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Original Article

Habitual posture and weekly time spent sitting do not contribute to the lumbopelvic curvature during active unilateral knee extension in sitting test

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Abstract. [Purpose] To investigate whether habitual pelvic posture and time spent sitting are primary contributing factors to performance in the active unilateral knee extension in sitting test in young people. [Participants and Methods] The participants' ages ranged from 20 to 40 years. LUMOback, a wearable electronic device, was used to measure the proportion of the days spent in a neutral pelvic posture (posture score) and time spent sitting over a week. The lumbopelvic sagittal curvature from T12 to S2 (θ) during the active unilateral knee extension in sitting test was also assessed using a flexible ruler. A multiple regression analysis was performed with the primary independent variables of the posture score and time spent sitting, undertaking priori considerations of potential confounders of sex, and pain condition on the θ value. [Results] Eighty participants (21.7 ± 3.8 years) were enrolled in the study (24 males and 56 females). Neither the posture score nor time spent sitting statistically significantly contributed to the θ value. [Conclusion] Neither the proportion of the day spent with neutral pelvic posture nor time spent sitting detected by LUMOback was the primary contributing factor to the active unilateral knee extension in sitting test performance.
Key words: Habitual posture, Sitting, Wearable electronic devices

INTRODUCTION

Optimal lumbopelvic control during movement is important to minimize biomechanical contributing factors to low back pain (LBP). Several clinical tests to evaluate lumbopelvic control during limb movement have been proposed[1–3]. One test of such ability is active unilateral knee extension in sitting (AUKEiSit)[4–6], whose quantitative examination can be conducted reliably[7, 8]. Criteria for good performance of the AUKEiSit test is to maintain a neutral lumbar lordosis during knee extension while poor performance is indicated by posterior pelvic tilt and a kyphotic lumbopelvic curvature during knee extension[9]. One explanation for poor performance on this test is when hamstring muscle flexibility is relatively less than the lumbar extensor muscles, inducing posterior pelvic tilt. Maintaining muscles in a shorted position reduces muscle flexibility[10], hence habitual posterior pelvic tilt such as slouched sitting may reduce relative flexibility of hamstring muscles to the lumbar extensor muscles and the AUKEiSit performance. However, there has been no study investigating contributions of habitual postures and movements to the AUKEiSit test performance.

In addition to the habitual postures and movements, pain and demographic features may contribute to the AUKEiSit test performance. Although there are individual variabilities, in general terms, nociceptive inputs tend to alter muscle activity

patterns[11]. Therefore, the presence of LBP may contribute to the AUKEiSit test performance. Further, a systematic review concluded that age and gender contributed to lumbopelvic rhythm during sagittal plane movement[12]. This may be due to the fact that age above or below 45 years has an effect on hamstring muscle flexibility[13]. An episode of LBP in young age increases the likelihood of LBP in later life[14]. Therefore, a study recruiting young people should be prioritized, considering a context of improving motor control so as to minimize recurrence of LBP in later life.

The purpose of this study was to investigate whether habitual posture and sitting behaviors can be primary contributing factors to AUKEiSit test performance, considering confounders of gender and LBP status in young people.

PARTICIPANTS AND METHODS

The current study was a cross-sectional study design. Approval for this study was granted by the human research ethics committee in the Saitama Prefectural University (No. 27109). Written informed consent was obtained from each participant prior to data collection.

A sample of convenience was used with participants recruited via advertising in the Saitama Prefectural University. Inclusion criteria were; 20–40 years of age, no history of symptoms or mobility deficit in the hip and the knee, no history of diagnosed structural deformity (e.g. scoliosis) or diagnosed neurological disorders, and no history of spinal surgery or fracture. Participants were not considered eligible when they had leg symptoms or altered lumbar curvature during the AUKEiSit test which were influenced by a change in ankle position from dorsiflexion to plantarflexion, indicating that the limitation during the AUKEiSit test was related to peripheral nerve sensitivity.

Lumbopelvic sagittal alignment (θ) during the AUKEiSit test on the right side was the dependent variable in the current study. This study used an established procedure for performance of the AUKEiSit test[7–9, 15], with the process standardized using a metal orthosis (Fig. 1). Lumbopelvic curvature from T12 to S2 was traced on paper using a flexible ruler (Shinwa Rules Co., Ltd., Tsubame, Niigata, Japan) during the AUKEiSit test. Participants were instructed to actively extended their right knee to 10° flexion while maintaining their maximum lumbar lordosis and anterior pelvic tilt. The measurement was repeated five times by a research assistant, who was blinded to participant's information, and the subsequent mean value was used as a representative value for each participant[7, 8]. The θ value was calculated using two different methods; 2-point-method and max-method. The detailed description for these methods is described in previous studies[7, 8].

In the 2-point-method, the angle between two tangential lines at T12 and S2 vertebral levels drawn on a trace line of lumbopelvic curvature was calculated using Image J software (National Institute of Mental Health, Bethesda, USA). Inter-session and inter-examiner reliability for this method is excellent with intra-class correlation coefficients (ICC) of 0.97 and 0.93 respectively[8]. A positive θ value indicated lumbar kyphosis and a negative θ value indicated lumbar lordosis. The θ value was calculated by another research assistant, who was blinded to participant's information and their LUMOback data.

In the max-method, the length between the T12 and S2 vertebral levels (L) and the maximum depth to the curvature (H) are calculated from the trace line and an angle of lumbopelvic sagittal alignment (θ) determined using the following formula:

$$\theta = 4 \text{ Arc tan} \frac{2H}{L}$$

A positive θ value indicated lumbar kyphosis and a negative θ value indicated lumbar lordosis.

The θ value from the 2-point-method was used as a primary dependent variable. The θ value from the max-method was used as a secondary dependent variable and presented in Appendix Table 1 because the 2-point-method tends to reflect the cobb angle on the x-ray in standing (ICC=0.94–0.96)[7] although the max-method is more convenient than the 2-point method.
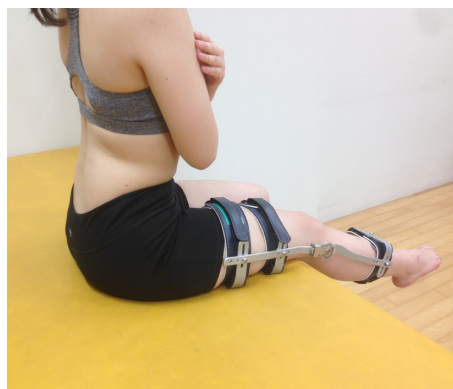
Fig. 1. The active unilateral knee extension in sitting test.
Participants actively extended the right knee to 10° flexion that was standardized using a metal orthosis while maintaining their maximum lumbar lordosis and anterior pelvic tilt. Source[8]

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Table 1. Characteristics of total participants (n=80)

Variables	Participants
Age (years)	21.7 ± 3.8
Japanese version of the EuroQol five dimensions questionnaire (0–1)	0.9 ± 0.1
International Physical Activity Questionnaire short version, minutes×Mets	2,865.5 ± 2,533.7
Participants with low back pain, n (%)	33 (41.3%)
Japanese version of the Oswestry Disability Index* (%)	11.8 ± 8.6
P4*, 0–40	9.7 ± 6.5
Duration of low back pain* (months)	27.3 ± 32.6
θ with the 2-point-method† (degrees)	−3.5 ± 13.9
θ with the max-method† (degrees)	4.1 ± 16.5
Posture score (%)	44.0 ± 10.8
Time spent sitting (min)	506.5 ± 102.1

Values are presented with mean ± SD unless specified.
*n=33.
†A positive θ value indicated lumbar kyphosis and a negative θ value indicated lumbar lordosis.

The independent variables were the mean value of the posture score and time spent sitting over a week obtained from the LUMOback (Lumo Bodytech Inc., Mountain View, CA, USA). Participants wore the LUMOback at the level of L5-S1 during the day. The current study used the same setting of the LUMOback and the detailed LUMOback settings are described in previous studies[16, 17]. Briefly, the posture score is the proportion of time in a day with neutral pelvic posture relative to the time with a pelvic posture at a pre-determined threshold, 'very slouched' in the LUMOback setting, over a week. The threshold of 'very slouched' included ≥7° posterior or ≥14° anterior tilt of the pelvis relative to the calibrated angle in sitting and ≥8° posterior or ≥12° anterior tilt of the pelvis relative to the calibrated angle in standing. Inter-session reliability of the posture score was ICC of 0.82 in individuals with LBP and 0.91 in healthy individuals[16]. The inter-session reliability of time spent sitting was ICC of 0.75 in individuals with LBP and 0.85 in healthy individuals[16].

The following information was collected to understand features of the current cohort: 1) demographics, 2) Japanese version of the EuroQol five dimensions questionnaire (EQ-5D-Japanese)[18], 3) the International Physical Activity Questionnaire short version (IPAQ)[19, 20], and 4) The P4[21]. The EQ-5D-Japanese is a common measure for quality of life, where a greater score indicates better quality of life with a maximum score of one[22]. The IPAQ is a reliable and valid self-reporting questionnaire for assessing average activity level with minutes × Mets[20, 23, 24]. The P4 was used to identify participants with (total score >0) or without LBP (total score=0). The P4 is a reliable and valid measure for pain intensity with four 0–10 numerical rating scales (0: no pain, 40: the highest possible pain level)[21]. For participants with LBP, the following information was also collected: 1) the Japanese version of the Oswestry Disability Index (ODI)[25, 26], and 2) the duration of LBP. The duration of LBP was defined as the number of months since the last pain-free month, a measure based on a previous recommendation[27].

After the measurement of the lumbopelvic curvature during the AUKEiSit test, participants wore the LUMOback device daily for seven consecutive days continuously during waking hours except when playing water sports and taking a shower.

It is recognized that multiple regression analysis requires at least 80 participants and at least 10 participants per independent variable. In the current study, the maximum number of independent variables was four. Thus, the current study aimed to include 80 participants.

Descriptive statistics were used to summarize characteristics of the participants. SPSS version 21.0 (IBM Corporation, NY, USA) was used for statistical analyses. Alpha value was set at 5%.

At the first step, Pearson's *r* values between the θ value and gender, and pain condition (participants with or without LBP) were calculated. When the p-value was less than 0.1, the independent variable was included in multiple regression analysis. At the second step, multiple regression analysis was undertaken with the enter method using the independent variables of posture score and time spent sitting and the identified variables in the first step. The interpretation of the R^2-value was as follows;<0.3: a none—very weak effect size, 0.3 − 0.5: a weak—low effect size, 0.5 − 0.7: a moderate effect size, and >0.7: a strong effect size[28].

RESULTS

There were no missing data in the current study. No participant had an increase in LBP during the AUKEiSit test. Table 1 present participants' characteristics.

In the first step, only p-values of gender was <0.01 in each dependent variable (Appendix Table 1) and thus, three independent variables of the posture score, time spent sitting, and gender were included in the regression modeling. Apart from gender, neither the posture score nor time spent sitting statistically significantly contributed to the performance of the AUKEiSit test for each outcome (Table 2). The result of analysis of variance (ANOVA) was statistically significant for each

Table 2. Results of multiple regression modeling for the lumbopelvic sagittal alignment (θ) during the active unilateral knee extension test in sitting on the right side

Outcome	Model	Unstandardized coefficients (B)	Standardized coefficients (β)	p-value (95% CI)
The 2-point-method	(Constant)	5.72		0.53 (−12.12 to 23.56)
	Posture score	0.22	0.17	0.09 (−0.03 to 0.47)
	Time spent sitting	−0.02	−0.12	0.24 (−0.04 to 0.01)
	Gender*	15.37	0.51	<0.001 (9.41 to 21.33)
The max-method	(Constant)	25.76		0.018 (4.59 to 46.92)
	Posture score	−0.02	−0.01	0.89 (−0.32 to 0.28)
	Time spent sitting	−0.02	−0.10	0.32 (−0.05 to 0.02)
	Gender*	18.23	0.51	<0.001 (11.16 to 25.30)

R^2=0.29, ANOVA p<0.001 in each outcome.
A positive θ value indicated lumbar kyphosis and a negative θ value indicated lumbar lordosis.
*Females=0, Males=1.

modeling. The R^2-values in each modeling indicated a none—very weak effect size. The Durbin–Watson statistic was 1.62 in the modeling with the 2-point-method and 1.89 in the modeling with the max-method. Only one outlier whose predicted value of the measured value was above ± 3 SD was detected in the modeling with the max-method. Appendix Table 2 presents summarized characteristics for males and females with statistical comparisons between the two groups.

DISCUSSION

The current study found that neither posture score nor time spent sitting measured with the LUMOback device contributed to the performance of the AUKEiSit. This is in agreement with a previous study by Arab and Nourbakhsh[29]. These researchers investigated whether hamstring flexibility was associated with lifestyle factors such as habitual chair sitting or performing activities of daily living while seated on the floor. Consequently, they found no statistically significant main effect of such lifestyle factors on hamstring flexibility assessed by the active knee extension test in lying (F=0.57, p=0.44). These findings, as well as those in the current study, indicate that improvement of lumbopelvic control during the AUKEiSit test would not be expected with correction of habitual posture and sitting behavior only, and specific exercises are necessary.

The current study also found that gender contributed to the AUKEiSit test performance, where males had a greater θ value than females. This finding indicates that males tend to have poorer performance in the AUKEiSit than females, which is in agreement with other studies indicating greater lumbopelvic movement in males than females using other clinical tests[12, 30, 31]. In the current study, the presence of LBP did not contribute to the AUKEiSit test performance. This indicates that not all individuals with LBP have impaired AUKEiSit test performance and there is individual variability in lumbopelvic control.

In the current study, the AUKEiSit test was used as the dependent variable but different clinical tests might have revealed a correlation between habitual pelvic posture and time spent sitting and lumbopelvic control. For example, bilateral knee extension[5, 32] may induce greater lumbopelvic flexion than unilateral knee extension and may become more sensitive test than the AUKEiSit test to present deficits in lumbopelvic control. Timing of lumbopelvic flexion during trunk forward bending or during heel sitting in a quadruped position may also be another promising dependent variable. More studies would be required to fully understand whether the ability to control neutral lumbopelvic posture during limb movements is associated with habitual posture or sitting behavior.

There are two potential limitations in the current study. One is with respect to the sample size and sampling method. An exact priori sample size estimation was not undertaken and a sample size of 80 was decided as a matter of convenience and convenience sampling was used. Furthermore, potentially biased samples may be a reason why the presence of LBP was not a contributing factor to the lumbopelvic curvature during the AUKEiSit test in the current study. Sampling was undertaken in a university setting and thus those who have severe deficits were not likely be included in the current study, resulting in potential bias to the minimum deficit level. In fact, ODI >13% is considered to be a cut-off for a clinical population with LBP in Japan[33] but the mean ± SD of the ODI in the current cohort was 11.8 ± 8.6%, and nobody had aggravation of LBP during the AUKEiSit test. The presence of LBP may contribute to the performance of the AUKEiSit test in different cohorts. It may be possible to find a statistically significant correlation by collecting data from a larger sample. However, considering the none—very weak in the current study, habitual pelvic posture and time spent sitting detected by the LUMOback are not highly likely to be strong contributing factors to the AUKEiSit test performance. In this study, subgroup analysis was not undertaken based on classifications in movement patterns, pain and psychological status, such as proposed by Sharmann[4]. It is unknown if there are specific subgroups of individuals in terms of movement pattern whose AUKEiSit test performance is

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particularly influenced by habitual posture or sitting behavior. Further research will be required to investigate this.

In conclusion, the current study found that neither the habitual pelvic posture nor time spent sitting detected by the LUMOback was the primary contributing factor to the AUKEiSit test performance.

Conflict of interest

There was no conflict of interest for the authors.

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Appendix

Appendix Table 1. Pearson's r coefficients (p-value) between the lumbopelvic sagittal alignment (θ) during the active unilateral knee extension test in sitting on the right side and potential contributing factors with 80 participants

Measurement method	Gender* (females or males)	Pain[†] (no pain or pain)
θ with the 2-point-method	0.50 (<0.001)	−0.13 (0.23)
θ with the max-method	0.53 (<0.001)	−0.14 (0.21)

A positive θ value indicated lumbar kyphosis and a negative θ value indicated lumbar lordosis.
*Females=0, Males=1.
[†]No pain=0, Pain=1.

Appendix Table 2. Characteristics summarized for females and males

Variables	Females (n=56)	Males (n=24)	p-value
Age, years	21.3 ± 3.5	22.4 ± 4.3	0.25
Japanese version of the EuroQol five dimensions questionnaire, 0–1	0.89 ± 0.11	0.87 ± 0.13	0.35
International Physical Activity Questionnaire short version, minutes × Mets	2,826.5 ± 2,406.8	2,956.7 ± 2,860.9	0.83
Participants with low back pain, n (%)*	21 (38%)	12 (50%)	0.30
Japanese version of the Oswestry Disability Index[†] (%)	8.9 ± 7.1	17.0 ± 8.9	0.01
P4[†], 0–40	8.4 ± 5.9	11.8 ± 7.2	0.15
Duration of low back pain[†] (months)	19.6 ± 27.5	40.8 ± 37.6	0.11
θ with the 2-point-method[‡] (degrees)	−8.0 ± 11.1	7.1 ± 14.4	<0.001
θ with the max-method[‡] (degrees)	−1.5 ± 14.8	17.3 ± 12.1	<0.001
Posture score (%)	45.2 ± 11.4	41.4 ± 9.0	0.16
Time spent sitting (minutes)	516.6 ± 105.6	482.8 ± 91.3	0.18

Values are presented with mean ± SD unless specified.
Comparisons between the two groups were undertaken using two-tailed independent sample t-test except specified.
*Fisher exact test.
[†]12 men and 21 women.
[‡]A positive θ value indicated lumbar kyphosis and a negative θ value indicated lumbar lordosis.

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