

# Quantitative Ultrasound Densitometry in University Level Cricket Fast Bowlers and Nonathletes

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## ABSTRACT

**Background:** Fast bowling in cricket is an important skill that imparts mechanical loads on limbs. The differential loading patterns involved in bowling affect the peripheral limb bone status.

**Objective:** To evaluate bone properties using quantitative ultrasound densitometry (QUS), among fast cricket bowlers in comparison with nonathletes. A secondary objective was designed to find correlation between QUS parameters and bone-specific physical activity questionnaire (BPAQ).

**Methodology:** A total of 80 subject, 40 fast cricket bowlers of both gender (20 male and 20 female) and 40 nonathletes (20 male and 20 female) were included in our study and all are aged between 20 and 25 years. Bone speed of sound (SOS) was measured bilaterally at the distal radius and the mid tibia using Sunlight Omnisense™ device.

**Results:** There was a significant difference between dominant side and nondominant side radial SOS ( $p < 0.05$ ) and tibial SOS ( $p < 0.05$ ) in cricket bowlers favoring dominant radial bone SOS and nondominant tibial bone SOS which was not found in nonathletes. Significant difference in dominant radial bone SOS values ( $p < 0.05$ ) and nondominant tibial bone SOS ( $p < 0.05$ ) values existed between cricket bowlers and controls. Positive correlation was found between tibial SOS and past BPAQ in all subjects.

**Conclusion:** QUS parameters were significantly higher in young cricket bowlers with greater values observed in the dominant arm and leading foot, thus reflecting the osteogenic effect that occurs due to the nature of the game. Further BPAQ is significantly correlated with lower limb bone properties as measured by QUS at mid shaft tibia.

**Keywords:** Ultrasound densitometry, Cricketers, Speed of sound, Bone-specific physical activity questionnaire, Radius, Tibia.

**How to cite this article:** Shenoy S, Parthasarathy S, Sandhu JS. Quantitative Ultrasound Densitometry in University Level Cricket Fast Bowlers and Nonathletes. *J Postgrad Med Edu Res* 2013;47(2):83-89.

**Source of support:** Nil

**Conflict of interest:** None declared

## INTRODUCTION

Bone status is influenced by variety of genetic and environmental factors. Exercise is an important dynamic factor that imparts mechanical loading on a living bone tissue. Mechanical loading is an essential component for maintenance of normal bone mineral density (BMD) and bone mineral content (BMC).<sup>1-3</sup> Weight-bearing activities induce mechanical loading and influences development and

maintenance of positive bone health at all ages.<sup>1-3</sup> Bone is subjected to different type of mechanical loading due to differential functional forces involved in different games. Further, it is also known that bone responds differently under constant loading, such as in marathon and weight lifting than under short-term maximum strain as in sprinting and gymnastics.<sup>4</sup>

Frost's (1987) Mechanostat theory states that bone strength and mass normally adapts to the largest voluntary loads on bone<sup>2,5</sup> and thus the largest physiological loading system on bone is muscle.<sup>6</sup> Muscular mass together with the maximum of muscular strength generated per unit of time leads to corresponding elastic deformations of bone tissues and thus results in modeling process in order to maintain bone mass.<sup>4</sup> Bone and muscular system act as one unit<sup>6</sup> and muscle power is a deciding factor for bone strength. Further it is assumed that athletes who apply one-sided loading to the musculature must have different BMD in the corresponding bone sections.<sup>4</sup> Physical exercise can change the properties (structure and/or density) of weight-bearing bone and this can be detected by measuring ultrasound velocity.<sup>7-9</sup> The knowledge that physical activity can influence bone properties has lead to the development of a bone-specific physical activity questionnaire (BPAQ) by Weeks and Beek (2008),<sup>10</sup> which the authors tested with BMD values obtained by dual energy X-ray absorptiometry (DXA) and calcaneal broadband ultrasound attenuation and reported that the BPAQ had the sensitivity to predict indices of bone strength at skeletal sites of osteoporotic fracture while other physical activity measurement tools did not. Physical activity questionnaires to predict bone statuses have not been the subject of vigorous investigation and we believe it may be of importance as a quick tool for the same.

Quantitative ultrasound densitometry (QUS) is a reliable and efficient way to demonstrate bone properties without exposure to radiations. Higher bone properties have been reported through ultrasound parameters in weight-bearing exercise, such as dancing and soccer<sup>8</sup> and in nonweight-bearing exercise like swimming<sup>11</sup> as compared to healthy nonathletes. QUS has been used in studies of athletes engaged in different sports activities. T and Z scores based on speed of sound (SOS) as reflected in ultrasound densitometry are highly correlated to DXA scores,<sup>12,13</sup> the gold standard for studying bone density and is recommended as the choice for primary screening in field studies.<sup>14</sup>

Cricket a highly popular game in the commonwealth countries that demands differential loading to the playing arm and leading foot. Cricket bowling is a skill which most likely causes impact and high weight-bearing loads on lower limb. The loading occurs during the landing phase of lead foot over the bowling crease and impact force is greater in fast bowlers than spinners. A university level professional cricket fast bowler might play two or three matches per week and a single match may involve 45 to 70 bowling spells. Also during a practice session, cricket bowlers may perform bowling for a higher number of bowls. Each cricket player goes through a session of high catches and short distance catches with a leather ball weighing 160 gm impacting at different speeds predominantly into the playing hand, to catch the ball causing an unequal distribution of force on the dominant and nondominant limbs. This study was devised with the primary objective of studying how the unique forces generated while bowling could influence bone properties as detected by QUS in university level cricket players. A secondary objective was to compare how these properties differed from sedentary age matched controls. Further, we also wished to examine if the BPAQ would be sensitive to reflect the changes in bone properties as examined at peripheral sites as measured by QUS.

## METHODOLOGY

A total of 80 subject participated in our study. Forty fast cricket bowlers of both gender (20 male and 20 female) played cricket in university level and 40 nonathletes (20 male and 20 female) were involved in the study and all are aged between 20 and 25 years. Cricket bowler's average experience for male players was  $11.25 \pm 2.98$  years and for females was  $6.7 \pm 1.8$  years and trained 3 to 7 times a week. Control subjects did not participated in regular physical activity more than 2 times a week (as determined by a questionnaire).

Exclusion criteria were history of eating disorder, metabolic diseases of bone that hamper bone growth, medical disorders known to affect skeletal growth, history of drug treatment regularly known to influence bone (example steroids and thyroid replacement therapy) for 6 months before this study. All subjects were Asian Indians and none were smokers.

Each subject received a detail explanation of the purpose of the study, the method executed, the benefits and the potential risk or discomforts. All the subjects signed a form of informed consent approved by the review board at the Guru Nanak University for participation in the study.

Each subject filled questionnaire regarding their medical history, training history and physical activity and BPAQ. BPAQ has two components, past activity component and

current activity component. The BPAQ is designed to be self-administered to quickly obtain a comprehensive account of lifetime physical activity. Respondents record type, frequency and years of physical activity involvement. Independent sections for past (from 1 year of age) and current (previous 12 months) regular activity facilitate examination of the temporal and age-specific effects of mechanical loading on the skeleton. Basically an effective load rating is assigned to common sports and activities from ground reaction force (GRF) measures of fundamental actions observed in each sport/activity. An algorithm which weights the factors of load intensity, years of participation and frequency of historical and current activity in order to convert the raw BPAQ data into a score that reflects total bone relevant physical activity history. The algorithm used to analyze the current BPAQ (cBPAQ) =  $[R + 0.2R(n-1)] \times a$ , where R = effective load stimulus (available in appendix of the BPAQ), n = frequency of participation (per week), a = average weighting factor (age weightings also given). Past BPAQ (pBPAQ) =  $R \times y \times a$  = effective load stimulus, R = years of participation, a = age weighting factor (also given in BPAQ).

Anthropometric measures such as body weight, body height and length of forearm and tibia were measured. Grip strength for both dominant and nondominant hand was measured using Jamar hand dynamometer.

We used the Sunlight Omnisense™ device (Sunlight medical) to measure bone SOS. The procedure for the measurement followed was as recommended by the manufacturers and is the same as that conducted by Falk et al.<sup>15</sup> It is a noninvasive ultrasound device capable of measuring bone SOS at one or more skeletal sites. This consists of a main unit and hand held probes designed to measure SOS at specific skeletal sites. For a detailed description of the device and technique, see Njeh et al (1999). The probe contains a set of two transmitters and two receivers.<sup>16</sup> Bone SOS values were recorded for both the dominant and nondominant sides at the distal third of radius and midshaft tibia. The dominant limb was determined by asking the subject which hand they preferred for writing and which leg they preferred for kicking. All measurements were performed according to a specific methodology, as follows:

*Distal radius:* A line was marked midway between the olecranon process of the elbow and the extended third phalanx. The probe was placed parallel to the radius on its medial surface and a wide scan from side-to-side was carried out.

*Tibia:* A line was marked midway between the apex of the top of the knee and the sole, while the subject was in a

sitting position. The probe was placed parallel to the bone surface and a wide scan from side-to-side was carried out.

At the start of each day of testing, probe and system were checked by undertaking a system quality verification procedure against a standard acrylic phantom. Results are expressed in m/sec reflecting the upper 95th percentile of the sorted SOS values and same operator performed all measurements in order to minimize operator and technical intervariability.

### STATISTICAL ANALYSIS

SPSS software (version 16.0; SPSS, Inc) was used for statistical analysis. Descriptive statistics were tested for all groups on demographic data, grip strength and physical activity level and years of experience. Group difference in quantitative ultrasound parameter was tested using analysis of variance (ANOVA). Following ANOVA, a post hoc Tukey's HSD (honestly significant difference) test was performed to address the statistically significant differences between variables of all groups. Dominant and nondominant side differences in variables were tested by paired Student t-test. Bivariate correlation analysis between quantitative ultrasound parameters with grip strength, age, body mass index (BMI), physical activity levels and years of experience were tested by Pearson product-moment correlation coefficient test. Data are presented as mean ± standard deviation in the following table. The significant level was set at  $p < 0.05$ .

### RESULTS

The subject characteristic, hand grip strength, physical activity level, experience of players appears in Table 1.

#### Subject Characteristics

There was no significant difference ( $p > 0.05$ ) in age and BMI between the groups. However, the cricket bowlers were taller and heavier than controls without considering gender. There was a significant difference between male and females

of both the group ( $p < 0.05$ ) with no significant difference between same genders.

#### Hand Grip Strength

There was no significant difference in hand grip strength between same genders ( $p > 0.05$ ). The grip strength of male and female cricketers was 5.7 and 12.74% higher than controls but there was no statistical significant difference existed ( $p > 0.05$ ). We also recorded marked difference favoring dominant hand grip strength than contralateral side in all the groups ( $p < 0.05$ ).

#### Physical Activity Levels

Physical activity level was measured using BPAQ. It has two components namely past and current BPAQ algorithm. The estimated past BPAQ algorithm for cricket male, cricket female, nonathlete male and nonathlete female were  $16.54 \pm 8.66$ ,  $14.95 \pm 6.09$ ,  $10.62 \pm 4.1$  and  $9.57 \pm 3.74$  respectively. The estimated current BPAQ algorithm for cricket male, cricket female, nonathlete male and nonathlete female were  $41.14 \pm 15.33$ ,  $49.07 \pm 19.52$ ,  $21.56 \pm 8.79$  and  $21.10 \pm 7.57$  respectively.

QUS values are represented in the Table 2.

#### Differences in Upper Extremity Bone Properties

Comparison of the dominant radial SOS values of cricketers and nonathletes revealed a significant difference in both males ( $p = 0.015$ ) and females ( $p = 0.008$ ) which was not observed in the comparison of the nondominant sides.

There was a significant difference between dominant radial bone SOS and nondominant radial bone SOS, both in male cricketers ( $p = 0.006$ ) and female cricketers ( $p = 0.001$ ). No significant difference were recorded between dominant radial SOS and nondominant radial SOS in control males ( $p = 0.709$ ) and control females ( $p = 0.07$ ).

A percentage difference in the SOS values between the dominant and nondominant sides revealed that the difference was greater for cricket players both males ( $1.482 \pm 2.1$ ) and

**Table 1:** Characteristics of cricket bowlers and nonathletes

Characteristics	Male (n = 20) Cricket bowlers	Male (n = 20) Nonathletes	Female (n = 20) Cricket bowlers	Female (n = 20) Nonathletes
Age (years)	21.7 ± 1.77	22.85 ± 1.9	21.65 ± 1.66	22.2 ± 1.96
Height (cm)	176.2 ± 5.3	174.2 ± 3.31	164.6 ± 7.9	162.9 ± 6.14
Weight (kg)	69.98 ± 8.67	67.82 ± 8.15	58.52 ± 9.23	55.30 ± 8.24
BMI (kg/m <sup>2</sup> )	22.52 ± 2.48	22.88 ± 2.7	21.5 ± 2.37	21.48 ± 3.93
D hand grip strength (kg)	50.80 ± 6.85	48.3 ± 6.5	31.85 ± 4.89	28.25 ± 2.91
ND hand grip strength (kg)	44 ± 6.36	45.8 ± 6	25.30 ± 3.86	25.35 ± 3.5
Past BPAQ component*	16.54 ± 8.66	10.62 ± 4.1	14.95 ± 6.09	9.57 ± 3.74
Current BPAQ component*	41.14 ± 15.33	21.56 ± 8.79	49.07 ± 19.52	21.1 ± 7.57
Experience (years)	11.25 ± 2.9	NA	6.70 ± 1.8	NA

BPAQ: Bone-specific physical activity; BMI: Body mass index; D: Dominant; ND: Nondominant; \*Significant difference from nonathletes of corresponding genders. Values are mean ± SD

females ( $2.65 \pm 1.68$ ) compared to nonathletic males ( $0.1 \pm 1.17$ ) and females ( $1.07 \pm 2.54$ ). Further a comparison of these percentage differences between cricketers and controls was significant for both males ( $p = 0.03$ ) and females ( $p = 0.026$ ). Values are represented in the Table 3.

### Differences in Lower Extremity Bone Properties

Comparison of the dominant tibial SOS values of cricketers and nonathletes revealed a nonsignificant difference in both males ( $p = 0.799$ ) and females ( $p = 0.577$ ). However, a comparison of the nondominant SOS between cricketers and control group subjects revealed that the difference was significant in both males ( $p = 0.005$ ) and females ( $p = 0.003$ ) with greater values being observed in cricketers of both genders.

There was a significant difference between dominant tibial bone SOS and nondominant radial bone SOS, both in male cricketers ( $p = 0.003$ ) and female cricketers ( $p = 0.004$ ). A significant difference were recorded between dominant and nondominant tibial SOS in control males ( $p = 0.041$ ) and but not in control group females ( $p = 0.979$ ).

A percentage difference in the SOS values between the dominant and nondominant sides revealed that the difference was greater for cricket players both males ( $-2.04 \pm 2.68$ ) and females ( $-1.67.65 \pm 2.24$ ) compared to nonathletic males ( $0.53 \pm 1.1$ ) and females ( $0.05 \pm 1.8$ ). Further a comparison of these percentage differences between cricketers and controls was significant for both males ( $p = 0.0001$ ) and females ( $p = 0.016$ ).

### Relationship of Physical Activity and Ultrasound Bone Properties

The correlation between current BPAQ algorithm with that of SOS of radial and tibial bone in both cricketers and controls was nonsignificant. A positive correlation was recorded between past BPAQ algorithm with dominant tibial SOS and nondominant tibial SOS in cricket male ( $r = 0.569$  and  $r = 0.450$ ); cricket female ( $r = 0.579$  and  $r = 0.725$ ); control male ( $r = 0.712$  and  $r = 0.688$ ); and control female ( $r = 0.721$  and  $r = 0.821$ ) correspondingly. The past BPAQ scores were not significantly correlated to dominant and nondominant radial bone SOS in all the groups except for male cricket bowlers where dominant radial bone SOS ( $r = 0.478$ ) and nondominant radial bone SOS ( $r = 0.450$ ) respectively were positively correlated to past physical activity algorithm.

### DISCUSSION

The main purpose of this study was to examine the bone properties of cricket fast bowlers compared to inactive controls. The results of our study support site specific impact adaptation of bone in cricket bowlers. This can be attributed to the differential loading patterns that occur due to the nature of cricket bowling. The SOS as a bone property in cricket players were better than controls, implying that cricket bowling is an active exercise model that imparts positive bone health. The results support the site specific adaptation in the bones of the upper body as well as the lower body where the nondominant tibia has greater SOS

**Table 2:** Speed of sound (meters/sec) at radial and tibial bone in cricket bowlers and nonathletes

Bone site	Males		Sig.	Females		Sig.
	Cricket bowlers	Nonathletes		Cricket bowlers	Nonathletes	
D distal radial SOS*	4,080 ± 106.5	4,002.2 ± 84.2	0.015*	4,076.1 ± 90.97	4,008.2 ± 60.17	0.008*
ND radial SOS	4,019.2 ± 128.59	3,996.3 ± 94.2	0.524	3,967.4 ± 96.08	3,964.4 ± 97.7	0.921
Significance	0.006*	0.709	–	0.0001*	0.07	–
Difference (%)*	1.482 ± 2.1	0.13 ± 1.17	0.03*	2.65 ± 1.68	1.07 ± 2.54	0.026*
D midshaft tibial SOS	3,853.4 ± 152.2	3,863 ± 70.84	0.799	3,866.2 ± 101.54	3,845 ± 134.8	0.577
ND tibial midshaft SOS*	3,929.3 ± 110.02	3,842 ± 68.35	0.005*	3,929.4 ± 71.02	3,845.4 ± 94.78	0.003*
Significance	0.003*	0.041*	–	0.004*	0.979	–
Difference (%)	–2.04 ± 2.68	0.53 ± 1.1	0.0001*	–1.67 ± 2.24	–0.05 ± 1.8	0.016*

D: Dominant; ND: Nondominant; SOS: Speed of Sound; \*Significant difference. Values are mean ± SD

**Table 3:** Correlation between hand grip and SOS in cricket players and nonathletes

		Cricket		Nonathletes	
		DRSOS	NDRSOS	DRSOS	NDRSOS
Males	DHG	0.199	–	0.135	–
	NDHG	–	0.152	–	0.234
Females	DHG	0.039	–	0.4	–
	NDHG	–	0.131	–	0.34

DRSOS: Dominant radial speed of sound; NDRSOS: Non-dominant radial speed of sound; DHG: Dominant hand grip; NDHG: Non-dominant hand grip

values which could be because of the greater forces experience on the nondominant lower limb in bowling as it is the lead foot which takes the impact as the bowler bowls.

Greater osteogenesis in bones of athletes was also demonstrated using both DXA as well as QUS as measurement tools.<sup>12,13</sup> DXA uses a dual energy spectrum from an X-ray source which allows for bone mineral to be assessed independent of soft tissue in homogeneities and the output is in either BMC or BMD. However, in addition to quantitative change, qualitative change, such as porosity and fragility may also influence bone status. Recently, there is an increasing interest in evaluating both bony quality and quantity by US via measuring ultrasonic velocity or attenuation. The elastic waves used in QUS mechanically interact with the bone structure and therefore offer the potential to measure bone characteristics other than just the amount of bone such as tissue material properties or microarchitecture QUS techniques have mainly been used in the context of osteoporosis. Measurements of the SOS and BUA are now established clinical modalities for fracture risk prediction. However, the apparent paradox of QUS approaches is that although these techniques have been studied over 20 years providing the clinicians with a diversity of technical developments and clinically useful parameters<sup>16</sup> the physics underlying the interaction between US and bone structure is still not fully understood.<sup>17</sup> Despite experimental evidence showing that QUS parameters could reflect additional information that is not captured by DXA it has not been possible yet to extract this information due to a lack of a comprehensive and accurate theoretical framework.<sup>17</sup>

A quantitative ultrasound measurement reflects the effect of high impact activities. Many sports impose greater unilateral loads and participation in these sports expected to be associated with increased BMD and bone properties at skeletal sites that experience greater loads.<sup>18-20</sup> Various studies on different athletic groups with weight-bearing exercise and nonweight bearing exercise support site-specific adaptation of bone.<sup>8,19-22</sup> Athletes participating in tennis, squash and base ball have been shown to display greater BMD in the dominant arm,<sup>19-21</sup> results which concur with those of our study where the dominant arm SOS was greater than nondominant arm SOS in fast cricket bowlers ( $p = 0.006$ ).

Side-to-side difference in leg BMD and calcaneal bone properties have been demonstrated by many studies.<sup>18,21</sup> McClanahan et al found side-to-side difference favoring nondominant leg in young male foot ball and tennis players, but no significant difference in athlete involved in baseball, basket ball, golf, soccer, cross country, running, indoor and outdoor track events or volleyball.<sup>21</sup> Oral et al has reported

overall enhanced bone properties of nondominant side leg reflected by ultrasound measurement in foot ball players.<sup>18</sup> Wu et al examined side-to-side differences in BMD at the proximal femur in female gymnasts and found that the left leg for takeoff displayed higher measurements than the right leg for landing.<sup>23</sup> Calbet JAL et al reported 4% higher BMD on landing leg which was nondominant side than dominant side in volley ball players.<sup>3</sup> On examining the bilateral differences in the SOS measurement at the tibiae, we found that the nondominant tibiae of bowlers had higher SOS than dominant tibiae. All our subjects were right-handed bowlers and were right leg dominant. In cricket, fast bowling involves takeoff and landing from the nondominant leg, which was the left leg for our subjects and showed significantly higher bone properties as reflected by SOS compared with dominant leg and also greater than controls nondominant leg SOS. Studies have shown that the action of cricket fast bowling requires the body to absorb a vertical force around 4.1 times the body weights and a horizontal deceleration of around 1.6 time the body weights at front foot impact, which was the nondominant leg for our subjects.<sup>24,25</sup> This impact force may be attributed to the osteogenic effect in lead foot and our study showed a significant difference in SOS favoring lead foot than back foot, thus indicating stronger bone properties of lead foot of an fast cricket bowlers.

We also examined the BPAQ scores for correlation with the radial and tibial SOS values recorded for both athletes and controls. Past literature indicates that the current activity component of BPAQ is a significant predictor of variance in femoral neck BMD, lumbar spine BMD, and whole body BMD in men.<sup>10</sup> However, we found no relation between current BPAQ scores with SOS values of both radial and tibial bone in both athletes and controls. On evaluating the construct of current BPAQ algorithm, it was found to be based on the frequency of participation per week. The equation of current BPAQ did not include normalization to the duration of each activity an athlete was involved. If an athlete plays for 30 minutes then he may not have the same intensity of bone mechanical strain as in an athlete played for 60 minutes for the same game. The results obtained from current BPAQ will cause disparity of scores among athletes involved for same activity. This explains the possible dissociation between SOS values and current BPAQ.

Weeks et al reported that the past activity component of BPAQ predicted calcaneal BUA for women.<sup>10</sup> A positive correlation between past BPAQ scores and tibial bone SOS in both athletes and controls was also observed in this study. The bone-specific physical activity assessment tool was based on effective load stimulus which was derived from the estimated GRF on lower limb for each type of physical

activity or sports.<sup>10</sup> However, they did not estimate reaction forces for upper limb and also did not relate upper limb bone parameters with past or current BPAQ scores. We believe that this could be the possible explanation why the tibial bone SOS parameters were positively related to past BPAQ, though radial bone SOS parameter did not significantly correlate with either past BPAQ or current BPAQ. We suggest that further investigation and upgradation, through addition of reaction forces and estimation for effective load stimulus on the upper limb for the construction of BPAQ tool will better predict upper extremity bone status.

Further, a weak correlation was observed in the past BPAQ scores with the radial bone SOS of male cricket players. The male cricket players had put in on an average 11.25 years of play as compared to female cricketers who had put in only 6.7 years of play. It is possible that a minimum number of years and therefore hours of play or cumulative stress may be necessary for the bone response to occur so that it is reflected in past BPAQ in the upper limb, even though the construct of BPAQ does not include any significant measures of upper limb bone status in sporting activity.

A third parameter we investigated was the influence of muscle strength on bone properties. We had hypothesized that significantly greater hand grip strength would predict better bone properties. We examined the correlation between hand grip strength with SOS and found no significant correlation. The inconsistency in the relation between radial SOS and grip strength may be due to the reason that isometric flexor grip strength as a single factor cannot influence bone status, but combination of extensor, supinator and pronator muscle power may relate to bone status at radius. Longitudinal studies examining the effect of site-specific muscular strengthening exercise on QUS values would be required to establish a relationship between muscle strength and bone properties.

In a study by Nicholson and Alkalay (2004),<sup>26</sup> which investigated the use of quantitative ultrasound at the axial skeleton, BMD and failure load with and without normalization for bone size. Their results confirm the feasibility of vertebral quantitative ultrasound *in vitro* indicating that US did provide information on both BMD and failure load. Further they reported that the paradox of US performance of ultrasonic measurements for failure load was comparable to or greater than that of BMD suggesting that US has the potential to be as useful as BMD in the assessment of vertebral bone. Normalizing US measurements for bone size reduced the strength of correlations because both BMD and bone strength reflect bone size to a certain extent.

## CONCLUSION

QUS parameters were significantly higher in cricket bowler thus, reflecting the osteogenic effect that occurs due to the nature of the game. The past BPAQ scores predict the tibial QUS parameter and thus past level of activity can define present bone status of lower extremities. However, further studies on BPAQ as a tool are required for determination of upper limb bone status. Our findings suggest that playing cricket can improve bone status level in young population and acquiring better bone peak mass, thus prevent osteoporosis in later life.

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