Time Estimation of Return to Sports Based on Classification of Health Levels of Anterior Cruciate Ligament Using a Convolutional Neural Network after Reconstruction Surgery

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Abstract : Background and Objective: Sports-related rupture of the anterior cruciate ligament (ACL) and following injuries have been associated with various disorders, such as long-lasting changes in muscle activation patterns in athletes, which might last after ACL reconstruction (ACLR). The rupture of the ACL might result in abnormal patterns of movement execution, extending the treatment period and delaying athletes' return to sports (RTS). As ACL injury is especially prevalent among athletes, the lengthy treatment process and athletes' absence from sports are of great concern to athletes and coaches. Thus, estimating safe time of RTS is of crucial importance. Therefore, using a deep neural network (DNN) to classify the health levels of ACL in injured athletes, this study aimed to estimate the safe time for athletes to return to competitions. Methods: Ten athletes with ACLR and fourteen healthy controls participated in this study. Three health levels of ACL were defined: healthy, six-month post-ACLR surgery and nine-month post-ACLR surgery. Athletes with ACLR were tested six and nine months after the ACLR surgery. During the course of this study, surface electromyography (sEMG) signals were recorded from five knee muscles, namely Rectus Femoris (RF), Vastus Lateralis (VL), Vastus Medialis (VM), Biceps Femoris (BF), Semitendinosus (ST), during single-leg drop landing (SLDL) and forward hopping (SLFH) tasks. The Pseudo-Wigner-Ville distribution (PWVD) was used to produce three-dimensional (3-D) images of the energy distribution patterns of sEMG signals. Then, these 3-D images were converted to two-dimensional (2-D) images implementing the heat mapping technique, which were then fed to a deep convolutional neural network (DCNN). Results: In this study, we estimated the safe time of RTS by designing a DCNN classifier with an accuracy of 90 %, which could classify ACL into three health levels. Discussion: The findings of this study demonstrate the potential of the DCNN classification technique using sEMG signals in estimating RTS time, which will assist in evaluating the recovery process of ACLR in athletes.

Keywords : anterior cruciate ligament reconstruction, return to sports, surface electromyography, deep convolutional neural network

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