM restrictions may arise from multiple factors, such as abnormal muscle tone, prolonged maintenance of a fixed posture, reduced physical activity, pain, contracture (Rodby-Bousquet et al., 2013; Skalsky & McDonald, 2012). In adults with cerebral palsy, ROM limitations have been reported across multiple joints, and greater limitations have been associated with lower gross motor function (Wibeck et al., 2023). In individuals with severe cerebral palsy, postural asymmetry has also been associated with hip and knee contractures and reduced ability to change position (Rodby-Bousquet et al., 2013).

Furthermore, adults with childhood-onset disabilities, including cerebral palsy, may experience age-related declines in walking and mobility (Morgan & McGinley, 2014). In adults with intellectual disabilities, objective assessment of muscle strength, balance, flexibility, endurance, and mobility has been recommended to identify age-related changes in physical function (Hilgenkamp et al., 2010; Maring et al., 2013). These findings are relevant to long-term rehabilitation and disability support because people with long-term disabilities may require ongoing support for age-related functional changes across adulthood. They also underscore the need to assess physical function, including ROM, individually and longitudinally rather than inferring functional status solely from chronological age or diagnosis.

Walking requires adequate movement at the hip, knee, and ankle joints. Restricted lower-extremity ROM may alter joint motion and compensatory strategies during standing and walking (Attias et al., 2016; Hyodo et al., 2017). In particular, limited knee extension may result in persistent knee flexion during stance and may interfere with lower-limb support, standing posture, and forward progression of the body (Attias et al., 2016; Harato et al., 2008). Lower-extremity ROM and muscle strength have also been associated with physical performance, including mobility (Jung & Yamasaki, 2016).

Goniometric ROM measurements are influenced by examiner, procedure, joint, and positioning (Gajdosik & Bohannon, 1987; Mutlu et al., 2007). Standard measurement positions may be impractical in disability welfare settings because of severe impairment, muscle tone, communication difficulties, or environmental constraints. Evidence describing both the feasibility of multi-joint ROM assessment and its association with walking status in heterogeneous welfare-service populations is limited. We therefore characterised routinely measured ROM and measurement completion in adults with long-term disabilities and explored associations with clinical walking status and age. All analyses were exploratory.

2. Materials and Methods

2.1. Study Design

This exploratory retrospective cross-sectional observational study used existing ROM data collected as part of routine practice at a disability welfare facility. The study period was from April 6 to June 9, 2026. This study was reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement.

2.2. Participants

The study population comprised 48 individuals registered at a disability welfare facility during the study period (Table 1). All users lived either at home or in group homes and attended the facility on weekdays to participate in daytime activities. One individual who had been on long-term leave, had almost no facility attendance, and had no available ROM data was excluded. Consequently, 47 participants were included in the analysis. No formal sample size calculation was performed because this retrospective exploratory study included all eligible facility users with available data during the predefined study period.

Age, sex, primary diagnosis, and walking status were obtained from medical or facility records. Walking status was determined for all participants by the same physical therapist based on routine physical function assessments performed at the facility. This was a facility-specific, physical therapist-defined binary classification and was not based on a validated or standardised measure of walking ability. Participants were classified into the walking-capable group when at least one stance phase and one swing phase were achieved with each lower limb without direct assistance to either lower limb, even if a walking aid, supervision, or hands-on assistance for trunk or balance control was required. Participants were not classified as walking-capable when a caregiver directly assisted lower-limb advancement or forward movement of the foot. No standardised assistance scale was used; assistance status was described clinically based on routine facility records. Walking status was determined independently of ROM measurements, based solely on the physical therapist's routine clinical observations of each participant's actual walking performance. ROM values were not used for walking-status classification.

Participants who could maintain standing but were judged unable to advance the lower limbs sufficiently to per-

form a walking movement were classified into the walking-difficulty group.

Of the 47 participants, 17 were classified into the walking-capable group and 30 into the walking-difficulty group. The frequency and degree of walking assistance were not systematically recorded using a standardised scale; therefore, detailed assistance levels could not be quantified retrospectively.

2.3. Range of Motion Measurements

ROM measurements were performed as part of routine practice by one physical therapist employed at the facility. A plastic goniometer (OG Wellness Technologies Co., Ltd., Okayama, Japan) was used. Passive ROM was measured in 5° increments in accordance with the ROM measurement and reporting methods recommended by the Japanese Orthopaedic Association and the Japanese Association of Rehabilitation Medicine. Measurements followed the recommended anatomical landmarks, goniometer axis, stationary arm, and moving arm for each joint movement.

ROM was not measured when joint contracture or deformity prevented reliable identification of the recommended anatomical landmarks or application of the recommended goniometric procedure. For extension movements, inability to reach the neutral 0° position was recorded as a negative value representing the degree of extension limitation. Each item was measured twice, and the mean of the two measurements was used for analysis.

ROM measurements were performed within a pain-free range, and no ROM measurement was omitted because of pain during the study period.

Measurements included bilateral shoulder flexion, elbow flexion and extension, knee flexion and extension, and ankle dorsiflexion. However, only items considered safe and feasible were measured, taking into account the participant's physical condition, muscle tone, pain, refusal of measurement, cognitive or comprehension difficulties, and the feasibility of securing an appropriate test position. Unlike a medical institution, the study facility did not have dedicated physical therapy examination beds or measurement assistants available at all times. Therefore, when a standard test position on a bed could not be secured, measurements were performed in a wheelchair-seated position or another feasible position, with priority given to safety and participant burden. In particular, knee flexion measurement often required transfer to a bed and assistance to secure the measurement position. Because the facility did not have a dedicated examination bed and only one physical therapist was available, knee flexion measurement was not feasible for some participants because of environmental and staffing limitations. Accordingly, missing ROM measurements were considered potentially non-random because feasibility of measurement was influenced by participants' physical characteristics as well as environmental and staffing constraints. Because the reasons for non-measurement were not systematically recorded for each individual ROM variable, the specific reasons for missingness could not be quantified retrospectively for each joint movement.

The measurement position used for each ROM assessment was recorded. Because standard positioning was not always feasible, measurements were performed in sitting, supine, or side-lying positions according to participant condition and safety. The number of measurements performed in each position for each joint movement is summarised in Supplementary Table 1.

2.4. Outcome Measures

The principal exploratory outcomes were between-group differences in ROM across the 12 bilateral joint-movement comparisons. No single ROM variable was prespecified as a confirmatory primary outcome. Additional exploratory outcomes included the distribution of ROM values, the number and proportion of participants for whom each joint movement could be measured, and the association between age and ROM. The measurement completion rate for each joint movement was calculated separately for the left and right sides by dividing the number of participants with an available measurement by the total number of analysed participants (n = 47).

2.5. Ethical Considerations

This study was approved by the Research Ethics Committee of Kochi Professional University of Rehabilitation (approval no. KPUR2026E0009). Because this retrospective study used existing data obtained during routine practice, information about the study purpose, the data to be used, the handling of personal information, and the right to decline participation was disclosed to participants and their families, and an opportunity to opt out was provided. Study-specific identification numbers were assigned, and directly identifying information was removed before analysis.

2.6. Statistical Analysis

Continuous variables are presented as means and standard deviations or medians and interquartile ranges, as appropriate. ROM values used for between-group comparisons are presented as medians and interquartile ranges. Categorical variables are presented as numbers and percentages. For Table 3, the 25th and 75th percentiles were computed from available individual-level data using linear interpolation.

ROM values were compared between the walking-capable and walking-difficulty groups using the Mann–Whitney U test. Analyses were performed using available data for each ROM variable, and no imputation of missing ROM values was performed. Associations between age and ROM were explored using Spearman's rank correlation coefficient. Effect sizes for all 12 comparisons were calculated as $r = |Z|/\sqrt{N}$ using the Z statistics from the SPSS Mann–Whitney U output and the available sample size for each comparison. For the left and right knee-extension comparisons, 95% confidence intervals for r were estimated separately from

the individual-level data using stratified nonparametric bootstrap resampling (20,000 iterations) within walking-status groups. Percentile confidence limits were calculated using the 2.5th and 97.5th percentiles of the bootstrap distribution; the bootstrap estimates used tie-adjusted normal approximation without continuity correction.

Mann–Whitney U tests and Spearman correlations were performed using IBM SPSS Statistics version 22.0 (IBM Corp., Armonk, NY, USA). Effect size calculations and bootstrap confidence intervals were performed separately using Python (SciPy and NumPy). All tests were two-sided, and $p < 0.05$ was considered statistically significant. Because 12 bilateral ROM comparisons were performed as exploratory between-group analyses, nominal p values were reported for each comparison. As a sensitivity check for multiplicity, a Bonferroni-adjusted significance threshold of $p < 0.0042$ (0.05/12) was considered alongside the nominal p values. Given the small and heterogeneous sample and the substantial variation in the number of available ROM measurements across joint movements, multivariable adjustment was considered statistically unstable and was therefore not performed. Accordingly, all between-group comparisons should be interpreted as unadjusted associations.

3. Results

The characteristics of the 47 participants are shown in Table 1. The groups also differed descriptively in age, sex, and primary diagnosis. The walking-difficulty group included a higher proportion of participants with cerebral palsy, whereas neurodevelopmental or intellectual disability was observed only in the walking-capable group. Descriptive statistics, the number of participants with available measurements, and measurement completion rates for each joint movement are shown in Table 2. Completion rates varied by joint and direction of movement and were lowest for knee flexion on both sides.

Table 1

Participant characteristics

Variable	All participants (n = 47)	Walking-difficulty group (n = 30)	Walking-capable group (n = 17)
Number of participants, n	47	30	17
Age, years	42.4 ± 15.0	39.3 ± 16.0	47.8 ± 11.7
Male, n (%)	21 (44.7)	17 (56.7)	4 (23.5)
Female, n (%)	26 (55.3)	13 (43.3)	13 (76.5)
Primary diagnosis, n (%)			
Central nervous system disorder (cerebral palsy)	17 (36.2)	14 (46.7)	3 (17.6)
Central nervous system disorder (other neurological disorders)	23 (48.9)	16 (53.3)	7 (41.2)
Neurodevelopmental or intellectual disability	7 (14.9)	0 (0.0)	7 (41.2)

Note. Values are presented as mean ± standard deviation or number (%).

Table 2

Descriptive statistics and measurement completion for each joint movement

Movement	Participants measured, n	Completion rate, %	ROM, °
Left shoulder flexion	36	76.6	110.2 ± 29.6
Right shoulder flexion	36	76.6	108.3 ± 29.1
Left elbow flexion	38	80.9	141.3 ± 18.6
Right elbow flexion	37	78.7	142.0 ± 20.1
Left elbow extension	36	76.6	−8.9 ± 19.9
Right elbow extension	34	72.3	−13.2 ± 23.1
Left knee flexion	20	42.6	134.2 ± 29.5
Right knee flexion	19	40.4	120.1 ± 41.3
Left knee extension	42	89.4	−19.5 ± 24.5
Right knee extension	42	89.4	−16.9 ± 21.0
Left ankle dorsiflexion	38	80.9	3.4 ± 17.6
Right ankle dorsiflexion	38	80.9	3.2 ± 18.3

Note. ROM values are presented as mean ± standard deviation.

Among the 17 participants classified as walking-capable, 5 walked without physical assistance or supervision, 4 required supervision only, and 8 required hands-on assistance during daily walking. Regarding walking aids and orthotic use, 9 used no device, 5 used a walker, 1 used a cane, and 2 used a lower-limb orthosis. Hands-on assistance included trunk support, bilateral hand support, or unilateral hand support.

The comparisons of ROM according to walking status are shown in Table 3. At the nominal significance level ($p < 0.05$), the walking-capable group had greater knee extension ROM, indicating less extension limitation, on both the left (walking-difficulty group: $n = 30$; walking-capable group: $n = 12$; $U = 79.5$, $p = 0.005$, $r = 0.43$, 95% CI 0.21–0.63) and right (walking-difficulty group: $n = 30$; walking-capable group: $n = 12$; $U = 87.0$, $p = 0.009$, $r = 0.40$, 95% CI 0.18–0.60) sides. However, neither knee extension comparison met the Bonferroni-adjusted significance threshold of $p < 0.0042$ for the 12 exploratory ROM comparisons. No other joint movement showed a nominally significant between-group difference. Comparisons based on very small subgroups, particularly knee flexion in the walking-capable group ($n = 2$), should be interpreted descriptively and with caution. Exploratory analyses using Spearman's rank correlation coefficient showed no significant associations between age and ROM for any joint movement.

Table 3

Comparison of range of motion according to walking status

Movement	Walking-difficulty group, n	Median [Q1–Q3], °	Walking-capable group, n	Median [Q1–Q3], °	U	p	r
Left shoulder flexion	26	105.0 [86.2–131.9]	10	102.5 [91.2–120.0]	123.5	0.818	0.04
Right shoulder flexion	27	102.5 [90.0–130.0]	9	105.0 [95.0–122.5]	109	0.647	0.08
Left elbow flexion	27	150.0 [140.0–150.0]	11	140.0 [132.5–150.0]	122	0.388	0.14
Right elbow flexion	28	145.0 [140.0–151.2]	9	140.0 [130.0–150.0]	93	0.238	0.19
Left elbow extension	27	−10.0 [−25.0–5.0]	9	0.0 [−10.0–15.0]	80	0.127	0.26
Right elbow extension	26	−10.0 [−23.8–0.0]	8	−3.8 [−16.2–1.2]	85.5	0.451	0.13
Left knee flexion	18	142.5 [130.6–150.0]	2	146.2 [144.4–148.1]	13.5	0.568	0.13
Right knee flexion	17	140.0 [80.0–150.0]	2	143.8 [143.1–144.4]	13	0.593	0.12
Left knee extension	30	−25.0 [−40.6–−2.5]	12	0.0 [−6.9–0.0]	79.5	0.005	0.43
Right knee extension	30	−25.0 [−31.9–0.0]	12	0.0 [−6.2–0.0]	87	0.009	0.40
Left ankle dorsiflexion	26	8.8 [−3.8–15.0]	12	8.8 [0.0–12.5]	143	0.681	0.07
Right ankle dorsiflexion	26	0.0 [−11.9–16.9]	12	11.2 [8.8–15.0]	97.5	0.065	0.30

Note. ROM values are presented as median [Q1–Q3]. Between-group comparisons were performed using the Mann–Whitney U test. Effect size r was calculated as $|Z|/\sqrt{N}$. Reported p values are two-sided asymptotic p values; the Bonferroni sensitivity threshold for 12 comparisons was $p < 0.0042$. For left and right knee extension, respectively, bootstrap 95% CIs for effect size r were 0.21–0.63 and 0.18–0.60. Quartiles were calculated from the available individual-level ROM values using linear interpolation (25th and 75th percentiles).

4. Discussion

The main exploratory finding was a nominal between-group difference in bilateral knee extension ROM (left: $p = 0.005$, $r = 0.43$; right: $p = 0.009$, $r = 0.40$), with less extension limitation in the walking-capable group. Neither comparison met the Bonferroni-adjusted threshold ($p < 0.0042$); thus, these associations are preliminary and require confirmation. No other ROM comparison showed a nominally significant group difference, and no statistically significant correlation with age was detected.

These results suggest that knee extension ROM may be one aspect of physical function associated with walking status in users of disability welfare facilities. During walking, the lower limbs must support the body during stance while the centre of mass progresses forward. When knee extension is restricted, persistent knee flexion during stance may interfere with lower-limb support, standing posture, and forward progression. Lower-extremity contractures have been reported to alter gait kinematics and to induce compensatory movements in adjacent joints and the trunk, depending on their location and severity (Attias et al., 2016). Simulated knee flexion contracture has also been shown to produce trunk flexion and altered lower-limb loading during standing and walking (Harato et al., 2008). Therefore, knee extension ROM may represent one physical impairment-related factor associated with lower-limb support and walking status. For therapists working with adults with long-standing disabilities, reduced knee extension ROM may warrant further assessment of mobility-related factors, including posture, activity, muscle tone, strength, pain, and assistance needs. Previous research in adults with cerebral palsy has demonstrated ROM limitations across multiple joints and greater ROM limitations among individuals with lower gross motor function (Wibeck et al., 2023). In individuals with severe cerebral palsy, postural asymmetry has been associated with hip and knee contractures and a reduced ability to change position (Rodby-Bousquet et al., 2013). Although the present sample included a range of diseases and disabilities rather

than cerebral palsy alone, the greater knee extension limitation observed in the walking-difficulty group is consistent with previous reports linking ROM limitations to mobility. No prespecified threshold for a clinically meaningful between-group difference in knee extension ROM was defined in this study; therefore, the clinical importance of the observed differences cannot be established from these data alone.

Because this was a cross-sectional study, it was not possible to determine whether knee extension limitation contributed to walking difficulty or whether reduced opportunities to walk and prolonged wheelchair sitting led secondarily to knee extension limitation. Prolonged immobility, muscle weakness, muscle imbalance, and sustained positioning may contribute to the development and progression of contractures (Skalsky & McDonald, 2012). Participants with walking difficulty may have had fewer opportunities to position the knees near full extension and may have spent longer periods sitting in a wheelchair with the knees flexed. However, this interpretation remains speculative because habitual posture, wheelchair sitting time, and physical activity were not measured.

Walking status depends on several factors, including ROM, muscle strength, tone, balance, pain, cognition, assistive devices, and assistance needs. Knee extension ROM should therefore not be interpreted as a stand-alone indicator of walking ability or future walking potential. In routine disability welfare practice, it may be considered as supplementary impairment information alongside broader assessments of posture and mobility. However, the present results were unadjusted, did not survive correction for multiple comparisons, and did not establish a clinically meaningful threshold or causal relationship.

No statistically significant age–ROM association was observed. Similarly, a study of middle-aged adults with cerebral palsy reported ROM restrictions without a clear association with age within the examined range (Wibeck et al., 2023). Our small sample cannot exclude an age effect. Muscle tone, disease duration, posture, activity, pain, and contracture may also influence ROM. Given reported declines in mobility among adults with childhood-onset disabilities (Morgan & McGinley, 2014), assessment should encompass multiple dimensions of function (Hilgenkamp et al., 2010; Maring et al., 2013).

Reduced fitness can precede decline in mobility and daily function (Oppewal et al., 2014). For long-term disability support, repeated ROM assessment may be more informative when interpreted alongside walking status, daily mobility, and individual changes rather than chronological age alone. Such monitoring may guide reassessment of positioning and activity-related support, although benefits were not tested here.

4.1. Limitations of the Study

This study has several limitations. First, ROM could not be measured for all joints in all participants because of physical condition, joint deformity, contracture, muscle tone, pain, refusal, cognitive or comprehension difficulties, and difficulty securing an appropriate measurement position. Therefore, the number of participants included varied across measurement items, and findings for items with small sample sizes should be interpreted cautiously. Participants for whom ROM could not be measured may have had more severe motor impairment, greater muscle tone, or more severe contracture than those who could be measured. Thus, the observed ROM values may overestimate ROM in the facility population as a whole. This pattern of non-random missingness may have introduced selection bias into the observed ROM distributions and between-group comparisons. Second, walking status was classified using a facility-specific binary classification determined by a single physical therapist rather than a validated or standardised measure of walking ability. No validated or standardised mobility or walking measure was available in the retrospective dataset. Therefore, the present findings should be interpreted as associations with walking status rather than as direct evidence of functional walking ability. Third, the between-group analyses were unadjusted. Age, sex, and primary diagnosis distributions differed between groups, and these factors may have confounded the observed ROM differences. Therefore, the observed differences in knee extension ROM should be interpreted as unadjusted associations with walking status and not as evidence of an independent effect of knee extension ROM on functional walking ability. Fourth, ROM was measured by a single therapist under routine-practice conditions, and formal inter-rater or intra-rater reliability was not evaluated in this sample. Some measurements were also obtained in nonstandard positions when standard positioning was not feasible, which may have introduced measurement variability. Fifth, this was an exploratory retrospective cross-sectional observational study with a small sample from a single facility, limiting generalisability. The relatively short study period of approximately two months further limits the generalisability of the findings and reinforces their interpretation as preliminary, exploratory evidence from a single facility. The sample included adults with diverse disabilities and was not limited to older adults; therefore, the findings should be interpreted as evidence from a disability welfare setting involving adults with long-term disabilities rather than as findings from a purely geriatric cohort. Some subgroup comparisons were based on very small sample sizes, particularly knee flexion in the walking-capable group (n = 2), and these results should therefore be interpreted primarily as descriptive rather than inferential. Other potentially important confounding factors, including muscle tone, muscle strength, pain, habitual physical activity, and assistive-device use, were not comprehensively measured or adjusted for in the present analysis. In addition, 12 exploratory joint-movement comparisons were performed. Although bilateral knee extension differences were observed at the nominal significance level, neither met the Bonferroni-adjusted threshold; these findings may reflect chance findings due to multi-

ple testing and should be regarded as hypothesis-generating rather than confirmatory.

Causality cannot be inferred. Future prospective research should use standardised walking assessments, record assistance levels, establish ROM measurement reliability, and examine longitudinal ROM changes in relation to posture, strength, tone, activity, and mobility.

5. Conclusions

In this disability welfare cohort, the walking-capable group had less bilateral knee extension limitation at nominal significance, but neither difference survived Bonferroni correction. Other ROM comparisons and age correlations were not statistically significant. Routinely measured knee extension ROM may complement clinical assessment of mobility-related impairment, but the small sample, unadjusted comparisons, and cross-sectional design preclude causal or independent-effect conclusions. Further confirmation is needed.

Conflict of Interest

The authors declare no conflicts of interest.

Ethics Approval

Approved by the Research Ethics Committee of Kochi Professional University of Rehabilitation (approval no. KPUR2026E0009). An opt-out procedure was used for this retrospective study of existing routine-practice data.

Data Availability

The data are not publicly available because they contain information derived from facility records. De-identified data may be available from the corresponding author upon reasonable request and subject to appropriate ethical and institutional approval.

Trial Registration

Not applicable.

Author Contributions

T. Matsuda: conceptualization, investigation, data curation, formal analysis, methodology, writing—original draft, and writing—review and editing; Y. Akezaki: methodology, supervision, and writing—review and editing; Y. Tsuji: methodology, supervision, and writing—review and editing. All authors have read and approved the final manuscript.

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OpenAI's ChatGPT was used to assist with manuscript preparation, responses to reviewers, and Python code development for supplementary statistical calculations. The primary statistical analyses were performed by a co-author using IBM SPSS Statistics. All results and interpretations were reviewed by the authors, who take full responsibility for the manuscript.

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Supplementary Material

Supplementary Table 1

Measurement positions used for each range-of-motion assessment

Movement	Left sitting, n	Left supine, n	Left side-lying, n	Right sitting, n	Right supine, n	Right side-lying, n
Shoulder flexion	20	11	5	21	13	2
Elbow flexion	22	11	5	21	14	2
Elbow extension	19	12	5	19	13	2
Knee flexion	1	13	6	1	15	3
Knee extension	21	15	6	22	17	3
Ankle dorsiflexion	20	14	4	19	17	2

Note. Values indicate the number of ROM measurements performed in each position. Measurement position was selected according to participant condition, safety, and feasibility when the standard position could not be achieved. ROM, range of motion.