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GRADUATE RESEARCH ARTICLE

Association of Intrinsic Factors with Non-contact Injury Prevalence of Front Foot Knee Pain Among First Class Fast Bowlers in Colombo Division

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ABSTRACT

Background: Cricket is one of the most popular sports in Sri Lanka. Both intrinsic and extrinsic injury prevention and increase performance are of cardinal importance to a fast bowler to reach optimal performance. Intrinsic prevention methods may protect the fast bowler against too high level of stress experienced during bowling. In this study we aimed to assess the incidence of front foot knee pain and the associated intrinsic risk factors among first class cricket fast bowlers, to come up with recommendations to improve training regimes to prevent non-contact injury.

Method: Descriptive Cross-Sectional study was conducted with 30 fast bowlers with front foot knee pain. Severity of knee pain was measured by using knee evaluation form. Q angle, Hip internal rotation were measured using a modified goniometer. Quadricep and hamstring muscle strength were measured by cuff adapted sphygmomanometer. Ankle dorsiflexion was measured by Lunge Test.

Results: An insignificant, positive correlation in Ankle dorsiflexion (p=0.780, r=0.053), hip internal rotation (p=0.194, r=0.244), and quadriceps hamstring muscle strength ratio (p=0.952, r=0.012) of the fast bowlers with front foot knee pain was observed. Also, there was an insignificant negative correlation between quadriceps angle (p=0.827, r=-0.042) and front foot knee pain.

Keywords: Knee Pain, Fast Bowlers, Intrinsic Factors

1 Introduction

Modern day sport is highly competitive hence requires considerable amount of training outside the field. Today sportsmen and women are expected to train longer, harder, and earlier in life to excel in their chosen sport. Hence, they are more prone to musculoskeletal injury including pain and knee injuries (26.5%). [1]
Cricket is the most popular sports in Sri Lanka. The value placed on Sri Lankan cricketers is further increased because of the repetitive nature of the game. However, cricket is generally considered as a low injury risk sport compared to other sports such as rugby, football, and athletics. Out of all the various roles of the cricketers in the field fast bowlers has the highest risk of injury and is specifically at risk of lower back and lower limb (lower quarter) injury due to the inherent, high load and the biomechanical nature of the fast-bowling action. [2] [3] [4] [5]
Depending on individuals bowling action, bowlers are more prone to get pain in front foot knee due to their heavy workload and repetitive stress acting through body alignment which is a result of ground reaction force during front foot impact and back foot impact with flexion and extension. According to [6], the anatomical site of most cricket related musculoskeletal pain is the knee. The types of pain experienced by the subjects are mostly discomfort, sharp pain, dull aching pain, spasm and swelling. The intensity of pain experiences ranges from moderate too low to high and severe [6]. A retrospective study was done to investigate the prevalence and nature of cricket related musculoskeletal pain among male adolescent cricket players. The subjects (n=234) were recruited from five secondary schools in KwaZulu-Natal, age ranged between 14 to 17years and they were required to complete a self-reported questionnaire probing the incidences of musculoskeletal pain within the last 12 months. The probability was set at p<_0.05. Result showed that 188 subjects experienced cricket related musculoskeletal pain and the most common anatomical site of musculoskeletal pain was the knee (30%) [6].
Both Intrinsic and extrinsic factors work in combination to predispose knee pain among fast bowlers. Intrinsic or personal factors including muscle strength, flexibility, balance, bowling technique, shoulder depression, horizontal flexion strength for the dominant limb, quadriceps power, hip internal rotation, ankle dorsiflexion, hamstring flexibility, knee angle and BMI. Extrinsic factors or environmental related factors include bowling workload (the number of balls a bowler bowls), player position (1st, 2^{nd}, and 3^{rd} changes) and time of play (morning and afternoon) [3].
Dennis et.al (2008) conducted a prospective cohort study using a sample of 91 male adolescent and adult fast bowlers among Australian high-performance cricketers to recognize risk factors which could contribute to injuries. Bowlers' injuries were recorded over the 2003-2004 season.to measure ankle dorsiflexion, lung test was used, and hip internal rotation was measured by using modified goniometry. In result two variables were identified. Bowlers with hip internal rotation of <_30 on the leg ipsilateral to the bowling arm were at a significantly reduced risk of injury compared with bowlers with >40 of rotation. Bowlers with an ankle dorsiflexion lunge of 12.1-14 cm on the leg contralateral to the bowling arm were at significantly increased risk than bowlers with lunge of >14cm [5].
A cross sectional comparative study was done to compare the eccentric knee flexor strength and asymmetries across elite, sub-elite and school level cricket players. Seventy-four male cricketers of three distinct skill level have performed three repetitions of the Nordic hamstring exercises on the experimental device. Strength was assessed as the absolute and relative mean peak force output for both limbs, with bilateral asymmetries. According to study the results showed that there was no significant difference between bowlers and batters in mean peak force and bilateral asymmetries. There were non-significant differences between front and back limb mean peak force output. However, this study has presented the potential role of eccentric knee flexor muscle strength and bilateral asymmetry in predisposing cricket players to such injury [7].
A longitudinal observational design was done to stabilize the relationship between pace bowling performance and regional spine and knee kinematic by analysing 31 injury free, premier league cricket pace bowlers over the age of 18 years. Performance ball release speed and accuracy were captured and Pearson's

correlation coefficient, NOVA and Turkey's post hoc comparisons were used to analyse the relationship between kinematic and performance before and after a cricket season. The result showed, a more extended knee angle (r=0.362; p=0.037) correlated with higher ball release speed at the start of the season and a smaller change in knee angle at the end of the season. This study has discussed a front knee angle closer to 180 degrees at front foot placement has the capacity to transfer kinetic energy to the knee resulting in a strain leading to an injury. This research has decided that it may be ideal for pace bowlers to flex their knees at front foot placement and extend their knees to more than 150 at ball release [3].

Both intrinsic and extrinsic injury prevention and increase performance are of cardinal importance to a fast bowler to obtain an optimal performance. Extrinsic prevention methods include guidelines on bowling workload, while intrinsic prevention method may protect the pace bowler against injury in the presence of high stressful nature of the pace bowling.

With this background, the aim of this study was to assess the incidence of front foot knee pain and the associated intrinsic risk factors among first class fast bowlers in Sri Lanka to prevent non-contact injury.

1.1 Objectives

- To evaluate the association of intrinsic factors with non-contact injury prevalence of Front foot knee pain among 1st class cricketers
- To assess the association of quadriceps and hamstring muscle strength ratio with non-contact injury prevalence of front foot knee pain
- To investigate the association of hip internal rotation and ankle dorsiflexion with non-contact injury prevalence of front foot knee pain
- To investigate the knee angle with non-contact injury prevalence of front foot knee pain

2 Methods

The study was a descriptive cross-sectional study. Thirty first class fast bowlers from Sinhalese cricket club, Nondescript cricket club, Moors sports club and Tamil union cricket club located in Colombo was recruited to take part in the study. Participants who had complains about front foot knee pain were evaluated using IKDC knee pain score. Players who had intolerable pain during the measurement gaining procedure and subjects with a history of any neurological disorders, cardio-vascular diseases were excluded from the study. An information sheet with all the details about the study including the aims, methods and the ethical concepts was given to all the subjects. Any further details were clearly explained upon request of the subjects. Written informed consent was taken prior to the data collection. Ethical clearance was obtained from the Ethics Review Committee (ERC) of the Faculty of Medicine, General Sir John Kotelawala Defense University. Permission to conduct the research was obtained from the relevant authorities of the 1st class cricket clubs in Colombo division.

After taking the consent and explaining the procedure to participants of the study, the subjects underwent a 5-minute warm-up session and a 5-minute static stretching exercises session of the whole body, specially targeting the hamstring, quadriceps, low back, and lower extremity muscle groups to minimize the variability and the standard error of the measurements by reducing the impact of different muscle temperature on muscle flexibility. After finishing their warm-up session, the examiners filled the interviewer administered questionnaire which includes the demographic data including name, age, gender, nationality, front foot and information about the sport career, past medical, surgical, and traumatic history and all the other relevant information through individual interviews. Then IKDC knee evaluation forms were filled by all subjects.

Three stations were arranged for the measuring procedures as shown in table 1. In each station, there was 1 specific examiner with relevant equipment all the time to examine the specific test to avoid the examiner bias. All the measurements were taken at a place where patient's privacy was secured.

Table 1: *Specific stations used in the data collection process and the measurements taken at each station.*

Station number	Measurements taken
Station 1	Anthropometric parameters (Height, Weight and BMI)
Station 2	Hip internal rotation and ankle dorsiflexion & Q angle
Station 3	Quadriceps muscle strength and Hamstring muscle strength

Hip internal rotation and external rotation was measured by using modified goniometer. A spirit level was connected to one arm of the goniometer to modify it and test was used to assess the hip rotation in a neutral position. The bowler laid in a prone position with both knees bent to 90 degrees, chin resting on the bench, arms by their sides. Then the bowler was asked to let both of their ankles move away from each other as far as possible, while the examiner ensured that pelvic motion and hip flexion did not occur. The bowler straightened their contralateral knee and let the ankle of testing leg drop towards the opposite side of the body as for as possible. Both measurements measured the angle formed by the line of the tibia, relative to the vertical [5].

Quadriceps angle was measured by using modified goniometer. When applying to subjects who were standing was usually more suitable due to the normal weight bearing forces being applied to the knee joint as occurs during daily activity. The Q angle was measured on the front foot and back foot of all subjects. During the test, subjects were in standing position with the erect weight-bearing to both legs. The anterior superior iliac spine (ASIS), the midpoint of the patella, and the tibial tuberosity was determined and marked. The hinge of the goniometer was located at the midpoint of the patella. The goniometer arms were positioned to the line joining the ASIS and the line joining with the tibial tuberosity. Then the small angle that showed on goniometer was taken as the reading of the Q angle. This angle was measured 3 times and the mean value of the angle was calculated [8] [9].

Quadriceps and hamstring muscle strength and muscle strength was measured by using modified sphygmomanometer. Prior to data collection, modified sphygmomanometer was calibrated using standard free weights to verify whether the equipment provided was consistent throughout the study and for possible adjustment of systemic error, if necessary.

The modified sphygmomanometer, each with a dial divided into increments of 2mmHg was first inflated into 100mmHg, and its valve remains closed to remove the folds from the inflatable portion. Then the valves were opened, and pressure was reduced to 20 mmHg, and the valve was closed again to prevent leakage, providing 20 - 304 mmHg measurement range [10].

Standard 5Kg weight plates were consistently stacked one by one on the cuff part of the modified sphygmomanometer. A wood apparatus was built to keep the weight plates aligned. The output was read and recorded on a calibration sheet. A uniform increase in pressure values could be identified with the added weight plates, with consistent baseline reading of 20mmHg, as well as there was a uniform decrease in pressure values when removing weight plates [10].

The reading showed stable and reliable pressure measurement throughout testing, to verify that modified sphygmomanometer gave consistent reading, calibration test was again performed halfway through and at the termination of data collection [10].

Lunge test was used to measure the range of dorsiflexion at the ankle joint and mobility in the mid foot. A tape measure was fixed along the floor with “0” cm point at the junction of the floor and wall. The bowler positioned their foot on the tape on the floor so that their heel line and big toe were aligned on the tape measure. The examiner held the bowler’s heel to prevent it from lifting off the floor and manually locked the subtalar joint, so it remained in a neutral position throughout the test. Then bowler was asked to lunge forward until their knee touched the wall. The maximum distance from the great toe to wall was recorded to the nearest 0.1cm [11].

3 Results

Data analysis was done using the statistical package for the social science soft Ware (SPSS) by the research team. Descriptive statistics were used to analyse the data. Spearman correlation was used to assess the association between two variables.

3.1 Distribution of intrinsic factors

BMI, Q angle, Hamstring Quadriceps ratio, Ankle dorsiflexion, Hip internal rotation were analyzed under the descriptive statistics.

Table 2: *Descriptive statistics of BMI values*

N	Mean (kg/m2)	Minimum (kg/m2)	Maximum (kg/m2)	Std. Deviation
30	22.9387	18.61	29.32	2.69624

Table 2 shows descriptive statistics of BMI values. The BMI varied between 18.61-29.32 kg/m2 among the study population, with a mean value of 22.9387 kg/m2 (SD = 2.69624)

Table 3: *Descriptive statistic of Quadriceps hamstring ratio*

	N	Mean	Minimum	Maximum	Std. Deviation
Front foot	30	0.997	0.8	1.2	0.0928
Back foot	30	0.958	0.0	1.3	0.2342

Table 3 shows descriptive statistic of Quadriceps hamstring ratio. The mean front foot Quadriceps Hamstring Ratio of the sample was 0.997 and back foot was 0.958. (Standard Deviation / front foot =0.0928, back foot= 0.2342) in which the minimum ratio was 0.0 and the maximum was 1.3.

Table 4: *Descriptive statistics of Hip internal rotation values*

	N	Mean ○	Minimum ○	Maximum ○	Std. Deviation
Front foot	30	35.70	20	65	9.791
Back foot	30	36.50	23	60	8.419

Table 4 represents descriptive statistics of Hip internal rotation values. The mean front foot Hip internal rotation value of the sample was 35.70 and back foot was36.50. (Standard Deviation / front foot =9.791, back foot= 8.419) in which the minimum value was 20 in front foot and 23 in back foot. The maximum was 65 in front foot and 60 in back foot.

Table 5: *Descriptive statistics of Ankle dorsiflexion values*

	N	Mean ○	Minimum ○	Maximum ○	Std. Deviation
Front foot	30	3.467	1.5	7	1.4138
Back foot	30	3.630	1.5	7	1.4317

Table 5 represents descriptive statistics of Ankle dorsiflexion values. The mean front foot Ankle dorsiflexion value of the sample was 3.467 and back foot was 3.630. (Standard Deviation / front foot =1.4138, back foot= 1.4317) in which the minimum value was 1.5 in front foot and 7 in back foot. The maximum was 7 in front foot and back foot.

Table 6: *Descriptive statistics of Q angle values*

	N	Mean	Minimum	Maximum	Std. Deviation
Front foot	30	12.13	7	21	3.104
Back foot	30	12.30	7	23	3.175

Table 6 represents descriptive statistics of Q angle values. The mean front Q angle value of the sample was 12.13 and back foot was 12.30. (Standard Deviation / front foot =3.104, back foot=3.175) in which the minimum value was 7 in front foot and 7 in back foot. The maximum was 21 in front foot and 23 in back foot.

Table 7: *Descriptive statistics of Front foot knee pain values*

N	Mean	Minimum	Maximum	Std. Deviation
30	4.73	2	9	1.680

Table 7 represents descriptive statistics of Front foot knee pain values. The mean knee pain value of the sample was 4.73 (standard deviation= 1.680) in which the minimum value was 2 and the maximum values was 9.

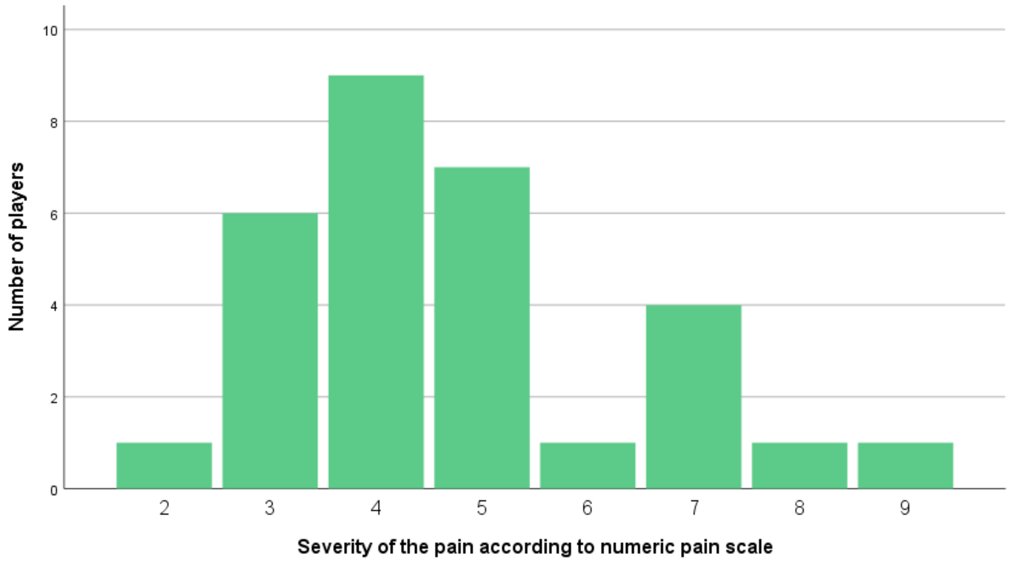

Figure 1: *Distribution of knee pain among population according to numeric pain scale*

Figure 1shows distribution of knee pain among population according to numeric pain scale: Majority of the players have moderate knee pain at 3, 4, 5 levels in the numeric pain scale. Very few players have complain sever knee pain at 8, 9 levels in the numeric pain scale.

3.2 Relationship between front foot knee pain and intrinsic factors

Spearman correlation test was done statistically to find out the correlation between front foot knee pain and intrinsic factors.

Table 8: *Relationship between front foot knee pain and quadriceps and hamstring muscle strength ratio, hip internal rotation*

	Significant value	Correlation coefficient
Quadriceps and hamstring muscle strength ratio of front foot	0.952	0.012
Hip internal rotation of front foot	0.194	0.244
Ankle dorsiflexion of front foot	0.780	0.053
Q angle of front foot	0.827	-0.042

Table 8 shows relationship between front foot knee pain and quadriceps and hamstring muscle strength ratio, hip internal rotation: According to the results it was illustrated an insignificant positive correlation between front foot knee pain and quadriceps and hamstring muscle strength ratio, hip internal rotation, and ankle dorsiflexion. Insignificant negative correlation between front foot knee pain and Q angle.

4 Discussion

Thirty first class fast bowlers with front foot knee pain were enrolled to the study. Out of this 11 (36.66%) were right front foot bowlers and 19 (63.33%) were left front foot bowlers. The mean age was 22.37 years (range 18-31).

According to the current study knee pain evaluation was done under IKDC knee evaluation form. In numeric pain scale, 20% of population had showed a IKDC score of 8 and 30 % of population had showed an IKDC score of 7 followed by23% of population with a score of 6, indicating that most of the sample was had knee pain.

The BMI of the current study sample was varied between 18.61- 29.32kg/m2 with a mean value of 22.94kg/m2 (SD=2.696). According to the result of the study BMI had showed an insignificant negative correlation with the front foot knee pain (significant value=0.174, correlation coefficient = -0.255). Our finding is backed by a study conducted by Forrest et. al, (2017) [12] Indicating that there was no significant association between ankle injury and BMI.

The quadriceps and hamstring muscle strength ratio was varied between 0.8-1.2 with a mean value 0.997 (SD=0.0928). The muscle strength ratio between the front foot and the back foot varied between 0.0 and 1.3 with a mean value 0.958 (SD=0.2342). Our study shows that there was an insignificant positive correlation between the front foot muscle strength ratio and knee pain. (Correlation ecoefficiency=0.012, significant value=0.952). Furthermore, our results indicated that both front and back foot mean muscle strength ratio was closer to 1, and this is a ratio observed in normal muscle strength. Only limb hamstring muscle strength gave a significant correlation at 0.01. (Correlation ecoefficiency=0.507, significant value=0.004). Our observations could be due to an increase hamstring muscles strength or decrease in quadriceps muscles strength leading to a musculature imbalance around the knee causing knee pain. According to a study by Wade et.al, (2016) [7] there were no significant difference observed between bowlers and batters in mean peak force and bilateral asymmetries. Also there were no significant differences between front and back limb mean peak force output. However, this study has presented the potential role of eccentric knee flexor muscle strength and bilateral asymmetry in predisposing players to such injury.

Our results indicated that the correlation between hip internal rotation and front foot knee pain showed an in significant positive correlation (Correlation coefficiency=0.244, significant value=0.194). A study done on bowling kinematics, lumber bowling kinematics, trunk endurance and reduced movement control done by Bayne et.al, [13] in Australia also reported an insignificance difference in internal or external hip rotation.

(46.1_+5.6; 50.7_+5.5; p=0.049). However, conflicting result were found by Dennis et. Al, (2008) [5] in his cohort studies that reduced hip internal rotation on the leg ipsilateral to the bowling arm, was significantly associated with a reduced risk of injury. (<30 vs. >40, OR= 0.20, 95% CI 0.06-0.73). In our study finding result may be due to high internal load during delivery stages such as at front and back foot impact. Dennis et.al, [5] had showed inadequate gluteus medias control may be another reason for that.

Same as hip internal rotation there was an insignificant positive correlation of the ankle dorsiflexion and front foot knee pain. (Correlation coefficiency =0.053, significant value=0.780). The ankle dorsiflexion varied between 1.5 and 7 degrees with a mean value of 3.467 (SD=1.4138). Between front and in back foot it varied between 1.5 and 7 with a mean value 3.630 (SD=1.4317). Souza et. al, (2009) [14] conducted a study on Late rearfoot eversion and lower-limb internal rotation caused by changes in the interaction between forefoot and support surface shows lateral wedges under the forefoot, increase rearfoot eversion during mid-and late stances, which may cause proximal kinematic changes throughout the lower-extremity kinetic chain. Hence our observation for the above results could be due to changing both tibial and femoral alignment with the increasing load on the knee via closed kinetic chain and calf musculature tightness.

The standard value of Q angle in male are ranged between 12-15 [15]. According to the result of current study sample, the Q angle was varied between 7-21 in front foot and 7-23 in back foot. Mean value of front foot Q angle was 12.13 and for back foot it was 12.30. The range of the Q angle has increased than the standard values with a negative no significant correlation. It may be due to the lower study population in the study sample compared with the other study done on the topic. However, our results are in conflict with the result obtained Ferdinands et. Al, (2009) [16], who had released an abstract book, showing the subject who experienced knee pain had abnormal Q-angles (right knee-12.71; left knee-11.19) (P<0.0001) which further precipitated their risk of injury at the knee joint and knee was the most common anatomical site of pain.

5 Conclusions

According to the result of the current study, there was an insignificant positive correlation between front foot knee pain and quadriceps and hamstring muscle strength ratio, hip internal rotation, and ankle dorsiflexion. But an insignificant negative correlation between front foot knee pain and Q angle.

As the sample size of this study is limited, we highly recommended conducting another similar study with a large sample size. As the setting of this study was limited to Colombo division, we believe another similar study should be conducted to cover all the provinces in Sri Lanka for a better representation of the demographics in the country. This study could be helpful for coaches and players to better identify injury prevalence and take precautions to prevent injury.

6 Declarations:

6.1 Competing Interests

There are no conflicts of interest that are relevant to this study for the authors of this manuscript.

6.2 Publisher's Note

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References

[1] Butcher JD, Zukowski CW, Brannen SJ, Fieseler C, O'Connor FG, Farrish S, Lillegard WA. Patient profile, referral sources, and consultant utilization in a primary care sports medicine clinic. Journal of family practice. 1996 Dec 1;43(6):556-60.

[2] Orchard JW, Blanch P, Paoloni J, Kountouris A, Sims K, Orchard JJ, Brukner P. Cricket fast bowling workload patterns as risk factors

for tendon, muscle, bone and joint injuries. British journal of sports medicine. 2015 Aug 1;49(16):1064-8.
[3] Olivier B, Taljaard T, Burger E, Brukner P, Orchard J, Gray J, Botha N, Stewart A, Mckinon W. Which extrinsic and intrinsic factors are associated with non-contact injuries in adult cricket fast bowlers?. Sports Medicine. 2016 Jan 1;46(1):79-101.
[4] Stretch, RA* & Venter D. Cricket injuries a longitudinal study of the nature of injuries in South African cricketers. South African Journal of Sports Medicine. 2003 Jun 1;15(2):4-8.
[5] Dennis RJ, Finch CF, McIntosh AS, Elliott BC. Use of field-based tests to identify risk factors for injury to fast bowlers in cricket. British Journal of Sports Medicine. 2008 Jun 1;42(6):477-82.
[6] Noorbhai MH, Essack FM, Thwala SN, Ellapen TJ, Van Heerden JH. Prevalence of cricket-related musculoskeletal pain among adolescent cricketers in KwaZulu-Natal. South African Journal of Sports Medicine. 2012;24(1).
[7] Chalker WJ, Shield AJ, Opar DA, Keogh JW. Comparisons of eccentric knee flexor strength and asymmetries across elite, sub-elite and school level cricket players. PeerJ. 2016 Feb 18;4:e1594.
[8] Khasawneh RR, Allouh MZ, Abu-El-Rub E. Measurement of the quadriceps (Q) angle with respect to various body parameters in young Arab population. PloS one. 2019 Jun 13;14(6):e0218387.
[9] Denızoglu Kulli H, Yeldan I, Yildirim NU. Influence of quadriceps angle on static and dynamic balance in young adults. Journal of back and musculoskeletal rehabilitation. 2019 Jan 1;32(6):857-62.
[10] Helewa A, Goldsmith CH, Smythe HA. The modified sphygmomanometer—an instrument to measure muscle strength: a validation study. Journal of Chronic diseases. 1981 Jan 1;34(7):353-61.
[11] Bennell K, Talbot R, Wajswelner H, Techovanich W, Kelly D, Hall AJ. Intra-rater and inter-rater reliability of a weight-bearing lunge measure of ankle dorsiflexion. Australian Journal of physiotherapy. 1998 Jan 1;44(3):175-80.
[12] Forrest MR, Hebert JJ, Scott BR, Brini S, Dempsey AR. Risk factors for non-contact injury in adolescent cricket pace bowlers: a systematic review. Sports medicine. 2017 Dec;47(12):2603-19.
[13] Bayne, Helen, et al. "Lumbar load in adolescent fast bowlers: a prospective injury study." *Journal of Science and Medicine in Sport* 19.2 (2016): 117-122.
[14] Souza TR, Pinto RZ, Trede RG, Kirkwood RN, Pertence AE, Fonseca ST. Late rearfoot eversion and lower-limb internal rotation caused by changes in the interaction between forefoot and support surface. Journal of the American Podiatric Medical Association. 2009 Nov;99(6):503-11.
[15] Sanchez HM, Sanchez EG, Baraúna MA, Canto RS. Evaluation of Q angle in differents static postures. Acta ortopedica brasileira. 2014 Nov;22:325-9.
[16] Ferdinands RE, Kersting U, Marshall RN. Three-dimensional lumbar segment kinetics of fast bowling in cricket. Journal of biomechanics. 2009 Aug 7;42(11):1616-21.