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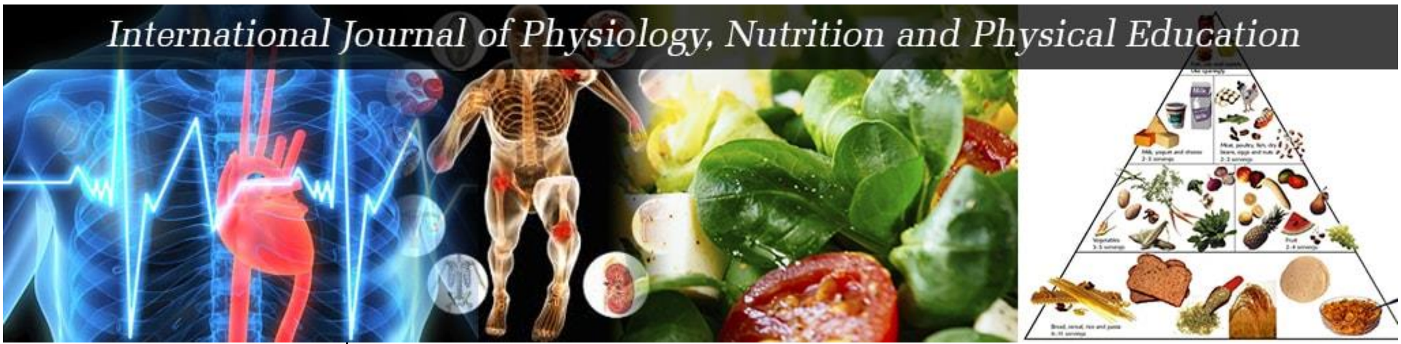

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Estimation of static navicular drop and its correlation with selected anthropometric and lower extremity anatomical alignment variables in university level female judo players

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Abstract
The present study was undertaken to determine the anthropometric variables and lower extremity anatomical alignments, those which have impact on the magnitude of navicular drop. 81 university level female judo players of age group 18-25 years were selected purposively from different universities of northern India for the study. Eleven selected parameters such as height, weight, Body Mass Index (BMI), right total leg length, right lower leg length, right tibiofemoral angle, right femoral anteversion, right Q-angle, right genu recurvatum, right tibial torsion, and right navicular drop were measured on each player following standard techniques. Significant positive correlation of right ND was seen with weight, BMI, right total leg length, right Q-angle, right genu recurvatum and right tibial torsion. Results concluded that weight, BMI, total leg length, Q-angle, genu recurvatum and tibial torsion have significant impact on the magnitude of static ND.

Keywords: Judo, Q-angle, BMI, talonavicular motion, genu recurvatum, tibial torsion, navicular drop

Introduction

Judo is a system of self defence, which makes use of an opponent's strength to overcome them, meaning that a smaller opponent can defeat a larger opponent. 'Ju' means gentleness or giving way, and 'do' means way of life, thus making Judo mean literally 'the gentle way' or 'the way of giving way.' Judo was founded in 1882, in Japan, by Professor Jigoro Kano, who envisioned it as a way of becoming physically and mentally fit through disciplined training (International Judo Federation). Judo has been characterized as a high-intensity intermittent combat sport, consisting of many different techniques and actions during a match [1].

According to the National Collegiate Athletic Association injury surveillance system for 2000–2001, the most common injury sites were the ankle, knee, and lower leg among collegiate soccer, field hockey, basketball, and lacrosse athletes [2]. The most common injury types were muscle strains, ligament sprains, and contusions.

Prevention and intervention have become focal points for researchers and clinicians. Before these types of studies can be used, the risk factors for injury must be clearly established. Many injury risk factors, both extrinsic (those outside of the body) and intrinsic (those from within the body), have been suggested [3]. Extrinsic risk factors include level of competition, skill level, and shoes type, use of ankle tape or brace, and playing surface. Intrinsic risk factors include age, sex, previous injury and inadequate rehabilitation, aerobic fitness, body size, limb dominance, flexibility, limb girth, muscle strength, imbalance and reaction time, postural stability, anatomical alignment, and foot morphology.

One of the methods frequently used in clinical practice is measurement of the navicular drop (ND). The navicular drop describes the range of sagittal deformation of the midfoot during the stance phase of gait [4]. Depending of the foot size the dynamic navicular drop for healthy persons is on average 5.3 mm (±1.8 mm) [5] but can vary up to 15 mm in problematic cases. The dynamic navicular drop is measured as the change in the navicular height from the time of heal strike to the time of lowest navicular height during the stance phase of gait [6] The navicular drop has been suggested to be the most appropriate parameter for the assessment of foot pronation [7] as it is a valid indicator of talonavicular motion [8] and rear foot movement [9]. The size of navicular drop appears to have important consequences for subjects who participate in weight bearing sports such as running. Excessive movement of the navicular places the subject in higher risk of developing injuries to the medial side of the shin [10, 11] as well as the knee [12]. It is believed that when the navicular moves excessively and the foot collapses, it causes increased forces being transmitted to the tibia (shin bone) as well as increased internal rotation of the tibia which alters the biomechanics of the lower extremity [13, 14].

Navicular drop measurement is gaining popularity with clinicians and researchers for quantifying midfoot mobility. Several investigators [15-19] have suggested that ND measurement may be the most valid and reliable static clinical measure of foot pronation currently available to clinicians. Navicular drop measurement is defined as the difference in height of the most prominent aspect of the navicular tuberosity when the subtalar joint is placed in neutral as compared with when the foot is positioned in a relaxed standing foot posture [20, 21]. Therefore, the measurement is used to quantify midtarsal joint pronation or flattening of the medial longitudinal arch during standing. Navicular height measurements have been shown to be an indicator of navicular bone movement during gait in people without foot deformity [18].

Being overweight (BMI ≥25 kg/m2) has been reported as a risk factor for lower extremity malalignment, particularly abnormal pelvic tilt, Q-angle, and tibiofemoral angle. This is because increased joint loading can produce injury to weight-bearing joints in the lower limbs [22, 23]. Obese persons may compensate for excessive loading by abnormal lower extremity alignment [22].

To our knowledge, no studies have investigated the influence of anthropometric and lower extremity anatomical variables on the static ND in judo players of northern India, which thus became the purpose of this study.

Design and Methodology

1. Design

The study design is based on cross sectional research, in which university level female judo players were included to provide a general description of selected anthropometric and lower extremity anatomical alignments and their correlation with navicular drop (ND).

2. Subject selection

The present study was based on the sample of 81 university level female judo players of age group 18-25 years, selected purposively from different universities of northern India. The age of the subjects was determined from their respective school records. A written consent was obtained from the subjects. The data was collected under natural environmental conditions while maintaining the privacy of the players. The study was approved by the university ethical committee.

3. Methods

a) Selected Anthropometric variables: All the measurements were recorded using the techniques described by Lohmann *et al.* [24] and were measured thrice with the median value used as the criterion.

- **Height:** The height was recorded during full inspiration using a stadiometer (Holtain Ltd., Crymych, Dyfed, UK) to the nearest 0.1 cm. The players were asked to stand erect on the stadiometer with bare feet. The horizontal bar of the stadiometer was placed on the vertex of the players and the readings were recorded.
- **Weight:** It measures the weight of the body with minimum clothes, when the bowel is empty and is taken on the digital weighing machine (Model DS-410, Seiko, Tokyo, Japan) to the nearest 0.1 kg. The readings were recorded from the reading scale of the digital weighing machine in kilograms (kg).
- **Body Mass Index (B.M.I):** The BMI was calculated by dividing weight in kg by square of height of subject in meters. Hence, it is represented by kg/m^2.
- **Right Total leg length (RT TLL):** It measured the vertical distance from the right anterior superior iliac spine (ASIS) to the right medial malleolus. The players were asked to stand erect on a horizontal surface stretching the body as much as possible. The starting point of the steel tape was allowed to touch the ASIS and the tape was extended down up to medial malleolus lower point. The readings were recorded in cm.
- **Right Lower leg length (RT LLL):** It measured the vertical distance between right tibia and the lowest point of the right medial malleolus of tibia. The players were asked to stand erect on a horizontal surface. The starting point of the steel tape was allowed to touch the joint line of knee joint medially and the tape was extended down up to medial malleolus lower point. The readings were recorded in cm.

b) Right lower extremity anatomical measurements

- **Right Navicular Drop (RT ND):** It was measured using a modification of a technique described by Brody [21]. The right navicular tubercle was palpated and marked with the players in a bilateral stance. Navicular height was measured with a straight edge ruler, with the players in subtalar joint neutral, the position in which the medial and lateral aspects of the talar head would be equally palpable on both sides. Then the players were instructed to relax the stance, and the difference between the height of navicular in STJN and relaxed stances were recorded in centimetres.
- **Right Tibiofemoral angle (RT TFA):** It is the angle formed in the frontal plane by the anatomical axes of the femur and tibia [25]. With the goniometer axis (modified with an extension piece on the stationary arm) over the right knee centre (midpoint between the medial and lateral joint line in the frontal plane), the stationary arm was aligned along a line from the knee centre to a proximal landmark (midpoint between the right anterior superior iliac spine and the most prominent aspect of the right greater trochanter), and the movable arm was aligned along a line from the knee centre to a distal landmark (midpoint between the right medial and lateral malleoli). While there is no universally accepted proximal landmark for clinical measurement methods of tibiofemoral angle, the rationale for using the midpoint between the anterior superior iliac spine and greater trochanter would be based on known anatomy, and thought to more closely approximate the anatomical axis of the femur compared to either the greater trochanter and anterior superior iliac spine, which may overestimate and underestimate, respectively, the measure [26]. The readings were recorded in degrees.
- **Right Femoral Anteversion (RT FA):** It was measured using the Craig's test [27] with the players in prone and the knee flexed to 90°. The examiner palpated the right

greater trochanter while passively rotating the right hip until the most prominent part of the greater trochanter reached its most lateral position. The angle between the true vertical line and the shaft of the right tibia was measured using a universal goniometer. The readings were recorded in degrees.

- **Right Q-angle (RT QA):** Q-angle represents the angle formed by a line from the anterior superior iliac spine (ASIS) to the patella centre and a line from the patella centre to the tibial tuberosity [28]. Right Q-angle was measured with the players in a standing, relaxed position with a universal goniometer [29]. The readings were recorded in degrees.
- **Right Genu Recurvatum (RT GR):** It was measured with the players in supine and a bolster positioned under the right distal tibia. The goniometer axis was positioned over the lateral joint line, the stationary arm aligned with the right greater trochanter, and the movable arm aligned with the right lateral malleolus. The measurement was recorded while the examiner applying a posteriorly directed force to the anterior knee until passive resistance had achieved [26]. The readings were recorded in degrees.
- **Right Tibial Torsion (RT TT):** It was measured using a modified technique [30]. With the players in supine and the right knees extended; the players had rotated the leg until the line between the femoral epicondyles was parallel to the plinth. In this position the axis of the goniometer was aligned at the midpoint along the line between the right medial and lateral malleoli. The angle formed by the line bisecting the bimalleolar axis and the true vertical line was measured using a universal goniometer. The readings were recorded in degrees.

4. Statistical analysis

Descriptive statistics (mean ± standard deviation) were determined for the directly measured and derived variables. To establish the dimension of relationship of right ND as dependent variable with set of anthropometric and right lower extremity variables, Karl Pearson's moment correlation coefficients were calculated. All the data were determined using SPSS (Statistical Package for Social Science) version 20.0. A 5% level of probability was used to indicate statistical significance.

5. Results

Table 1: showed the descriptive statistics of right navicular drop, various anthropometric variables and selected right lower extremity anatomical variables of university level female judo players (Mean ± SD: height 169.07±6.27 cm, weight 62.30±9.63 kg, BMI 21.73±2.64 kg/m^2, right total leg length 89.60±3.74 cm, right lower leg length 40.41±2.41 cm, right tibiofemoral angle 8.73±1.46 degree, right femoral anteversion 18.98±2.51 degree, right Q-angle 16.41±2.26 degree, right genu recurvatum 8.44±1.34 degree, right tibial torsion 17.56±2.29 degree, right navicular drop .81±.15 cm).

Table 1: Descriptive statistics of navicular drop, anthropometric variables and right lower extremity anatomical variables in university level female judo players.

Variables	N	Minimum	Maximum	Mean	SD
Height (cm)	81	158.00	183.00	169.07	6.27
Weight (kg)	81	47.00	88.00	62.30	9.63
BMI (kg/m^2)	81	18.07	28.73	21.73	2.64
Right Total Leg Length (cm)	81	83.00	98.00	89.60	3.74
Right Lower Leg Length (cm)	81	35.00	46.00	40.41	2.41
Right Tibiofemoral Angle (degrees)	81	7.00	13.00	8.73	1.46
Right Femoral Anteversion (degrees)	81	14.00	28.00	18.98	2.51
Right Q-Angle (degrees)	81	10.00	22.00	16.41	2.26
Right Genu Recurvatum (degrees)	81	5.00	11.00	8.44	1.34
Right Tibial Torsion (degrees)	81	12.00	22.00	17.56	2.29
Right Navicular Drop (cm)	81	.40	1.10	.81	.15

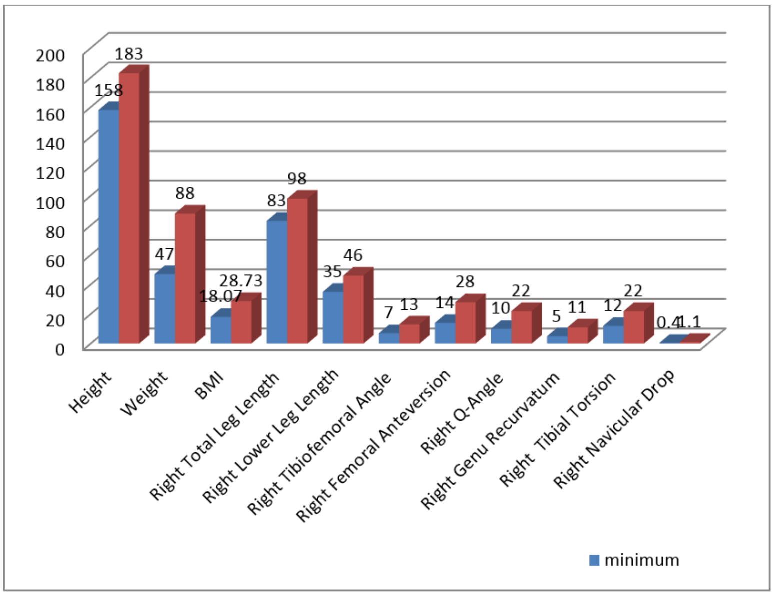

Fig 1: Graphical representation of descriptive statistics of right navicular drop, various anthropometric variables and selected right lower extremity anatomical variables of university level female judo players.

Table 2: showed correlation matrix of right navicular drop, anthropometric variables and right lower extremity anatomical variables in university level female judo players. Highly significant correlations ($p \leq 0.01$) were seen in Weight, RT QA, RT GR and RT TT. Positive significant correlations were also noticed in BMI and RT TLL ($p \leq 0.05$).

Table 2: Correlation matrix of right navicular drop, anthropometric variables and right lower extremity anatomical variables in university level female judo players.

	HEIGHT	WEIGHT	BMI	RT TLL	RT LLL	RT TFA	RT FA	RT QA	RT GR	RT TT	RT ND
HEIGHT	1	.600**	.162	.838**	.779**	.265*	.156	.082	-.013	.008	.185
WEIGHT		1	.885**	.555**	.537**	.165	.243*	.288**	.153	.110	.291**
BMI			1	.203	.211	.054	.214	.293**	.195	.134	.239*
RT TLL				1	.908**	.354**	.021	.004	.038	-.212	.228*
RT LLL					1	.330**	.031	.059	-.053	-.171	.175
RT TFA						1	.029	-.148	.120	.159	-.034
RT FA							1	.428**	.122	.354**	.214
RT QA								1	.146	.385**	.669**
RT GR									1	.106	.376**
RT TT										1	.315**
RT ND											1

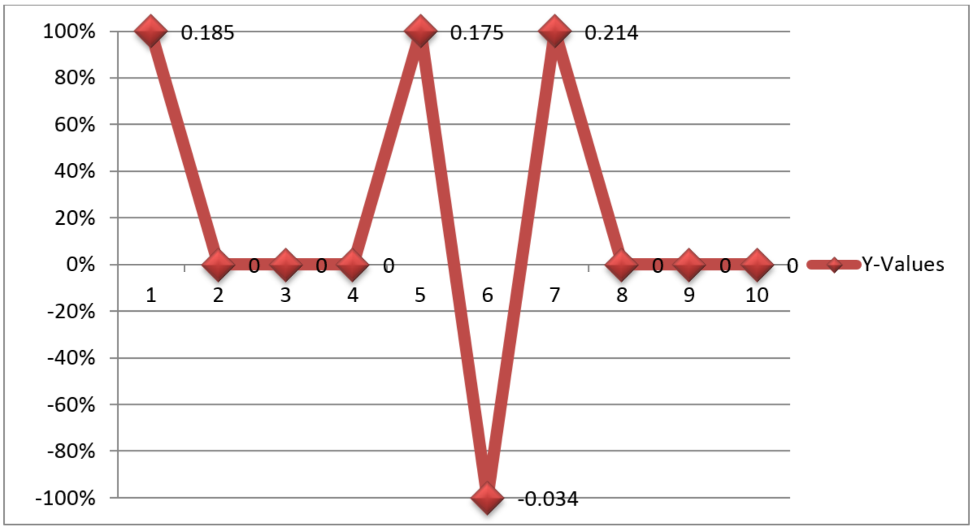

Fig 2: Graphical representation of correlation of selected anthropometric variables and right lower extremity anatomical variables with right navicular drop in university level female judo players.

6. Discussion

In the present study, we noted highly significant correlations in weight, right Q-angle, right genu recurvatum and right tibial torsion. Significant correlations were also noticed in BMI and right total leg length.

Previous study showed foot length had a significant influence on the navicular drop in both men and women, whereas no significant effect was found of age or BMI. The study demonstrated that the dynamic navicular drop is influenced by foot length and gender [31].

Some studies also revealed that the change in dorsal arch height during the Sit-to-Stand test offers the clinician a reliable and valid alternative to the navicular drop test [32].

Navicular drop and Q-angle showed both independent and interactive effects on neuromuscular responses to a weight-bearing, rotational perturbation. These interactive effects highlight the importance of considering the entire lower extremity posture rather than a single alignment characteristic, given the potential for one alignment factor to compensate for or interact with another [33].

The ND values were slightly greater than reported normal values of 6 to 8 mm in people with rheumatoid arthritis [34].

Study showed no correlation between SSNDT (sit-to stand navicular drop test) and dynamic navicular drop (DND), suggesting that static measures of NH change may not predict dynamic navicular motion in gait [35].

Another study showed a significant relationship between navicular drop and MTSS (medial tibial stress syndrome) but there was not any significant relationship between lower extremity alignment and MTSS in non-professional athletes [36].

Another study indicated that female athletes had higher mean value in BMI and lesser mean values in height, weight, right total leg length, left total leg length, right lower leg length, and left lower leg length than their male counterparts. The findings of lower extremity alignment variables in the study indicate that female athletes had higher mean values in right tibiofemoral angle, left tibiofemoral angle, right femoral anteversion, left femoral anteversion, right Q-angle, left Q-angle, right genu recurvatum, left genu recurvatum, right tibial torsion, left tibial torsion, right navicular drop and left navicular drop than their male counterparts [37].

The findings of another study indicated that in state level female basket-ball players, significant positive correlation ($p<0.01$) of right Q-angle was noted with right tibiofemoral angle, right femoral anteversion, right genu recurvatum and right navicular drop. Whereas, significant positive correlation ($p<0.01$) of left Q-angle was noted with left tibiofemoral angle, left tibial torsion and left navicular drop. Significant positive correlation ($p<0.05$) of left Q-angle was noted with left femoral anteverion [38].

7. Conclusion

Our results suggest that players with increased body weight, BMI, Q-angle, genu recurvatum, tibial torsion and total leg length can increase ND. In light of our study results, clinicians and researchers can address players with pronated or supinated foot (high or low arch foot) structures for greater risk of lateral ankle sprain than people with neutral foot structures. Identifying the postural factors that influence ND, excessive stress and potential injury is of considerable importance. The results of this study would be implicated for preseason screening as well as clinical diagnosis and treatment of athletes or patients. Various corrective exercise programs would be started as preventive measures in case of any malalignment persisting before and can be modified, which would prevent future injuries. Moreover, in rehabilitating stage of an injured player, regular checking of lower extremity would provide proper information towards treatment strategy. With the findings of the present study, coaches and therapists may arrange supportive devices, foot wear modification and corrective exercises for the athletes as per their lower extremity alignment for performance enhancement and educate the players to avoid various types of sports injuries.

8. Acknowledgements

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