Normal goniometric values to guide decision-making in lower-extremity rotational problems using Support Vector Machine techniques

J.M. Bru-Juanes[1], J.M. Bru-Lázaro[1], M. Herrera[2], J. Izquierdo[2]
[1]Centro de Podología y Posturología, Valencia
[2]Fluing-Instituto de Matemática Multidisciplinar, Universitat Politècnica de València
jbruj@estudiodelapisada.com, mahefe@upv.es, jizquier@upv.es

Abstract

Torsional analysis of the lower extremities has become an integral part of the decision-making process in treatment neuromuscular problems. Various studies have suggested that, aside from functional limitations and cosmetic concerns, abnormal gait or torsional malalignments may be risk factors for degenerative pathological effects on joints of the lower extremities [1,2]. Although there is a large amount of data on assessment methods and treatments for a variety of deformities, rotational problems in the transverse plane have been neglected due to the difficulty of assessment. Solid knowledge of normal development of torsional relationships is essential for treating musculoskeletal problems. As a prerequisite, a normal reference, that is to say, an objective and quantitative standard of measurement must be available for comparison prior to making a suitable decision.

In the nineteen eighties, Staheli [3,4] provided a great deal of information on normal ranges of lower limb rotation. Since then, a reduced number of studies using various classical statistical techniques and reduced amounts of data have contributed to the subject [5-9]. The aim of this paper is to update normality goniometric values that could be used as a reference for clinical analysis and to discover unknown compensating mechanisms between the involved segments. To this purpose we use a data base made out of one thousand and five hundred measurements of different parameters undergone by the same clinician (the first author) during the last fifteen years involving individuals of various characteristics. Data were obtained by following the Stanley Hoppenfeld protocol to measure both internal and external femoral and tibial rotations.

Currently, a number of approaches based on Intelligent Data Analysis and Machine Learning techniques have blossomed, which have shown to be more efficient than classical statistical techniques for a number of problems involving certain types of data. In this paper, we focus on a non-parametric clustering methodology based on support vectors (SVC). The proposed algorithm is able to deal with noise and outliers. Precisely, these last may provide richer information to the study.

Support vector machine (SVM) is a popular pattern classification method with many application areas. SVM shows its outstanding performance in high-dimensional data classification. SVM was first proposed by Vapnik [10] and has recently been applied in a range of problems including pattern recognition, bioinformatics and clustering, among others. The process of clustering is based on kernel methods that avoid explicit calculations in the abovementioned high-dimensional feature space, making clustering more efficient. In addition, our proposal has the computational advantage of relying on the SVM quadratic optimization that is able to reach global solutions.

To the best of our knowledge there is no study regarding the medical subject this paper addresses using SVM and, at the same time, using a database of such systematic and coherent amount of data, and measuring all the levels of the lower extremity. This makes it possible to develop a method for enhancing the applicability of our results. It is based on a process of support vector data description (SVDD) for each cluster, what allows achieving our outlined targets. The final accuracy of our proposed method outperforms traditional statistical methods and may be supplementary for other, such as computerized tomography.

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