Dynamic Off-Loading Knee Brace - A Novel Robotics Approach to Sports Rehabilitation

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Abstract

Those individuals participating in sports involving landing and cutting have a 2-3.5% risk of injuring the Anterior Cruciate ligament (ACL), which equates to 1 in 29 females and 1 in every 50 males actively and regularly participating in these sports. This injury is devasting requiring prolonged rehabilitation following surgery [1-4], with high reinjury rates [5, 6], failure to return to preinjury activity [7] and development of osteoarthritis [8]. In the general population estimated lifetime risk of knee osteoarthritis is 13.8%, ranging from 9.6% for non-obese males to 23.9% in obese females, with around 654 (95% CI, 565·–745) million individuals (40 years and older) having knee OA in 2020 worldwide. Patients with knee osteoarthritis suffer from joints which cannot tolerate loading, and since they can no longer load the joint, muscle atrophy and weakness ensue which then perpetuates the vicious cycle of making the joint even less able to tolerate load. Similarly, ACL injured individuals early in the period post injury or surgery also cannot tolerate high levels of loading through the knee joint because of the trauma created by the injury and surgery, and the potential trauma to the surgically reconstructed ligament [9]. Thus, a large group of patients exist who present themselves with load intolerant knee joints, who struggle to reload those joints to regain function of the joint and holistically.

Traditionally, these patients have undergone exercise rehabilitation programmes with varying degrees of success, to develop strength in the muscles and improve overall function [10, 11]. Two of the main barriers to succeeding with a purely exercise based approach are i) high levels of fear of movement (kinesiophobia) found, and ii) low starting point (poor baseline fitness) which requires considerable effort to be raised to levels allowing even for decent everyday function. These patients need to expose their joints to progressively increasing loads to build tolerance and exercise has successfully done this, however inconsistently. A potential solution would be to provide these patients with a means to initially off-load their joints, to allow recovery, followed by increased activity in the form of a system which adds progressively higher loads to the joints in order to build the tolerance to these loading activities. The aim of our work is to develop a knee brace with the ability to unload the patient's joint to the point where the physical fitness baseline activity can be raised in order to improve function. However, this would only improve the situation so far, as the joint is likely to rely to a greater or lesser extent on that support, so a strategy is required to return the joint to more normal levels of load, which could again be provided by a brace if that brace, as well as unloading the joint, could be adjusted to progressively add more load to the joint. Thus, the proposal is to develop a knee brace which can apply variable levels of off-loading capability to the knee joint, initially starting at a level to alleviate symptoms whilst maintaining or improving function, followed by progressing to less off-loading to the joint, so increased tolerance to load can be developed.

References

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