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ORIGINAL ARTICLE

Use of fiber optic goniometer to objectively assess the angle and reflex time of knee jerk in professional rugby players

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ABSTRACT

BACKGROUND: Rugby, being a contact and collision game, results in sudden application of forces on lower limb muscles which may injure them unless an immediate reflex contraction of the muscle occurs. This study aimed to assess the knee jerk reflex parameters of professional rugby players.
METHODS: Knee jerk parameters (latency, peak time, total duration, relaxation time and angle) of rugby players were assessed. The angle was measured by a bipolar joint angle sensor in the fiber optic goniometer. An electronic tendon hammer was used to elicit the knee jerk. These instruments were connected to a data acquisition hardware and data were recorded on LabChart 8 software (AD Instruments, Sydney, Australia).
RESULTS: Mean (SD) of age, height, weight and BMI were 27.4 (3.9) years, 1.72 (0.07) m, 83.4 (14) kg and 27.8 (4.3), respectively (N.=59). There is no correlation between BMI and reflex parameters (P>0.05 for all parameters). Knee jerk parameters from left and right sides did not show a statistically significant difference (P>0.05). Similarly, there was no statistically significant difference between the dominant and non-dominant sides. Individual parameters measured in right side showed a significant correlation (P<0.01) to their counterparts from the left. Latency showed a negative correlation with other parameters from the same leg while other parameters showed a positive correlation between each other.
CONCLUSIONS: A fiber optic electronic goniometer and an electronic tendon hammer along with data acquisition hardware and software can be used to objectively measure knee jerk parameters of rugby players.

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KEY WORDS: Fiber optic technology; Rugby; Athletes.

Rugby is identified as a physically demanding, high-intensity team sport that is played professionally in many countries worldwide.[1] It is regarded as a contact and collision sport, played at amateur, semiprofessional and professional levels. The physical conditioning programs prescribed for rugby players usually consist of aerobic fitness training, resistance training (for strength and power development), speed and agility sessions, along with skill and tactical development sessions. Fitness characteristics are considered important determinants of physical performance in team sports.[2]

Assessment of deep tendon reflexes is considered as part of the examination of the motor system in neurological assessment of patients. Deep tendon reflexes were first described by Wilhelm Heinrich Erb and Carl Friedrich Otto Westphal, more than a century ago.[3] It is also known as stretch reflex or myotatic reflex. It is elicited by tapping a tendon of a muscle with a tendon hammer (knee hammer). This causes brief and sudden stretching of the muscle leading to generation of sensory impulses from the structures known as muscle spindles located within the stretched muscle belly. These sensory impulses result in contraction of the same muscle instantaneously *via* a monosynaptic reflex.[4] The above-described stretch reflex constitutes a protective mechanism to prevent the muscle from being overstretched and being damaged due to external forces.

There are five primary deep tendon reflexes which are being tested commonly: biceps, brachioradialis, triceps, patellar (knee), and ankle. Each reflex evaluates the integrity of the components of the reflex arc linked to it. Patellar reflex or the knee jerk reflex refers to spinal roots L3 and L4 and the muscle involved is the quadriceps femoris. Clinically the knee jerk reflex is performed with the patient sitting and legs hanging free over the edge of the chair or bed. Clinically the deep tendon reflexes are graded from 0 to 4+ (*i.e.* 0 = no response; always abnormal, 1+ = a slight but definitely present response; may or may not be normal, 2+ = a brisk response; normal, 3+ = a very brisk response; may or may not be normal, 4+ = a tap elicits a repeating reflex [clonus]; always abnormal).[5] This grading is a subjective assessment. In the current study we assess the reflex time and magnitude of the knee jerk objectively using a fiber optic goniometer and an electronic knee hammer.

Rugby, being a contact and collision game, results in sudden application of forces on lower limb muscles which may pull them unless an immediate reflex contraction of the muscle occurs. Stretch reflex provides such a reflex mechanism. There have been no studies and literature on knee jerk reflex measurements in rugby players in the world and no literature available in Sri Lankan rugby players.

The aim of this study was to assess the bilateral knee jerk reflex in a group of national level rugby players using a fiber optic goniometer and electronic tendon hammer.

Knee jerk parameters measured on right leg or dominant leg will not show any significant difference to those obtained from left leg or non-dominant leg, respectively.

Materials and methods

Study design

The study design was a cross sectional analytical study in which a set of knee jerk parameters were assessed at baseline level.

Subjects

Fifty-nine rugby players were selected randomly from national level rugby players for the study. Reflex measurements were taken during the off-season strength and performance assessment of the players. Players with injuries were not included in the study. All participants signed an informed consent document. This study was approved by the Ethics Review Committee of the Faculty of Medicine, University of Ruhuna, Sri Lanka (2018/P/071) and the Sri Lanka Clinical Trials Registry (SLCTR/2019/036).

Knee jerk reflex measurements

An ordinary tendon hammer coupled with clinical judgement was used to assess tendon reflexes as the index test in literature, but a fiber optic goniometer was used as the reference standard in this study. In the current study, the knee jerk reflex parameters were assessed objectively using a fiber optic goniometer while no subjective clinical assessment was done.

In this study, knee jerk reflex time and the angle of movement were measured using a fiber optic goniometer (MLTS700, AD Instruments, Sydney, Australia) (Figure 1A). This is a bipolar joint angle sensor for single degree of freedom joints such as the knee or elbow, which is suitable for use in humans. The angle was determined by the amount of light passing through a pair of optic fibers running along the cantilever, and a light sensor was contained in one of the enclosures.

An electronic tendon hammer was used to bring about the knee jerk reflex (MLA93/D, AD Instruments) (Figure 1B). A piezo-electric sensor within the head, provides a momentary pulse

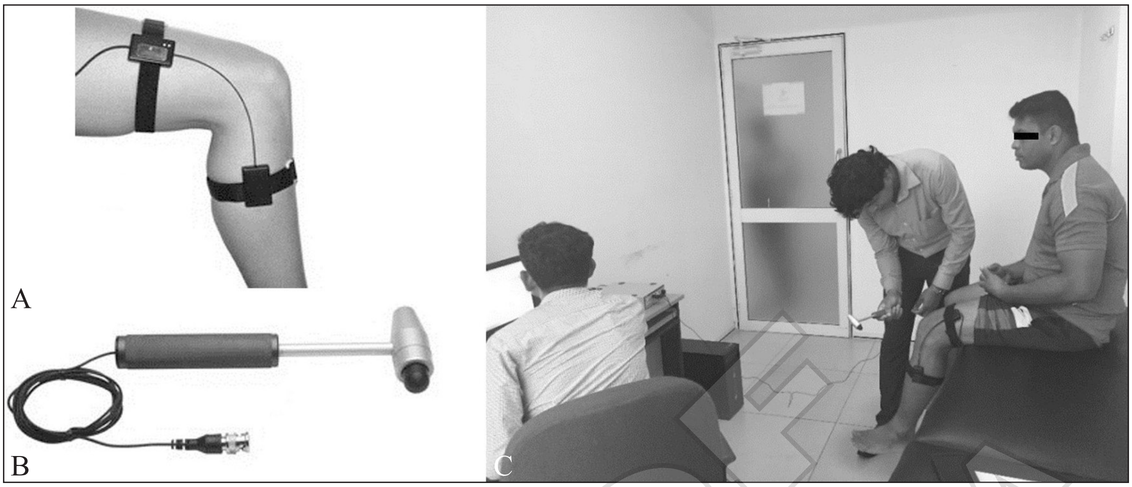

Figure 1.—A) Fiber optic goniometer; B) electronic tendon hammer; and C) the procedure of collecting data using the equipment.

when a surface is struck with the hammer which triggers the recording.

These two instruments were connected to a data acquisition hardware (Power Lab 26T, AD Instruments) to acquire data. Acquired data were recorded on LabChart 8 software (AD Instruments) running on a computer connected to the Power Lab 26T Data Acquisition Hardware.

Procedures

All the knee jerk measurements of rugby players were taken by the same person (Figure 1C) and the room temperature was set at 25 °C. Patellar tendon was struck with the electronic knee hammer at an angle of 90°. Latency period, time taken to reach the peak angle (peak time), total duration, relaxation time and the angle of movement of the knee jerk were measured in both lower limbs in all the participants. Five good recordings were obtained from each leg. Average value from the five readings were taken for statistical analysis. Data were recorded using LabChart 8 (AD Instruments) software as stated above. Signal from the electronic knee hammer was recorded on the channel 1 (top channel in the Figure 2) and the reflex movement of the knee was recorded in the channel 2 (lower channel in the Figure 2).

Statistical analysis

Group data on the same parameter from two legs were compared using paired *t*-test (when normal-

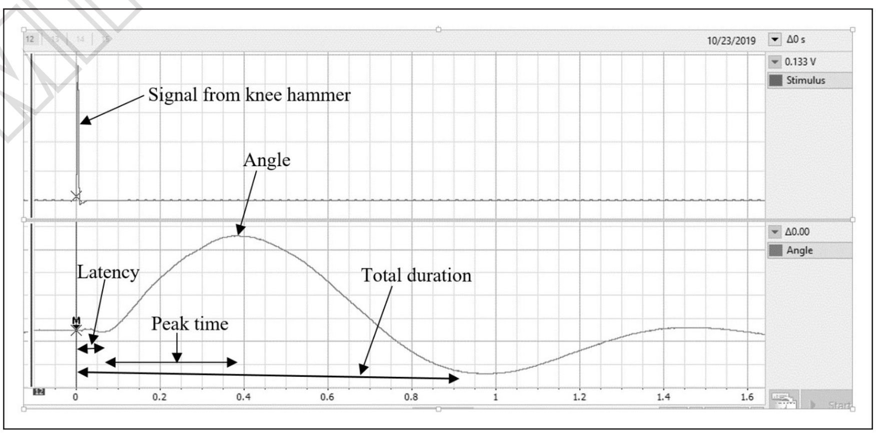

Figure 2.—Knee jerk measurements graph taken using the LabChart software (AD Instruments, Sydney, Australia).

ity test passed) or Wilcoxon Signed Rank Test (when normality test failed). Pearson correlation was used to measure the correlations between parameters. Statistical software SigmaStat (version 4; Systat Software, San Jose, CA, USA) was used to perform statistical analysis. P<0.05 was considered statistically significant.

Results

Fifty-nine professional rugby players were assessed. Mean (SD) of their age, height, weight and the Body Mass Index (BMI) were 27.4 (3.9) years, 1.72 (0.07) m, 83.4 (14) kg and 27.8 (4.3) kg/m^2, respectively. The study revealed that there is no correlation between the BMI and lower limb knee jerk reflex parameters of the players (P>0.05 for all parameters, Pearson correlation). All knee jerk parameters were obtained in both left and right sides. Comparison of parameters from left and right sides showed that there is no statistically significant difference of values from two sides (paired *t*-test or Wilcoxon signed rank test depending on whether the normality test is passed or not, respectively) (Table I).

There is a highly significant correlation of individual parameters from left side and right side when assessed using Pearson correlation (Table II).

Table III shows the correlation of parameters from the left side with the other parameters from the same side (Pearson correlation). It was noted that latency of the left side shows a statistically significant negative correlation with the angle of movement of the left knee (P<0.01). Left side peak time showed a significant positive correlation with left side total time (P<0.01) and left side angle of movement (P<0.05). Similarly, left side total time showed a significant positive correlation with left side relaxation time and left side angle of movement (P<0.01 in both instances). Left side relaxation time also showed a significant correlation with left side angle of movement (P<0.01).

As opposed to the left side, all the parameters showed a highly significant correlation between each other on the right side. Similar to left side, latency of the right side showed a negative correlation with all other parameters, but unlike on the left side, all of them showed a statistical significance (Table III).

Dominant side *vs.* non-dominant side data analysis

Eight rugby players were left side dominant and fifty-one were right side dominant. Data from right legs of 51 right side dominant player and data from left legs from eight left side dominant players were pooled together for this analysis (dominant side). Similarly, data from the left legs of 51 right side dominant players and data from right legs of eight left side dominant players were pooled together (non-dominant side). These two sets of pooled data were tested for significance with paired *t*-test or Wilcoxon Signed Rank

TABLE I.—*Comparison of left and right knee jerk variables (N.=59).*

Variable	Left knee jerk	Right knee jerk	Statistical significance	
Peak time (s) (mean [SD])	0.309 (0.0203)	0.30 (0.0298)	P=0.358	Paired *t*-test
Total duration (s) (mean [SD])	0.601 (0.0593)	0.612 (0.0847)	P=0.214	
Angle (°) (mean [SD])	10.408 (4.582)	10.221 (5.251)	P=0.701	
Latency (s) (median)	0.086	0.084	P=0.434	Wilcoxon Signed Rank Test
Relaxation time (s) (median)	0.283	0.290	P=0.096	

Note that none of the individual parameters from two sides show a statistically significant difference (P>0.05).

TABLE II.—*Correlation between individual parameters between left leg and right leg (N.=59).*

Variables	Correlation coefficient	Statistical significance
Left and right latencies	0.373	P=0.00366*
Left and right peak time	0.481	P=0.000117*
Left and right total duration	0.595	P=0.000000*
Left and right relaxation time	0.594	P=0.000000*
Left and right knee jerk angle	0.719	P=0.000000*

Note that all the individual parameters show a statistically significant positive correlation between two sides (Pearson correlation, *P<0.01).

TABLE III.—*Correlation between knee jerk parameters (N.=59).*

Side of the knee jerk	Parameters tested	Correlation coefficient	Statistical significance
Left side	Latency and peak time	-0.0264	P=0.843
	Latency and total duration	-0.114	P=0.39
	Latency and relaxation time	-0.119	P=0.369
	Latency and angle of movement	-0.438	P=0.000514**
	Peak time and total duration	0.494	P=0.0000691**
	Peak time and relaxation time	0.172	P=0.193
	Peak time and angle of movement	0.298	P=0.0220*
	Total duration and relaxation time	0.941	P=1.5×10^{-28}**
	Total duration and angle	0.399	P=0.00175**
	Relaxation time and angle	0.336	P=0.00918**
Right side	Latency and peak time	-0.514	P=0.0000306**
	Latency and total duration	-0.484	P=0.000103**
	Latency and relaxation time	-0.385	P=0.00260**
	Latency and angle of movement	-0.595	P=0.000000660**
	Peak time and total duration	0.718	P=0.000000000**
	Peak time and relaxation time	0.465	P=0.000204**
	Peak time and angle of movement	0.468	P=0.000183**
	Total duration and relaxation time	0.950	P=1.535×10^{-30}**
	Total duration and angle	0.447	P=0.000338**
	Relaxation time and angle	0.359	P=0.00529**

Pearson correlation *P<0.05; **P<0.01.

TABLE IV.—*Comparison of data from the dominant side and non-dominant side (N.=59).*

Variable, N.=59	Non-dominant side knee jerk	Dominant side knee jerk	Statistical significance	
Peak time (s) (mean [SD])	0.308 (0.0214)	0.307 (0.0292)	P=0.591	Paired *t*-test
Total duration (s) (mean [SD])	0.602 (0.0681)	0.611 (0.0780)	P=0.332	
Angle (°) (mean [SD])	10.423 (4.900)	10.206 (4.955)	P=0.658	
Latency (s) (median)	0.0852	0.084	P=0.336	Wilcoxon Signed Rank Test
Relaxation time (median)	0.280	0.292	P=0.121	

Note that there is no statistically significant difference with any of the parameters as P>0.05 for all of them.

Test depending on whether the normality test is passed or not, respectively. Knee jerk parameters between dominant side and non-dominant side showed no significant difference (Table IV).

Discussion

Why this study is important?

This is the first study to analyze all the knee jerk variables (latency, peak time, total duration and angle) in professional rugby players in the world. The findings have important implications for researchers and practitioners interested in improving the performance and safety of rugby players.

Effect of BMI on reflex parameters

There are no studies in the literature which examined the effect of BMI on knee jerk reflex time and magnitude in rugby players. Body composition (anthropometry) plays an important role in the performances of rugby players and determination of the playing position.[6, 7] Unlike other team sports, rugby players have always shown greater body mass and higher fat percentage.[1] As the players mature with age and training their strength has increased relative to body mass.[8] This study evidently shows that there is no correlation between BMI and knee jerk reflex measurements.

Knee jerk reflex analysis

Left side and right-side knee-jerk measurements were compared in this study and the results revealed that there is no significant difference in all the knee jerk parameters in left and right sides of the rugby players. Furthermore, there is no difference in values obtained from the dominant leg and non-dominant leg. It indicates that there is similar behavior of knee jerk measurements in both lower limbs in professional rugby players.

In both lower limbs, latency period showed a negative correlation with all other parameters measured in the same limb. This negative correlation of latency showed a statistical significance with all the parameters of the right side whereas only the angle of movement showed a significant negative correlation in the left side. Latency period in the present study was comparable with the findings of one group of researchers who assessed latency period with different angle of application of tendon hammer on the patellar tendon. We applied the patellar hammer at an angle of 90°. In both lower limbs, angle of movement showed a significant positive correlation with the peak time, relaxation time and total duration of the knee jerk. This can probably be explained by the fact that when the angle of movement is bigger, it takes longer time to reach the peak and also to come back to baseline as the range of motion is bigger.

To date no study has examined the knee jerk reflex objectively in rugby players. No standard reference tool is found in literature related to assessment of knee jerk in rugby players.

Conclusions

The present study was aimed to find the behavior of knee jerk reflex parameters in male rugby players. This cross-sectional analytical study revealed that the peak time, latency period, total duration and the maximum angle of the knee jerk has no correlation with BMI. This study did not show any significant difference of knee jerk measurements in left and right sides of the rugby players. There was no significant difference in dominant side compared to the non-dominant side in professional rugby players. A fiber optic electronic goniometer and an electronic tendon hammer along with data acquisition hardware and software can be used to objectively measure knee jerk parameters of rugby players.

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Conflicts of interest.—The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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