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The Comparison of Postural Stability in Different Knee Alignment

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ABSTRACT

Postural control has an important role in injury prevention and athletic performance. When genu valgum or genu varum alignment is present, the ability of the quadriceps femoris muscle group to provide dynamic postural stability in both the sagittal and the frontal planes may be compromised. The purpose of this study was to evaluate the dynamic postural stability in persons with different knee alignment on condition of jump landing on dominant leg. 33 athletically–active nonimpaired females (age, 23.30±1.25 y; height, 164.10±5.11 cm; weight, 56.85±5.01 kg) were assigned to 1 of 3 groups based on their knee alignment, normal knee (n=16) , genu varum (n=10) and genu valgum (n=7). To evaluate the varus or valgus of the knee joint, the frontal plane knee angle was assessed with a universal goniometer. The dynamic postural stability index was evaluated with two dynamic tasks (anterior-posterior and medial-lateral jumps) on the force plate. No significant difference was seen among three groups in anterior-posterior jumps and significantly higher DPSI and lower stability was found in the genu varum group compared to normal knee group in medial-lateral jump task($p<0.05$).The results showed that genu varum may increase the dynamic postural stability index and decrease of dynamic balance.
KEYWORDS: Genu varum, Genu valgum, Postural stability

INTRODUCTION

The maintenance and control of balance, whether under static or dynamic conditions, is an essential requirement for physical and daily activities [37].

The human postural system operates on the basis of the integrated information from three independent sensory sources: somatosensory, vestibular and visual inputs [22, 37].This information, which allows to assess the position and motion of the body in space, is constantly reweighted so as to generate the appropriate forces to control and maintain balance in a wide range of situations [22, 37]. Postural stability is defined as the ability to maintain or control the center of mass (COM) in relation to the base of support (BOS) to prevent falls and complete desired movements. Balancing is the process by which postural stability is maintained [39]. Postural control assessment can provide useful information when identifying individuals who are susceptible to postural control deficits [9, 24]. Furthermore, postural control assessment has been used in sports medicine for selection of talented athletes, identification of athletes at high risk for injury, and for the prevention of sports related injuries [9, 19 and 28].Genu valgum and genu varum are well-known structural abnormalities of the lower extremity [8]. When genu valgus or genu varus alignment is present, the ability of the quadriceps femoris muscle group to provide dynamic postural stability in both the sagittal and frontal planes may be compromised [27].

Because stability depends on postural chain mobility, misalignment of a given segment may demand compensatory movements in other segments in order to maintain stability [34]. For athletes with genu valgus or genu varus to effectively participate in the repetitious running and jumping demands of many sports, compensatory alignment via the hips, ankle, subtalar, and midtarsal joints is needed [27].It is known that postural alignment affects sensory afferent inputs to the central nervous system, the location of the center of gravity[34].The scientific evidence suggested that both deformities may affect the location of center of pressure and mechanical control of balance during single limb balance, in addition, genu valgum deformity may be associated with athletic injuries of the lower extremity [8]. Shojaedin et al., (2012) reported that subjects with genu varum deformity revealed higher peak of the vertical ground reaction force in calcareous contact in comparison of subjects with normal knee [33]. Early diagnosis and detection of balance impairments are important for management and prevention of functional decline and fall injuries [13]. Landing from a jump is a common task during athletic participation that is often implicated as an injury mechanism for a variety of lower extremity pathologies [12, 25].This task has been adopted in the research setting to study mechanisms and contributing factors to injury and performance [12]. Colby et al.[2]suggested that a static position does not sufficiently challenge the neuromuscular system in recreating athletic activity or even activities of daily living. More dynamic types of activities, such as jump-landing tasks, might be a more accurate tool for assessment of

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the lower extremity neuromuscular system during single-limb activities [38]. Gray et al., [11] reported that 58% of all injuries in female basketball players occurred while landing from a jump [40]. Similarly, Goodwin-Gerberich et al., reported that jump landings during volleyball competition were associated with 63% of all reported injuries, including 61% of knee injuries [10]. Successful landing from a jump requires strength, stability, and balance, which are also critical for providing inherent protection against joint injury. Thus, it is possible that the high rates of injury mentioned above were the result of strength deficits or impaired stability and balance [40]. Often, jump-landing tasks are used as an index of dynamic stability [12]. The Dynamic Postural Stability Index (DPSI) is a relatively new measure of dynamic postural stability that determine show well balance is maintained as the subject transitions from a dynamic to a static state [41]. The DPSI is a functional measurement of neuromuscular control because it is calculated during a single-leg hop-stabilization maneuver. It is also more informative than other measures (e.g., center of pressure scores)because jump landings are commonly reported as a mechanism for lower extremity injury [25, 41].During the landing phase of a jump landing, the lower extremity musculature is responsible for decelerating and stabilizing the body's center of mass by producing extensor moments to resist the collapse of the lower extremity and attenuate the vertical ground reaction force (VGRF) [4, 41].The DPSI indicates how well a subject can dissipate resultant ground reaction forces (GRF) from a jump landing. Moreover, the DPSI is a measure of motor control for the lower extremity and is dependent on proprioceptive feedback as well as reflexive, preprogrammed, and voluntary muscle responses [16, 42]. This study was designed to investigate the changes in dynamic postural stability index in subject with genu varum and genu valgum in comparison of normal control groups.

MATERIAL AND METHOD

This research project was reviewed and was approved by the human subject committee of the physical education and sport sciences Department at University of Guilan.

Subjects

33 athletically-active nonimpaired females participated in this study. Subject demographics are provided in Table1.

Subjects participated in a variety of recreational athletic activities 3 times per week. Participants were assigned to 1 of 3 groups based on their knee alignment (10 subjects with genu varum, 7 subjects with genu valgum and 16 normal subjects). Participants with genu varum and valgum were matched to normal subjects by height, mass, age and sport activity. To evaluate the varus or valgus of the knee joint, the frontal plane knee angle was measured using the anatomical axis of the femur and tibia with a universal goniometer [26]. The normal tibiofemoral angle is described 5.5º±2º and two standard deviation upper and lower than it was considered as genu valgum and genu varum, respectively. [18, 21 and 42]. The dominant was selected as the limb with which they would like kick a ball [12]. All participants preferred to kick the ball using their right leg. Their right leg was considered the dominant leg. Exclusion criteria were neurological or musculoskeletal pathology, sensory system disease, and previous injury in lower limb, complaints of pain or fatigue and pregnancy at the moment of the test. All participants signed their informed consent form and were familiarized with the study procedure.

Table1- Subject demographics

	Genu valgum (n=7)		Control (n=6)		Genu varum(n=10)		Control (n=10)	
	Mean	**±SD**	**Mean**	**±SD**	**Mean**	**±SD**	**Mean**	**±SD**
Age(yrs)	23.42	0.98	23.50	0.55	23.30	1.25	**23.90**	**1.59**
Height(cm)	166.29	5.41	168.67	6.25	164.10	5.11	163.90	5.10
Weight(kg)	62.80	5.24	66.47	7.49	56.58	5.01	53.95	4.16
Tibiofemoral angle(º)	10.40	0.57	5.25	0.59	-0.83	0.70	4.90	0.47

Data collection procedure

A force plate (Kistler 9286A) was used to collect ground reaction force data (600HZ) during tests. Dynamic postural stability was assessed using two dynamic tasks: 1) anterior-posterior (AP) jump and 2) medial-lateral jump (ML) [28].For the AP jump participants were instructed to stand on two legs at a distance of 40% of their body height from the force plate. Participants were instructed to jump forward over a 30 cm hurdle to the force plate and land on their dominant leg, stabilize as quickly as possible, and balance for 10 s with their hands on their hip. For the ML jump participants were instructed to stand at a distance equal to 33% of their body height away from the force plate. Participants were instructed to jump laterally over a 15 cm hurdle to the force plate and land on their test leg, stabilize as quickly as possible, and balance for 10s with their hands on their hips. For both dynamic tasks, upper extremity movement was unrestricted but participants were asked to quickly place their hands on their hips only after stabilizing. Trials were discarded and recollected if the

participant's non-stance limb touched the stance limb or the ground around the force plate. All of the subjects performed the AP jump first. Five successful trials were collected and used for data analysis for both tasks [32].

Statistical analysis and data reduction

A custom MATLAB script file was used to process data. DPSI was computed using the first 3 s of the ground reaction forces following identified as the instant the vertical ground reaction force. DPSI was calculated for each trial in each task according to [41]:

$$\text{DPSI} = \sqrt{[\sum(o-x)^2 + \sum(o-y)^2 + \sum(bodyweight - z)^2] \ / \text{number of data points}} \ .$$

A total of 5 trials were averaged and used for final analysis. A higher DPSI represents worse postural stability. All data were checked for normality using the Kolmogrov-Smirnov test. An independent sample T-test was to examine the differences mean values of DPSI between normal group and another group in two jump tasks. A significance level of $\alpha < 0.05$ was considered for this analysis. The SPSS V16 was used in data analysis.

RESULTS

The mean and standard deviation for DPSI during two jumps (AP and ML) between groups are presented in Table 2 and 3. The T test indicated that DPSI during ML jumps in genu varum group significantly higher than control group ,but there was not significant difference between two groups during AP jumps and the recorded DPSI in genu valgum showed no significant difference compared to the control group during two jumps.

Table2- DPSI in AP jumps

	Mean	±SD	T	P
Genu valgum	0.316	0.041	0.435	0.672
Control	0.308	0.037		
Genu varum	0.312	0.032	0.500	0.623
Control	0.305	0.031		

Table3- DPSI in ML jumps

	Mean	±SD	T	P
Genu valgum	0.257	0.055	-0.237	0.817
Control	0.264	0.038		
Genu varum	0.318	0.051	2.119	0.037*
Control	0.246	0.040		

DISCUSSION

Human postural control is a complex sensorimotor function that includes component such as movement detection, generation and control of coordinated voluntary and reflexive motor response [6, 7]. Impaired postural control may have implications for subsequent traumatic injury in sport and recreation [23]. The purpose of this study was to differentiate the postural stability of subjects with genu varum, genu valgum and matched normal groups. This study showed that genu varum deformity may affect the DPSI during ML jump task in comparison of normal group. But has no effect in the AP jumps. In addition this study revealed that the DPSI in AP and ML jumps may not be affected by genu valgum group on comparison of normal group. Valgum and varum deformities compensated by the subtalar joint [5].The degree of compensation depends on the range of motion. The normal subtalar eversion is 15° and inversion is 30°. In order that the foot should remain plantigrade, in genu varum there is compensatory subtalar valgus and forefoot pronation and in genu valgum there is compensatory subtalar varus and forefoot supination. Since the angle of inversion is more than angle of eversion, there is better compensation of genu valgum as compared to genu varum [3, 29]. The critical effect of abnormal foot motion on lower limb function has been demonstrated [24, 30, 35 and 36]. A lower extremity that is in varus will have its mechanical axis positioned medial to the midline of the knee. Conversely, the mechanical axis will fall lateral to the midline of a knee in a valgus lower extremity. Because the weight bearing axis of the lower extremity follows the mechanical axis, a varus knee will experience a shift in the joint compressive pressures towards the medial compartment and the valgus knee will, similarly, experience a shift of the joint compressive pressures toward the lateral compartment [20]. Anker et al. stated that asymmetry weight bearing may increase the postural sway [1]. Harrington (1983) indicate that it is easier to compensate for a valgum than for a varum deformity, since knees with varum deformity showed a more predictable loading pattern (location of the center of pressure) than did knees with valgum deformity [14].Gheluwe et al. (2005) stated that a genu varum deformity would tend to cause subtalar pronation moment to increase or a supination

moment to decrease during the contact on propulsion phase of walking [8]. Hertel et al. (2001) showed subjects with cavus feet used significantly lager COP excursion area that did subjects with rectus feet [15].Our finding is agree with Samaei et al. (2012) that stated the postural sway in the frontal and sagittal plane may not be affected by genu valgum deformity. This stability in the postural sway control was also seen in people with genu varum deformity only in the sagittal plane (anterior- posterior direction) , while their stability was perturbed in the frontal plane (medial-lateral direction) and it seems that genu varum deformity cause pronation position in the foot, which may alter the balance control strategy, so that the medial–lateral stability index is increased significantly [31].

CONCLUSION

The results of this investigation suggest that genu varum may increase DPSI in frontal plane jump landing and may decrease dynamic balance during sport activity. The subjects with genu varum deformity might be at risk of injury during sport activity due to the balance deficit. It seems that athletes with genu varum may benefit from training programs to reduce postural sway in the medial-lateral direction during dynamic activities like jump landing.

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