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Original Article

Normative ability of young females to control the lumbopelvic curvature during active knee extension in sitting

Hiroshi Takasaki, PT, PhD[1)*], Mayu Yanagisawa, PT, BSc[1)]

[1)] *Department of Physical Therapy, Saitama Prefectural University: 820 Sannomiya, Koshigaya, Saitama 343-8540, Japan*

Abstract. [Purpose] Active unilateral knee extension in sitting (AUKEiSit) is a clinical test for lumbopelvic control during limb movements. We aimed to identify the normal upper limit for the angle of lumbopelvic sagittal alignment (θ) during AUKEiSit in young females. [Participants and Methods] The primary inclusion criteria of the participant included asymptomatic females 18–44 years of age. Lumbopelvic curvature from T12 to S2 was traced on paper using a flexible ruler during right AUKEiSit. The θ value was calculated using 2 methods: 1) 2-point-method, calculating the angle between 2 tangential lines at T12 and S2 on a trace line using Image J software; and 2) max-method, calculating θ by measuring the distance between T12 and S2 and the maximum depth of the curvature. A negative value of θ indicated lumbar lordosis. The mean and 95% confidence intervals (CIs) were computed with bootstrapping. [Results] The data of 121 participants (mean age: 20.6 years) were analyzed. The mean and 95% confidence intervals of θ were −12.06° (−14.03° to −9.40°) with the 2-point-method and −5.40° (−7.62° to −2.73°) with the max-method. [Conclusion] In asymptomatic young females, the 95% confidence intervals of θ during AUKEiSit are negative regardless of the 2 different methods.

Key words: Bootstrapping, Lumbopelvic control, Normative data

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INTRODUCTION

Optimal control of the lumbar spine is important to minimize biomechanical contributing factors to low back pain (LBP). There has been an increasing concern about ability to control of the lumbar spine during limb movements[1–3]. One clinical examination of such ability is active unilateral knee extension in sitting[4–6] as the hamstring muscles arise from the pelvis and attach to the tibia.

Sahrmann[4] suggested that the lumbar spine normally remain flat during active unilateral knee extension to 10° flexion in sitting (AUKEiSit). However, this observation is based on the clinical experience of the expert, and not based on quantitative research. It is necessary to establish normative values for physical assessments such as the AUKEiSit to determine if any intervention is required in the prevention and management of LBP.

It has been reported that there are four distinct clusters with respect to hamstring muscle flexibility, which are characterized by gender and age above or below 45 years[7]. As females have a higher prevalence of LBP than men[8], and an episode of LBP in young age increases the likelihood of LBP in later life[9], it was considered important to investigate normative values for the ability to control the lumbopelvic curvature during the AUKEiSit in young females.

Lumbopelvic curvature can be conveniently assessed in the clinical setting using a flexible ruler. Previous studies[10, 11] have found that there are two reliable methods of measurement of lumbar curvature obtained using this device. The first method (2-point-method) uses Image J software to calculate the angle between two tangential lines at T12 and S2 vertebral

*Corresponding author. Hiroshi Takasaki (E-mail: physical.therapy.takasaki@gmail.com)

levels drawn on a trace line of lumbopelvic curvature. The 2-point-method tends to reflect the cobb angle on the x-ray in standing (Intraclass Correlation Coefficients: ICC=0.94–0.96)[12]. The second method (max-method) is clinically more convenient as it does not require Image J software. The max-method reflects the curvature of the lower back including the subcutaneous tissue. A positive value of the calculated angle of lumbopelvic sagittal alignment (θ) indicates lumbar lordosis and a negative value indicates lumbar kyphosis.

Lumbar flexion increases when ability to control the lumbar spine during the AUKEiSit is poor. Therefore, this study aimed to calculate an upper limit of the angle of lumbopelvic sagittal alignment during the AUKEiSit in young females. Based on Sahrmann's suggestion, it was hypothesized that the upper limit of the θ value during AUKEiSit is zero in the max-method, and negative in the 2-point-method.

PARTICIPANTS AND METHODS

Participants were recruited via advertising in a university from November 2016 to April 2017 using convenience sampling. Inclusion criteria were: asymptomatic females, 18–44 years of age, no history of symptoms or mobility deficit in the spine, the hip and the knee. Participants were excluded if they had leg symptoms or altered lumbar curvature during AUKEiSit which were influenced by a change in ankle position from dorsiflexion to plantarflexion. There is no rule of thumb for the sample size to determine normative values. However, Fukutake[13] suggested a need of at least 120 participants to obtain normative values and therefore sampling continued until complete data from 120 participants were obtained.

Approval for this study was granted by the human research ethics committee in the Saitama Prefectural University (No. 28834). Written informed consent was obtained from each participant prior to data collection.

The primary outcome measure was lumbopelvic curvature from the T12 to S2 during the AUKEiSit, which was traced on paper using a flexible ruler (Shinwa Rules Co., Ltd., Tsubame, Niigata, Japan). The AUKEiSit on the right side was standardized using a metal orthosis using the same methodology as previously reported[10]. Previously it has been established that five repetitions are required to obtain the highest degree of accuracy and reliability for the 2-point-method. Using five repetitions, the inter-examiner reliability and inter-session reliability were $ICC_{(1,5)}$=0.97 and $ICC_{(2,5)}$=0.93, respectively[10]. The minimum number of repetitions for the max-method was four, where the inter-examiner reliability and inter-session reliability were $ICC_{(1,4)}$=0.91 and $ICC_{(2,4)}$=0.91, respectively[11]. Therefore, five measurements were undertaken in the current study and the mean value was used as a representative value for each participant. Figure 1 illustrates the 2-point-method that was assessed with the Image J software (National Institute of Mental Health, Bethesda, USA). Figure 2 illustrates the max-method.

The secondary outcome measures included demographics, Body Mass Index and the International Physical Activity Questionnaire short version (IPAQ)[14, 15]. The IPAQ is a reliable and valid self-reporting questionnaire for assessing average activity level with minutes × Mets[15–17].

The angle of lumbopelvic sagittal alignment was analyzed with bootstrapping, which is a robust method for estimating 95% confidence intervals (CIs) of the mean. Briefly, the CIs are estimated with repetitions of data resampled by bootstrapping. There is no definite rule in deciding the number of repetition for the resampling[18]. The CIs reach a plateau with an adequate number of repetitions and 120 repetitions of resampling are generally recommended for estimating the 95%CIs[18] and therefore 120 resampling repetitions were undertaken in the current study. Although there are several bootstrapping methods to estimate the CIs, the following four methods were recommended by Yoshihara[18] and were investigated in the current study. The smallest CIs from the four bootstrapping methods were chosen as the final result as per recommended by Yoshihara[18]. The four methods were: 1) the normal method, 2) the basic method, 3) the studentized method and 4) the percentile method. The secondary measures were analyzed with descriptive analyses.

RESULTS

Data from 121 Asian participants (mean ± SD of age=20.6 ± 2.2 years) were analyzed in the current study. The mean ± SD values of the Body Mass Index were 20.3 ± 2.0 kg/m^2 and those of the IPAQ score were 2,300 ± 2,397.

Regarding the primary outcome measure, the studentized method had the smallest 95%CIs and was used in this study. There was no missing data. The means (95%CIs) of θ were −12.06° (−14.03° to −9.40°) with the 2-point-method and −5.40° (−7.62° to −2.73°) with the max-method.

DISCUSSION

The current study sought to identify the normative value for the angle of lumbopelvic sagittal alignment during the AUKEiSit in young asymptomatic females. The upper limit of the 95%CIs for the θ value during the AUKEiSit was −9.40° in the 2-point method, and −2.73° in the max-method, respectively. Clinically, a value for θ value of −2.73° is very close to a completely flat lumbopelvic curvature (which are equivalent to θ=0° in the max-method). Therefore, these findings correspond with the hypothesis that the upper limit of the θ value during AUKEiSit is zero in the max-method, and negative in the 2-point-method.

The θ value in the max–method was negative. This finding indicates that checking if the lumbar lordosis is maintained

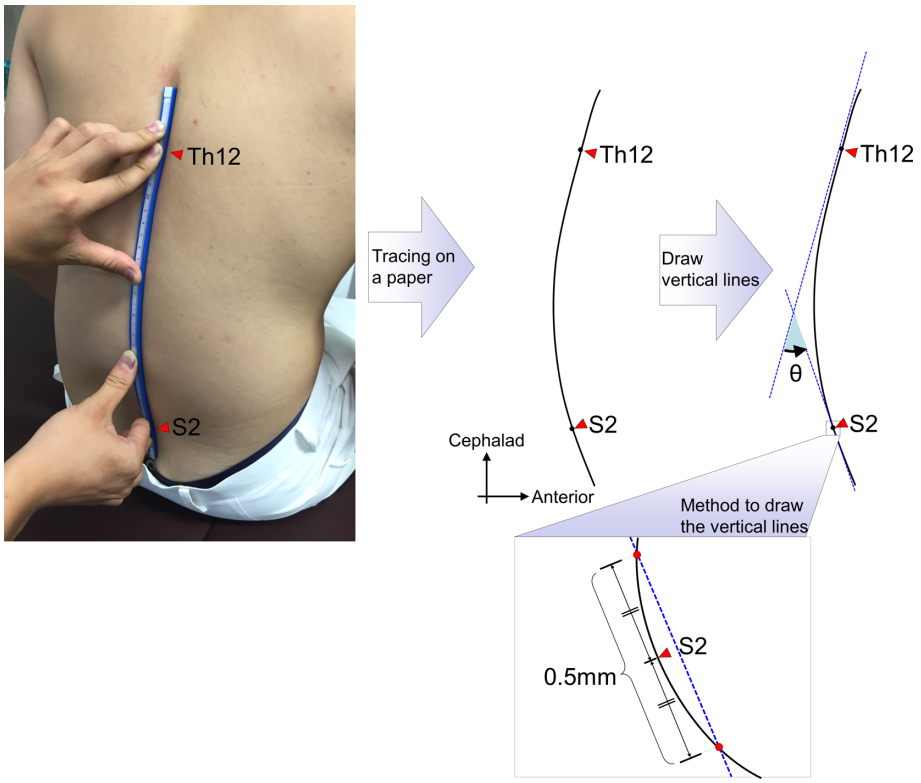

Fig. 1. Schema for calculation of the lumbopelvic sagittal alignment (θ) with the 2-point-method on ImageJ software.

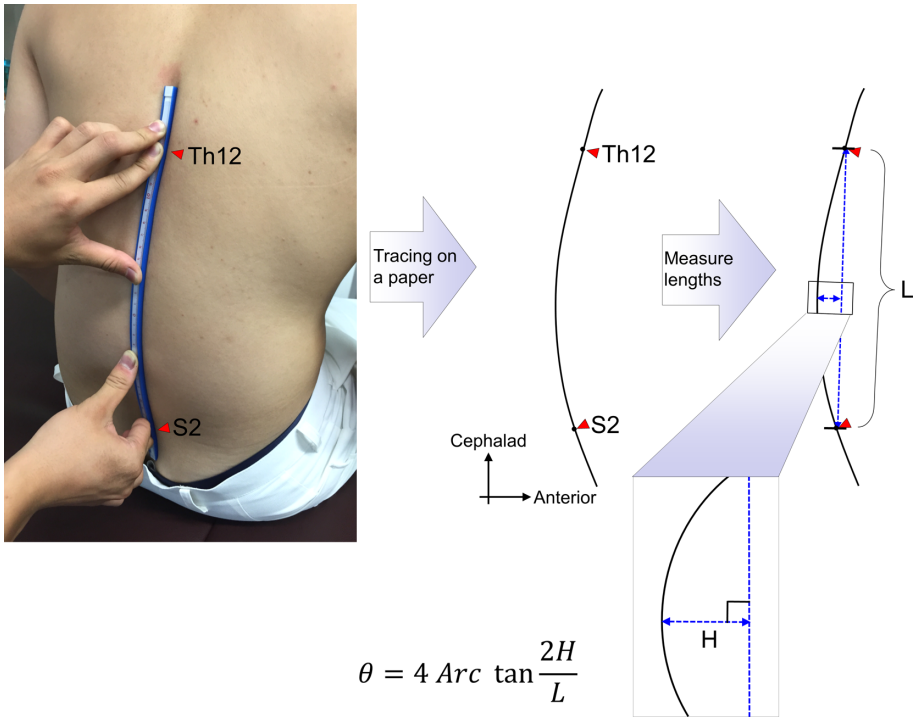

Fig. 2. Schema for calculation of the lumbopelvic sagittal alignment (θ) with the max-method.

during the AUKEiSit with a flat reference point such as a wall or ruler can be a simple screening if ability to separately control the lumbar spine from limb movements may be impaired. When lumbar kyphosis is detected during the AUKEiSit, it may be worthwhile to further investigate motor control deficits that may be contributing to development or recurrence of LBP.

A limitation of the current study is the convenience sampling method. The inclusion criteria included women aged 18–44 years but the majority of the participants were in their 20's. As it is normally expected to recruit participants with an age range of at least a decade for studies investigating normative values, more participants aged in their 30's should have been sought for inclusion. Further, all participants in the current study were Asian, although there has been no consensus with regard to racial differences in flexibility of skeletal muscles and connective tissues[19]. Therefore, caution is required when generalizing the current study findings.

Future research agenda includes investigations of the normative data in other clusters. Further, the normative threshold identified in the current study will enable us to investigate 1) what can result in an impairment of lumbopelvic control during limb movements, 2) if it is feasible and possible to correct the lumbopelvic control during limb movements to the normal level with certain exercises, and 3) if the impairment of the lumbopelvic control during limb movements can be a prognostic factor of LBP.

In conclusion, the 95%CIs of the angle of lumbopelvic sagittal alignment during the AUKEiSit were negative in asymptomatic young females. Therefore, Sahrmann's assumption that the lumbar spine normally remain flat during the AUKEiSit[4] was supported by the evidence in asymptomatic young females.

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Conflict of interest

There was no conflict of interest of the authors.

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