The Effect of Postural Stability on Genu Varum in Young Adults

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Purpose: Malalignment of the lower limbs may increase the difficulty of maintaining equilibrium. The purpose of this study was to study the effects of genu varum and poor posture in the sagittal plane on postural stability.

Methods: We had 27 subjects with varus and 27 normal subjects participate in this study. Subjects for whom the distance between the medial epicondyles of the knee joint was more than 3 cm were classified as varus group, and subjects for whom the distance was less than 3 cm were classified as normal group. The measurements of static and dynamic stability were used overall stability index (OSI), anterioposterior stability index (APSI), and mediolateral stability index (MLSI) using a Biodex balance system.

Results: When measuring the static stability index, there were significant differences in the mediolateral stability index between the varus and control groups. When measuring the dynamic stability index, there were significant differences in the overall, anterioposterior, and mediolateral stability index between the varus and control groups. These results demonstrated that genu varum affects mediolateral movement in static stability, and overall, anterioposterior and mediolateral movements in dynamic stability.

Conclusion: As genu varum affects static and dynamic stability in young adults, it increases the risk of injuries or falls. Exercise and surgery are required for realigning the genu varum. Future studies about postural stability in young children and elderly people who have a risk of falls due to lower postural control ability, are needed, as well as in young adults.

Keywords: Genu varum, Postural balance, Knee joint, Bone malalignment

I. Introduction

Postural stability is the ability to maintain the center of gravity of a body within a base of support with minimal sway.¹ Static stability is the ability to maintain a posture by locating the center of body within a stable base of support without body movement, and dynamic stability is the ability to maintain a posture by properly moving the center of body within a stable or unstable base of support while moving the body.²

Falls occur when the postural control system fails to maintain equilibrium.³ Postural controls include a sensory system, motor response synergy, higher nervous system components, and some sub-systems, including the musculoskeletal system.⁴ The postural response is executed by the musculoskeletal system, and changes to any part of the musculoskeletal system increases the difficulty of maintaining equilibrium: this allows us to predict the likelihood of injuries by measuring postural stability.⁵ ⁶ Postural stability issues are the main cause of injuries, falls or gait disturbance.⁷

Changes in the musculoskeletal system that disturb the equilibrium include weakness and malalignment of lower limbs, such as limited range of motion of the spine and peripheral joints.⁸ ¹² In particular, hip-knee-ankle alignment affects the knee load distribution.¹³ In previous studies of the relationship between the skeletal alignment in the sagittal plane and balance, researchers found a correlation between the knee flexion angle, balance abilities, and postural
sway. Malalignments in the frontal plane include knee malalignments such as varus or valgus deformity, and ankle malalignments such as pronated or supinated foot deformity. These deformities occur widely in young children or adults as well as in the elderly. Research is needed to prove the effect of malalignment in the frontal plane on postural stability in young adults.

Alignment in the knee joint is a key indicator of the load distribution. The load-bearing axis is indicated by a line drawn from mid-femoral head to mid-aniile. This line in the varus passes the medial compartment in the knee, and the moment arm is generated by increasing forces across the medial compartment. Medical transmission of the load imbalance originates from the adduction moment in stance phase, and this adduction moment reflects the size of the medial compression force on the medial compartment while walking. Malalignment affects the risk of osteoarthritis (OA) progression, and decreases functional status. In spite of the expectation that malalignment of the lower limbs increases the difficulty of maintaining equilibrium, studies about the effects of varus knee on postural stability are still rare. This study looks at the effects of varus deformity on postural stability in young adults.

II. Materials and Methods

1. Subjects

We had 27 subjects with varus and 27 normal subjects participate in this study. The participants were asked to put their bare feet together in a standing position. Subjects for whom the distance between the medial epicondyles in the knee joint was more than 3 cm were classified as varus group, and subjects for whom the distance was less than 3 cm were classified as normal group. Participants with neurological or orthopedic disease that could affect the results of the experiments were excluded. The height and weight in each group were denoted in cm, kg, and measured by the extensometer (ZENIX, Seoul, Korea), respectively. All subjects fully understood the experimental procedures and participation in this study was by voluntary consent.

2. Experimental methods

A Biodex Balance System (Biodex Inc., Shirley, NY, USA) was used for the measurement of postural stability, as this equipment is proven in terms of reliability and validity. The measurements used were used overall stability index (OSI), anterioposterior stability index (APSI), and mediolateral stability index (MLSI). To measure static postural stability, subjects positioned their center of pressure (COP) themselves in the center of the concentric circles shown on the monitor in a fixed footrest, and then the tests began. They were measured twice for 20 seconds. They had a 10 second break in the middle of each session to prevent fatigue. Measurements were recorded as OSI, APSI, and MLSI. The Biodex Balance System can be adjusted to various levels of instability from grade 1 (the most unstable) to 12 (the most stable); grade 5 was used in this study. Subjects positioned their COP themselves in the center of the concentric circles shown on the monitor in grade 5 to set a footrest, and then the tests began. They were measured twice for 20 seconds. They had a 10 second break in the middle of each session to prevent fatigue. Measurements were recorded as OSI, APSI, and MLSI.

3. Statistical analysis

IBM SPSS 19.0 for Windows (IBM Co., Armonk, NY, USA) was used for statistical analysis. Independent t-test was used to compare the experimental and control groups for OSI, APSI, and MLSI. The p-value was less than 0.05.

III. Results

No significant difference in the demographic data was found between varus and control group (Table 1).

<table>
<thead>
<tr>
<th>Table 1. Characteristics of the subjects</th>
</tr>
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<tbody>
<tr>
<td>Variable</td>
</tr>
<tr>
<td>Age (yr)</td>
</tr>
<tr>
<td>Height (cm)</td>
</tr>
<tr>
<td>Weight (kg)</td>
</tr>
<tr>
<td>Distance between</td>
</tr>
<tr>
<td>the knees (cm)*</td>
</tr>
</tbody>
</table>

Values are presented as mean±standard deviation.
*p<0.05.
Table 2. The differences in overall stability index (OSI), anterioposterior stability index (APSI), and mediolateral stability index (MLSI) of static and dynamic stability index between varus and control group

<table>
<thead>
<tr>
<th>Balance index</th>
<th>Varus group (n=27)</th>
<th>Control group (n=27)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Static</td>
<td>OSI</td>
<td>0.45±0.16</td>
</tr>
<tr>
<td></td>
<td>APSI</td>
<td>0.33±0.12</td>
</tr>
<tr>
<td></td>
<td>MLSI*</td>
<td>0.21±0.09</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dynamic</td>
<td>OSI*</td>
<td>1.59±0.26</td>
</tr>
<tr>
<td></td>
<td>APSI*</td>
<td>1.12±0.35</td>
</tr>
<tr>
<td></td>
<td>MLSI*</td>
<td>0.91±0.27</td>
</tr>
</tbody>
</table>

Values are presented as mean±standard deviation.

*p < 0.05.

There were no differences between OSI and APSI values of static stability between the experimental and control groups, but there was a significant difference in MLSI between groups. There were significant differences in OSI, APSI, and MLSI values in the dynamic stability index in the experimental and control groups (Table 2).

IV. Discussion

Alignment in the knee joint is a key indicator of the load distribution, and asymmetry of weight bearing is a cause to threat postural control.13 According to previous studies, there was a significant difference in the knee flexion angle, and knee alignment in the sagittal plane between fallers and nonfallers, and there was a statistically significant correlation between Berg’s balance scale and Timed UP and GO test.3 There was also a significant correlation with postural sway.14 This means that the knee flexion angle affects postural stability. Most of the limitations on the knee flexion angle are caused by aging, and issues are rare in young adults except in trauma such as fractures. However, changes in the musculoskeletal system in the frontal plane, particularly the knee varus deformity, were discovered in young children and young adults as well as the elderly, so there is a need to study the effects of varus deformity on postural stability at different ages.

In this study, the effects of varus deformity on postural stability in young adults were studied. Genu varum deformity can cause gait problems, chronic fatigue, spinal deformity, aging, back pain, and neuralgia.22 It also affects the risk of medial osteoarthritis disease progression, because imbalanced medial transmission of weight increases the medial compression force on the medial compartment of the knee joint.18-20 It decreases functional status, and increases the risk of injuries, falls, or collision.7-20

The hip, knee, and ankle joint are structurally and functionally connected, and so genu varum deformity is broken out by the combination of internal rotation of the femur, pronation of the feet, and hyperextension of the knee. The axis of flexion and extension is slantly positioned in the frontal plane by femoral internal rotation; hypertension occurs at the posterolateral side from this axis. As a result, the knee might bow, and lower legs are heavily slanted.23 As the tibia accompany the internal torsion, and toe is facing the inside, then toe-in and pronation of the subtalar joint occurs.24 The stretching of the posterolateral joint capsule and collateral ligament of the lower limb joints, and the weakness of the muscles that are involved in mediolateral stability, increase the instability of the lower limb joints. This may affect postural control. In this study, there were no significant differences between varus and control group in OSI and APSI, but there were significant differences in the MLSI. It seems that skeletal deformities of the hip, knee, and ankle joint, stretch of the lateral joint capsule and collateral ligaments, and muscle weakness affect mediolateral stability. There were significant differences between varus and control groups in OSI, APSI, and MLSI. Varus deformity affects dynamic stability in all directions, while it affects static stability in the mediolateral direction only. The hip and knee extension during standing is the locked position, and it facilitates posture without any or with just a few muscle contractions, so it is highly energy-efficient.

It seems that maintaining static stability consumes relatively less energy, compared to dynamic stability, so varus deformity only significantly influenced the value of MLSI in the static stability index. Dynamic stability has more challenging situations in terms of maintaining balance, and it requires more resources to maintain stability.

The purpose of this study was to study the effects of genu varum, and poor posture in the sagittal plane on postural
stability. When measuring the static stability index, there were significant differences in the MLSI between the varus and control groups. When measuring the dynamic stability index, there were significant differences in the OSI, APSS, and MLSI between the varus and control groups. These results demonstrated that genu varum affects mediolateral movement in static stability, and all anteroposterior and mediolateral movements in dynamic stability. As genu varum affects static and dynamic stability in young adults, it increases the risk of injuries or falls. Exercise and surgery are required for realigning the genu varum. Future studies about postural stability in young children and elderly people who have a risk of falls due to lower postural control ability, are needed, as well as in young adults.

References