STUDENTS' CORNER
SHORT COMMUNICATION

Dynamic knee valgus alignment in healthy young adults and its association with single leg triple hop distance and athletic single leg stability

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Abstract

A cross-sectional analytical study was conducted on a sample of 72 participants aged 18-26 years to determine the differences in dynamic knee valgus angulation (DKVA) in terms of gender and dominant/non-dominant side, as well as the relationship of DKVA with triple hop distance and athletic single leg stability. DKVA was found to be lower for dominant side as compared to non-dominant side, and higher for single leg tasks compared to drop jump screening test for both legs. Greater DKVA values were observed in females in all tasks. Males had poorer single leg athletic stability and covered greater distance in single leg triple hop as compared to females. No significant correlation of DKVA was observed with single leg triple hop distance or athletic single leg stability.

Keywords: Anterior cruciate ligament, Balance, Biomechanics, Knee, Stability,

DOI: https://doi.org/10.47391/JPMA.011047

Introduction

Knee is the most commonly injured joint during sports and physical activity among youngsters[1] with a prevalence of 10-25% globally among adolescents, with females being at a greater risk.[2] Valgus alignment of knee during landing and stance phase of gait are related to an increased incidence of knee injuries, including injury to the anterior cruciate ligament (ACL)[3] and the patellofemoral joint.[4] Recently, two dimensional (2D) analysis of knee kinematics has become more popular among researchers[5] compared to three dimensional (3D) analysis, because of its apparent benefits in terms of equipment cost and availability, as well as time to collect and analyse data.[5] Literature has also shown 2D analysis to be valid and reliable in terms of measuring dynamic knee valgus angulation (DKVA) in different tasks, such as drop jump landing and single leg landing.[5,6] For this reason, 2D analysis of DKVA can prove to be a very useful tool in terms of clinical assessment of patients.[5,6] Triple hop distance (THD) is another important test which was designed to assess functional performance in an injured extremity, and is found to be a strong predictor of lower extremity power and muscle strength in adolescents.[7] THD is also used as a screening tool prior to sports participation as it requires minimal time and equipment.[7] Furthermore, THD is also observed to distinguish limb asymmetry and weakness in ACL-deficient participants[7] and may have some relationship with frontal plane knee kinematics in terms of DKVA, as well as athletic single leg stability (ASLS). Finally, the biomechanical differences between males and females[8,9] is a critical factor in the incidence of injuries.

The current study was planned to determine the relationship of DKVA with THD and ASLS in sedentary healthy young adults, and also to analyse gender-based differences.

Subjects and Methods

A cross-sectional analytical study was conducted at the Foundation University Institute of Rehabilitation Sciences, Islamabad, Pakistan, from January 2019 to July 2019. After approval from the institutional ethics review committee, the sample size was calculated using Harvard sample size calculator while keeping a significance level of 0.05 and power of 0.8, with the assumption that the true change in the dependent variable would be 0.335 standard deviations per one standard deviation change in the independent variable.[10]

Those included were healthy young sedentary adults aged 18-26 years, assessed with the help of the guidelines of the Institute of Medicine and National Research Council of the National Academies,[11] scoring <14 on Godin Leisure-Time Exercise Questionnaire.[12-14] Individuals with lower extremity congenital anomalies, recent history of burn or trauma, amputation, ligamentous laxity, inflammatory disorders, and females with ongoing pregnancy were excluded.

After taking informed consent, DKVA, single-leg THD and ASLS were measured. DKVA was calculated in three different tasks. For drop jump landing and single leg landing tasks, the participants were instructed to stand on a 30cm high platform, and then jump 30cm in front of the

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platform with both feet for the drop jump landing task, or on a single foot for the single leg landing task. For the single leg squat task, the participants were asked to perform a single leg squat, and the squat depth was aimed at 45⁰ of knee flexion. The participants were also instructed to flex the contra-lateral knee adequate enough to avoid the foot from touching the floor.[15] For the purpose of 2D video recording a digital video camera was placed on a tripod stand 2m in front of the landing point of the participant at the level of the participant's knee, aligned at 90⁰ to the frontal plane. The video was converted into a slow-motion video and imported into the Quintic® biomechanics v31, and still images were extracted from the video. DKVA was recorded at the lowest point of landing phase with a maximum DKVA, which was then digitised and calculated. DKVA was calculated at the point of intersection of the two lines, the first line joining the markers placed on the anterior superior iliac spine (ASIS) and middle of the tibiofemoral joint, and the other line joining the middle of the tibiofemoral joint and the middle of ankle mortise.[5,15] Measurement of DKVA via 2D analysis has been reported to be a reliable procedure with correlation coefficient of 0.90 for drop jump landing and 0.89 for single step landing.[5]

ASLS was measured using the Biodex® balance system (BBS). At the start of each test, the participant was positioned on the platform and was asked to position the cursor to the centre point of the grid. Three trials were performed on each leg at platform level 5 with each trial lasting 20 seconds, and the average values were noted. A higher ASLS score signified poorer stability. Furthermore, THD has been reported to be a valid predictor for strength and power of the lower limb, with a test retest reliability intra-class correlation coefficient of 0.98.[16] The participants were inquired regarding their dominant leg first and then were positioned on the dominant leg having their big toe on the starting line, and asked to perform 3 consecutive maximal hops on the dominant leg. The distance was measured from the starting line to the point of impact of the heel after the third hop.[17] Participants were allowed a maximum of three practice trials, and not more than that to avoid fatigue. The test was repeated if the participant was unable to maintain his/her balance at the completion of the test or contacting the ground with the opposite leg.

Data was analysed using SPSS version 20. Shapiro-Wilk test was used to determine the normality of data and independent t-test and Mann Whitney U test were used for gender-based comparison based on data normality. Paired t-test and Wilcoxon signed-rank test were used for comparing the values of right (dominant) and left leg based on data normality. Freidman test was used for comparing the values of DKVA in different tasks for both right and left leg. Pearson and Spearman correlation were used to determine the relationship between two variables depending upon data normality and linearity of relationship. P<0.05 was considered significant with a confidence interval (CI) of 95%.

Results

Of the 72 subjects, 29(40.28%) were males and 43(59.72%) were females. Overall, 2(2.8%) participants were married and right side was the dominant side for all 72(100%) participants.

There was a significant difference (p<0.01) between males and females for DKVA only in drop jump screening test for both right and left leg, with females exhibiting a greater

Table: Average values for dynamic knee valgus alignment (DKVA) and gender-based differences for drop jump screening test, single leg landing and single leg squat.

Variable		Mean ± S.D	Median(IQR)	Gender				*p*-value
				Mean ± S.D		Median (IQR)		
				Male	Female	Male	Female	
Age (in years)		21.24±1.69	21.50(3)	20.93±1.87	21.44±1.55	21.00(3)	22.00(3)	0.000*
Weight (in kg)		59.79±12.51	58(19)	68.97±9.93	53.60±10.09	70(15)	53(12)	0.200
Height (in cm)		167.58±9.92	165.10(14.98)	175.50±5.90	162.23±8.40	175.26(7.98)	162.0(8.10)	0.025*
Body mass index (BMI)		21.27±3.77	21.28(4.57)	22.39±3.01	20.51±4.07	22.64(4.10)	20.76(4.13)	0.184
Single leg triple hop distance (in cm)	Left	217.41±51.59	210.41(67.72)	235.16±53.91	205.44±46.87	230.00(61.35)	198.12(68.07)	0.015*
	Right	219.40±48.96	213.18(61.68)	229.94±56.28cm	212.28±42.55	228.00(65.10)	203.20(61.00)	0.134
Athletic single leg stability	Left	5.24±4.37	3.55(4.53)	7.23±5.56	3.89±2.67	5.20(10.45)	3.20(2.40)	0.024*[a]
	Right	5.12±4.42	3.35(3.73)	7.81±5.60	3.31±1.94	5.90(8.05)	2.90(1.80)	0.00033*[a]
Dynamic knee valgus angle (⁰)								
Drop jump screening test (⁰)	Left	15.89±8.17	15.69(12.44)	13.00±8.10	17.84±7.71	10.34(9.06)	16.47(15.24)	0.013*
	Right	12.15±8.88	8.68(13.45)	9.50±7.85	13.95±9.17	6.18(11.08)	12.73(13.92)	0.036*[a]
Single leg landing (⁰)	Left	17.68±9.63	16.54(14.66)	17.61±11.00	17.72±8.72	15.83(13.13)	17.46(14.88)	0.960
	Right	12.50±7.28	11.43(10.45)	13.61±8.37	11.75±6.44	11.39(9.55)	11.48(10.01)	0.291
Single leg squat (⁰)	Left	17.43± 10.70	15.60(16.77)	18.09±12.26	16.98±9.63	16.60(18.59)	15.30(14.53)	0.950[a]
	Right	15.22±11.80	15.3650(16.41)	12.66±11.17	16.94±12.02	10.56(13.84)	16.02(16.40)	0.123[a]

SD: Standard deviation, IQR: Interquartile range, BMI: Body mass index, *Significant gender based difference (p<0.05); [a]P-value determined using Mann Whitney U test.

angulation. Moreover, males were found to have covered a significantly greater (p<0.01) THD compared to females, but the males were also found to have a significantly greater (p<0.05) score on ASLS compared to the females (Table).

There was a significant difference between the scores of DKVA of dominant (right) and non-dominant (left) leg in terms of drop jump screening test (p=0.015) and single leg landing (p<0.001), but the difference was not significant in terms of single leg squat (p=0.111). However, DKVA was greater in all tasks for the non-dominant (left) leg nonetheless. In terms of ASLS and THD, no significant difference was observed between dominant and non-dominant leg (p=0.854 and p=0.514).

There was no significant difference in the DKVA of the three tasks for both left (p=0.873) and right (p=0.311) legs, but DKVA in single leg tasks was greater than drop jump for both right and left leg.

In terms of single leg triple hop distance a statistically significant and strong positive correlation was observed between right and left side (r=0.871, p<0.001). However, no significant correlation of THD was observed, except for a negative correlation of THD of the dominant right side with body mass index (BMI) (r=-0.254, p=0.032).

In terms of DKVA in drop jump screening, DKVA of right (dominant) leg had a significant correlation with DKVA in both single leg landing (r=0.282, p=0.017) and single leg squat (r=0.372, p=0.001) on the same side and single leg squat on the opposite left side (r=-0.306, p=0.009), and also with weight and height (r=0.242, p=0.04). DKVA of left leg had significant positive correlation only with DKVA of right leg in single leg squat (r=0.259, p=0.028).

DKVA of right leg had a significant correlation with DKVA of right leg in single leg squat (r=-0.366, p=0.002). Moreover, DKVA of left leg had a significant correlation with DKVA of right leg in drop jump screening test (r=-0.254, p=0.031) and with DKVA of both right (r=0.280, p=0.017) and left leg (r=0.456, p<0.001) in single leg squat.

DKVA of right leg had a significant correlation with DKVA of right leg in drop jump screening test (r=0.372, p=0.001) and both right (r=0.346, p=0.003) and left (r=0.328, p=0.005) legs in single leg landing. DKVA of left leg had a significant correlation with DKVA of right leg in drop jump screening test (r=-0.306, p=0.009) and DKVA of left leg in single leg landing (r=0.352, p=0.002).

ASLS scores of both legs were positively correlated with each other (r=0.466, p<0.001), and ASLS of the left leg was significantly correlated with weight (r=0.407, p=0.001), height (r=0.346, p=0.003) and BMI (r=0.246, p=0.037), whereas ASLS of the right leg was significantly correlated only with height (r=0.265, p=0.025).

Discussion

In terms of gender-based comparison, the findings of the current study showed DKVA to be higher in females compared to males in drop jump landing, single leg landing and single leg squat, which was found to be consistent with literature.[8,18] This can perhaps be the reason that a greater incidence of ACL injuries and patellofemoral joint dysfunction is reported in females compared to males.[19,20] A recent study has shown 2D knee valgus angulation to be a predictor of patellofemoral pain.[21] Even though DKVA was found to be higher in females in all tasks, a significant difference was observed only in the drop jump screening test. Moreover, males were found to have significantly greater (p<0.01) THD scores which is also consistent with literature[22-24] as males possess greater muscle power due to greater muscle mass.[25] Furthermore, in the current study males were shown to have poorer ASLS overall stability index scores compared to females, demonstrating that males swayed more than females on both dominant and non-dominant legs, as greater score indicates poorer stability, and this finding is also supported by the existing literature.[26]

In terms of comparison between dominant and non-dominant leg, the current study showed greater values of DKVA for the non-dominant leg compared to the dominant leg in all tasks, with a significant difference between the scores of DKVA in drop jump screening test (p=0.015) and single leg landing (p<0.001). However, the difference was not significant in terms of single leg squat (p=0.111). These findings are in contrast with ones reported previously in the literature.[27-29] Perhaps the reason for this contradiction is that all of those studies are conducted in young athletes, whereas the current study was conducted on sedentary healthy young individuals. This supposition can be supported by evidence that different sports can affect DKVA in athletes, with different values of knee valgus angles in basketball, soccer and softball athletes, with the highest valgus angulation in basketball athletes, followed by soccer and softball.[27] Moreover, a study also showed a greater valgus angulation on the non-dominant (left) side in soft ball players in contrast to a greater valgus angulation on the dominant (right) side in basketball and soccer athletes.[27] Thus, it is perhaps safe to say that the type of sports an individual is involved in, can influence the difference between the dominant and non-dominant DKVAs. In terms of THD, no significant difference (p>0.05) was observed between dominant and non-dominant legs, but results show that greater distance was covered hopping on the dominant leg for both males and females,

which is in accordance with recent studies.[23] Furthermore, in terms of ASLS overall stability index, no significant differences were observed in terms of dominant and non-dominant legs, similar to earlier findings.[26]

In terms of comparison of DKVA in three different tasks, no significant differences were observed for both left (p=0.873) and right (p=0.311) legs, but DKVA in single leg tasks was found to be greater than drop jump for both right and left legs. These findings were in accordance with the previous literature.[30] Moreover, greater values of DKVA were noted for all the tasks in the current study compared to the earlier findings for both males and females.[30] Even though the average age in both the studies was similar, the reason for this difference in values can perhaps be due to difference in the ethnicity and anthropometry of participants in the two studies, with participants of the earlier study having been conducted in Salford, England, with greater participant height and weight.[30] The other cause of this difference could be the fact that the participants in the current study were sedentary individuals, whereas the participants in the other study were recreationally active participants.[30]

In terms of relationship of DKVA with other variables, no significant correlation was observed with THD or ASLS, but DKVA of the dominant leg in drop jump screening had a significantly positive correlation with weight and height.

In view of the findings, it is recommended that a similar study should be conducted with a larger sample size and with 3D analysis. Normative values of DKVA should be established for different age groups and ethnicities. Moreover, relationship of DKVA should be determined with other variables, such as age and quadriceps strength.

Conclusion

DKVA was lower for the dominant leg in all tasks, and was found to be higher for single leg tasks compared to drop jump screening test among sedentary young individuals. Greater values of DKVA were observed in females in all the tasks compared to their male counterparts. Moreover, scores for single leg THD and ASLS were higher in males compared to females. No significant correlation of DKVA was found with ASLS and THD.

Acknowledgement: We are grateful to Dr. Summiya Siddique Malik for her assistance in the research process.

Disclaimer: None.

Conflict of interest: None.

Source of Funding: None.

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