Investigating Lumbar and Thoracic Differences between Different Spinal Marker Sets in Cricket

Samuel R. Inchley[1], Sam Allen[1], Peter Alway[1,2], Mark King[1]
[1]Loughborough University, Loughborough, Leicestershire, United Kingdom
[2]Department of Science and Medicine, England and Wales Cricket Board, Loughborough, United Kingdom
Email: S.R.Inchley@lboro.ac.uk

Summary

This abstract indicates the need for a more complex spinal marker set to collect biomechanical cricket data, particularly in the thoracic spine. Previously used marker sets are not representative of spinal curvature, especially in maximum range-of-motion movements. This study aims to evaluate a three and four-segment marker set against a 12-segment set.

Introduction

Kinematic data collected via optoelectronic motion capture can inform a variety of assumptions that are useful for the assessment of cricketing injury risk. The evaluation of spinal movement is key for diagnosing potentially injurious techniques. Previously, cricket data has used three [1] and four [2] segment marker sets to explore the association between technique and injury in fast bowlers. While these sets provide an overview of full spine movements, they do not provide detailed insights into the joint angles at each vertebra and spinal curvature, meaning these are estimated. The IfB (Institute for Biomechanics, Zurich) marker set uses 12 segments, reducing the distance between markers and, therefore, providing more specific insight into lumbar and thoracic movement [3]. This study aims to investigate the errors in spine position prediction when marker sets are simplified.

Methods

Five elite academy fast bowlers (mean ± SD age 16.8 ± 0.4) participated in the study. Retroreflective markers were affixed to the spinous process of C7, T3, T5, T7, T9 and T10 and all lumbar vertebrae [1,2,3]. Markers were also placed on the posterior superiliac spines and were used to define the sacrum. Data was collected from static T-Pose (AP) and spinal flexion (F), extension (E), lateral flexion (LF) and rotation (AR) trials, recorded using 18 motion analysis cameras (250Hz). Data were analysed in Vicon Nexus 2.16 and MATLAB 2024b to compare average RMS displacement across thoracic and lumbar regions between marker sets using 3D cubic interpolating splines. These values were compared using a repeated-measures ANOVA with a Bonferroni post-hoc test. Greenhouse-Geisser corrected p-values were used following Mauchley's test for sphericity.

Results and Discussion

RMS differences across the whole spine show that the 4-segment marker set deviates less than the 3-segment from the estimated curvature (Figure 1, Table 1). Both splines are different ($p<0.05$) from the spline created by the IfB marker set during the thoracic region. However, in the lumbar spine, the 4-segment marker set is more similar to the 12-segment spline, as shown by the RMSd values of less than 2 mm (Table 1, $p > 0.05$). The largest differences between splines were for extension of the lumbar spine, and in maximum axial rotation for the thoracic spine. The 3 and 4-segment splines are not different in lumbar F ($p = 0.06$), thoracic AP ($p = 0.357$), LF ($p = 0.354$, $p = 0.577$) and AR ($p = 0.581$, $p > 0.999$). Maximum displacement in different positions indicates that both 3 and 4-segment spinal marker set splines vary from the IfB spline by similar maximum levels, likely due to the lack of markers in the thoracic region. The largest deviations (43 mm) occurred in this region during axial rotation.

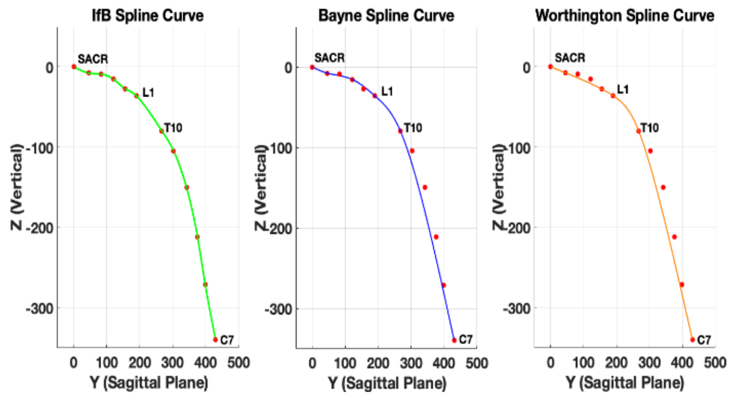

Figure 1: Visualisation of the spine using the created splines at flexion compared to the spine marker positions.

Table 1: Average RMS displacement of the 3-segment (3) and 4-segment (4) splines from the IfB marker set spline in different poses in the lumbar (L) and thoracic (T) spines.

position	3L (mm)	4L (mm)	3T (mm)	4T (mm)
AP	7.7 ± 1.2	1.4 ± 0.3	18.4 ± 4.0	18.9 ± 3.7
LF (R)	7.7 ± 1.8	1.6 ± 0.4	25.9 ± 7.1	22.9 ± 5.0
LF (L)	7.2 ± 1.5	1.7 ± 0.4	21.0 ± 5.8	20.9 ± 5.8
F	3.1 ± 1.0	1.7 ± 0.3	18.3 ± 4.4	17.2 ± 4.6
E	9.3 ± 1.4	1.4 ± 0.6	12.0 ± 5.3	13.2 ± 5.4
AR (R)	7.9 ± 1.3	1.4 ± 0.3	28.0 ± 2.1	27.8 ± 1.9
AR (L)	7.9 ± 0.7	1.6 ± 0.3	30.4 ± 8.1	27.5 ± 3.7

Conclusions

A more complex marker set is required to better understand spinal movements during cricket fast bowling, particularly in the thoracic spine. The greatest deviations occurred during extension movements in the lumbar spine and maximal axial rotation in the thoracic region.

References

[1] Worthington et al. (2013). *J. Appl. Biomech*, **29**: 78-84.
[2] Bayne et al. (2013) *J. Appl. Biomech*, **29**: 354-359.
[3] List (2013). *J. Strength Cond. Res.*, **27(6)**: 1529-1538.