COUNTERMOVEMENT JUMP VARIABLES AND ESTIMATED PEAK POWER IN FEMALE CHILDREN WITH DYNAMIC KNEE VALGUS

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The purpose of the current study was to evaluate countermovement jump biomechanical variables and to estimate peak power using different approaches in female children with dynamic knee valgus. Twenty-six female children, aged 10-14, with dynamic knee valgus were recruited. A Kistler force plate was used to record the kinetic data during three CMJ trials. Less peak power (estimated using allometric method) and greater landing force during countermovement jump were significantly correlated with valgus angle in female children (P= 0.033, R= -0.419, and P= 0.0.43, R= 0.413, respectively). Estimated peak power results using Sayers and Harman methods were significantly different from actual peak power outcomes (P=0.042, P=0.027 respectively). Greater landing force and decreased peak power during CMJ showed to be correlated with increased valgus angle in female children. Additionally, the allometric method seemed to be more accurate for estimating peak power compared to other methods.

KEYWORDS: force platform, performance, muscular power, allometric model

INTRODUCTION: Dynamic knee valgus is reported as a lower extremity malalignment more commonly observed in female athletes than their male counterparts which may increase the risks of Anterior Cruciate Ligament (ACL) injuries (Friel & Chu, 2013). Additionally, the excessive force imposed on the knee joint during the landing phase of jump-landing tasks such as countermovement jump (CMJ) is reported to be the other contributing factor to ACL strain (Ortega, Rodríguez Bíes, & Berral de la Rosa, 2010). Performing CMJ test on a force plate provides accurate information about jumping variables (Bovet, Auguste, & Burdette, 2007). However, this method is limited to the laboratory setting and is not easily accessible in the exercise and rehabilitation fields (Duncan, Hankey, & Nevill, 2013). Thus, several linear methods have been suggested for estimating peak power (PP) from jump height and body mass.

For instance, Sayers et al. (1999) equation (Sayers, Harackiewicz, Harman, Frykman, & Rosenstein, 1999) is suggested as a validate method used for PP estimation regardless of control for sex and age differences (Duncan et al., 2013), while Harman et al. (1991) suggested a scaling model for use with adults (Harman, Rosenstein, Frykman, Rosenstein, & Kraemer, 1991). However, these suggested methods for adults may not be a precise scaling approach for children. The main reason behind this is reported to be related to an age-dependent difference in the body size between children and adults, which also may affect muscle strength and functional performance tests outcomes (Jaric, 2002). Thus, it is important to choose a valid method that enables the researcher to calculate PP and jump height during CMJ test without being influenced by the body size. The allometric approach is being suggested by the researchers for scaling CMJ variables such as estimated peak power (EPP) in young athletes with the consideration of body mass (Jones, McNarry, & Owen, 2020). However, there is not enough study comparing the application of different EPP methods from the CMJ variables measured by a force plate.

The purpose of the current study was to evaluate the correlation between CMJ biomechanical variables and DKV angle in addition to comparing EPP using different methods in female children with DKV.

METHOD: Participants: Twenty-six female children, aged 10-14, with DKV were recruited to join this study. The DKV in the dominant leg was assessed during a single-leg landing from a 30cm-box by motion analysis cameras. The dominant leg was determined using a shooting questionnaire test (van Melick, Meddeler, Hoogeboom, Nijhuis-van der Sanden, & van Cingel, 2017). Participants with knee valgus angle greater than 4.4◦ ± 3.0◦ at maximum knee flexion during landing were determined to have DKV (Tamura et al., 2017).

Laboratory testing procedure: DKV during single-leg landing from a 30cm-box was recorded using 8 Vicon motion analysis cameras (120Hz - 2.2 mega-pixel Vero model cameras - UK). The DKV and kinetic outputs during CMJ were recorded using an embedded in-floor Kistler force platform (1200Hz - model 9286ba – 40cm × 60cm dimension – Switzerland). Sixteen retroreflective markers were placed on lower extremity landmarks based on the Plug-in-Gait marker system: laterally on posterior superior iliac spine (PSIS), anterior superior iliac spine (ASIS), lateral thigh, lateral femoral epicondyle, lateral shank, lateral malleolus, second metatarsal head, and calcaneus. DKV angle was determined using Euler angles from the relative orientations of the femur and tibia.

CMJ test: Participants were asked to stand behind the force plate, and started the test by the researcher's order. In the eccentric phase of CMJ, participants performed the squat with feet apart as the hips width and then jumped with maximum effort in the concentric phase with the arms swinging. Participants were instructed to land on both feet and to maintain the landing position stable for 5 seconds. This test was repeated three times (Duncan et al., 2013). CMJ variables including peak landing forces, flight duration, and linear duration were calculated from the force-time curve. Take-off and maximum velocity were derived from the displacements over time (Kibele, 1998). Then the jump height variable was calculated from the impulse-momentum method from the take-off velocity (Kibele, 1998). The actual peak power was calculated from the vertical ground reaction force (Fz curve) during the take-off phase of CMJ (Duncan et al., 2013). Peak power was estimated using Sayers et al. (1999) (Sayers et al., 1999), Harman et al. (1991) (Harman et al., 1991) linear regression models with regard to body mass and jump height (from unprocessed CMJ force-time output), and allometric equation. Allometric equation was developed from the linear regression analysis applied to the logarithmically transformed data of body mass, age, actual peak power, and jump height (Duncan et al., 2013). Data analysis was done using a self-made code by MATLAB software (version R2017b).

Statistics: Statistical analysis of this study was done by IBM SPSS (ver 24). Shapiro-Wilk's test of normality was run to analyze data distribution. Bivariate Pearson Correlation with the two-tailed test of significance was carried out for evaluating the correlation between DKV and CMJ kinetic variables ($\alpha \leq 0.05$). Additionally, paired sample T-test test was employed to examine any differences between EPP using different equations and actual peak power.

RESULTS: CMJ performance: Based on the statistical analysis, peak landing force during CMJ is positively correlated with DKV angle (P= 0.043, R= 0.413). Additionally, PP during CMJ estimated by the allometric approach was negatively correlated with DKV angle (P= 0.033, R= -0.419). No correlations were observed in the rest of the variables during CMJ task. However, other CMJ test variables, actual peak power, and EPP using Sayers et al. (1999) or Harman et al. (1991) methods were not significantly correlated with DKV angle (Table1).

Comparing EPP and actual peak power: Statistical analysis indicated that EPP outcomes using Sayers et al. (1999) and Harman et al. (1991) equations were significantly different from the actual peak power (P=0.042, P=0.027 respectively). However, no statistically significant difference was observed between EPP using the allometric method and actual peak power (Table2).

Table1: Correlation coefficient between CMJ variables and DKV angle/ *=significant/ - R score= inverse correlation, + R score=positive correlation

Variables	Mean±SD/N=26	P-value	R score
CMJ- flight duration	0.383 ± 0.039	0.744	0.067
CMJ- jump height	38.193 ± 4.374	0.	-0.217
CMJ- peak landing force	1.014 ± 0.387	**0.043***	**0.413**
CMJ- take-off velocity	1.913 ± 0.196	0.953	-0.012
CMJ- Max velocity	2.307 ± 0.367	0.383	-0.173
CMJ- linear duration	114.92 ± 475.904	0.173	0.276
CMJ- APP	78.107 ± 23.44	0.512	-0.098
CMJ- EPP Sayers	1083.69 ± 556.624	0.334	-0.197
CMJ- EPP Harman	4477.745 ± 443.702	0.614	0.046
CMJ- PP Allometric	53.253 ± 15.91	**0.033***	**-0.419**

Table2: Comparison between EPP using different approaches and actual peak power/ *=significant difference between EPP outputs from a method and actual peak power

Variables	Mean±SD/N=26	P-value
Actual peak power/EPP-Sayers	4477.745 ± 443.702	**0.042***
Actual peak power /EPP-Harman	1083.69 ± 556.624	**0.027***
Actual peak power /EPP-Allometric	53.253 ± 15.91	0.621

DISCUSSION: The outcomes of the current study indicated that greater landing force to be correlated with increased DKV angle. Previous findings reported greater ground reaction forces during landing in female athletes (Sigward & Powers, 2007). Since increased landing forces are suggested as one of the contributing factors to knee injuries, it is essential to consider reducing these forces during corrective and rehabilitative protocols in female children (Ortega et al., 2010). Our results also showed that lower rates of estimated peak power (using allometric equation) was correlated with increased DKV angle in female children. However, yet no study has evaluated the biomechanical link between DKV posture and produced power during jump-landing tasks. The closest results to this study were reported in a previous showing a significant relationship between isometric strength output during hip adduction, extension and external rotation, and side-lying plank tests and knee joint frontal plane projection angle (Stickler, Finley, & Gulgin, 2015). In another study, lower rates of hip abductors, adductor and extensors' isometric strength were shown to be closely linked with higher peak valgus angle in the knee joint (Abdullah, 2016). Additionally, we found that EPP results using allometric equation were not significantly different from actual peak power and seems to be an accurate method for estimating peak power in young females. Our findings are in accordance with a previous study reporting allometric equation to be suitable for healthy elite adolescent basketball players (Duncan et al., 2013). In the younger age group, a previous study reported the application of the allometric method from unprocessed CMJ jump height data as an accurate estimation approach for school children (boys and girls), aged between 7 to 11 (Jones et al., 2020). However, to the best of our knowledge, the results of the current study are the first outcomes showing the differences in CMJ variables and EPP using different regression methods compared to actual peak power in female children with DKV posture.

This study includes some limitations. Participants of the current study were female children only. Due to the sex-related biomechanical differences among female and male athletes, we recommend further researches on comparing both genders.

CONCLUSION: To conclude, less EPP and increased landing forces during CMJ showed to be significantly correlated with greater DKV angle in female adolescents. Based on our results, we suggest EPP using the allometric scaling approach to be more appropriate for female children with DKV, compared to previously used approaches more suitable for adults.

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