EFFECT OF PERTURBATION TRAINING ON FUNCTION AND GROUND REACTION FORCE IN ACL DEFICIENT PATIENTS DURING STEP UP AND DOWN

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ABSTRACT

Anterior cruciate ligament (ACL) defect (ACLD) is a very common injury. Following ACL injury, the neuromuscular system's function is weakened. Perturbation training is shown to be very effective for ACLD patients' function. The present paper reports on a randomized control trial examining the effect of perturbation training on ground reaction force (GRF) in ACLD patients. Ten ACLD patients participated in a ten-session perturbation training program. The vertical vector of GRF was registered using a force plate while the patient walked on two steps (h: 20 cm, w: 30cm). A cross hop test and a subjective IKDC questionnaire were used to measure patients' function. The control group included ten normal individuals. The post-treatment IKDS scores and functional test results significantly increased in the experimental group (p < .005). The pre-treatment maximum force of the involved leg at step down, which was lower than that of the uninvolved leg and that of the control group, significantly increased after the training program (p < .005) though remaining still lower than that of the uninvolved leg and that of the control group. The time to peak in the uninvolved and involved leg at step down significantly decreased at post-treatment measurement (p < .04). In ACLD patients, the GRF in uninvolved leg was shown to be lower than that of the uninvolved leg and that of the control group. The results of the present study show that not only does perturbation training improve ACLD patients' function but it also approximates the GRF to its normal state.

Keywords: ACL Tear, Ground Reaction Force, Perturbation Training

INTRODUCTION

The knee joint is designed in a way to generate optimal stability and movement (Darlene et al., 2006; Hurd and Snyder-Mackler, 2007). The elements involved in the stability of the knee joint may be classified into static and dynamic categories. The static elements include ligaments, meniscus, joint capsule etc. The dynamic elements mainly include the nerves and muscles (Darlene et al., 2006). In combination, the static and dynamic elements interact to generate a dynamic stability in the knee joint. Naturally, any defect in either of these elements would threaten the dynamic stability of the knee joint (Hurd and Snyder-Mackler, 2007; Williams et al., 2001). Published figures show a high rate of injury incurred in the anterior cruciate ligament (ACL) (Lawrence and Anthony, 2004). ACL has both mechanical and sensory functions in maintaining the knee stability (Carol, 2003; Scott et al., 2002). A rupture in the ACL may lead to sensory-corporeal and muscular activity pattern changes, a decrease in power and stability and other functional and biomechanical changes. These changes are mainly due to loss of the sensory function in the ACL (Christopher et al., 2008). If one could improve the neuromuscular function in ACL, the lost sensory function of the ACL would be relatively set off. Various methods have been recommended to enhance the neuromuscular functioning, including stability and power exercises, stabilometry, playometric exercises and perturbation training (Von Porat et al., 2007; Naserpur, 2008). Perturbation training, first proposed by Fitzgerald in 2000 (Fitzgerald et al., 2000), is designed to improve the feed forward mechanism through feedback mechanisms (Fitzgerald et al., 2000; Ann Shumway-Cook, 2007).
Studies show that normal individuals need lower extremities control while climbing down the steps but they mainly apply the lower extremities power for climbing up the stairs (Gretchen et al., 2001; Anastasia et al., 2007). Previous studies established that perturbation training improved ACLD patients' functioning (Fitzgerald et al., 2000; Naserpur, 2008; Abasi, 2008; Chemielewski et al., 2005; Motamedvaziri, 2003). The present study aims to find what corresponding changes occur in GRF function once improvement is gained in the ACLD. In ACLD patients, this function is a critical activity (control-wise) (Gretchen et al., 2001; Anastasia et al., 2007). No previous studies attempted to examine the effect of neuromuscular training on ground reaction force (GRF) in ACLD patients while climbing up and down the stair. The present study attempts to examine the effect of a perturbation training program on GRF changes in ACLD patients at step up and down.

MATERIALS AND METHODS

Method

A quasi-experimental research design with convenient sampling method was used to conduct the present study. A sample size of ten participants was used in this study (Naserpur, 2008; Abasi, 2008; Motamedvaziri, 2003). Inclusion criteria for the study were minimum muscular power of 4 at lower extremity muscles, non-existence of injury in other joints and other knee joint elements, non-existence of pain and inflammation, full extension range of knees and a minimum period of six months since the occurrence of the injury. After securing written consents, patients filled out the subjective IKDC questionnaire. Next, the patients were tested and recorded three times on cross hopping measure. The test was conducted on a tape 15 cm wide and 6 m long. While climbing up and down the step, the maximum vertical force (z axis) relative to the patient’s weight and the time to peak was recorded using a U.S.A made Bertec force plate. To do so, a 20 cm (h) × 30 cm (w) wooden box was placed on the force plate as the first step and another wooden box measuring 40 cm (h) × 30 cm (w) was placed next to it off the force plate. Therefore, the participant was required to climb up and down two small steps each 20 cm high. The patient would first place his involved leg on the first step and his uninvolved leg on the next step. The participants repeated this test three times. The tester eye balled the signal for health to rerun if required. Next the patient was asked to repeat the test applying his uninvolved leg first. This test was also run three times. In the next stage, step down tests were run for both legs. After conducting the pre-test, the patients underwent perturbation training. At the beginning of each session, the patient would warm up on a stationary bike for five minutes. The intervention program was based on the framework proposed by Fitzgerald, 2000. The patients were post-tested on the same measures at the end of the program. The participants in the control group were similarly tested. Data were analyzed using SPSS v.17.

Ethical Issues

The perturbation training program was fully explained to all participants in the experimental group and written consents, designed and approved by the ethical committee of the Rehabilitation School, Iran University of Medical Sciences, were secured from them. Participants were assured of the confidentiality of their personal information and the option to drop out at any time they wished.

RESULTS AND DISCUSSION

Findings

The goodness of fit test showed that the obtained data were not normally distributed, requiring the use of non-parametric tests (Wilcoxon, in this case). The results were as follows: the mean on the questionnaire rose from a pre-test value of 65.9 to a post-test value of 81.8 (p < .005). On the cross-hop test for the involved leg, the mean rose from a pre-test value of 423 cm to a post-test measure of 542 cm (p < .005). For the uninvolved leg, the pre-test mean increased from 521 cm to 586 cm on the post-test (p < .03). The proportion of the involved leg function test to the uninvolved leg rose from 81% on the pre-test to 92% on the post-test (p < .03). These graphs are brought under:
IKDC score, before training: 65.9
IKDC score, after training: 81.8

Cross hop test by involved leg, before training: 423 cm
Cross hop test by involved leg, after training: 542 cm

Cross hop test by uninvolved leg, before training: 521 cm
Cross hop test by uninvolved leg, after training: 584 cm
At step down by the uninvolved leg, the time to peak decreased from 0.21ms on pre-test to 0.159ms on the post-test (p < .04). This variable was measured to be 0.167ms in the control group. For the involved leg, this value decreased from 0.272ms on the pre-test down to 0.20s on the post-test (p < .05). These results are brought under by graphs. No significant changes were observed in the above variables in either of the legs at step up.
Discussion
The improvement gained on the questionnaire and function test scores on the post-test shows that patient's fear of and lack of confidence in his involved limb had decreased and his perceptions about his abilities enhanced. These findings are in line with the results of previous studies and the effect of the perturbation treatment program on improving the patients' function has clearly been established (Naserpur, 2008; Fitzgerald et al., 2000; Chemielewski et al., 2005; Abasi, 2008; Motamedvaziri, 2003). This study aimed to examine the effect of the perturbation training program on the GRF of patients while involved in the relatively challenging physical activities of climbing up and down the stair. The results showed that patients' function had enhanced through an increase in the GRF in the involved leg. Not only did the GRF in the involved leg increase to the level of normality but also the required time to peak dropped.

![](https://via.placeholder.com/150)

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significantly to a level similar to normal individuals. Since the patient had regained confidence in his involved leg after the treatment (as shown by the results of the re-administered questionnaire) he put weight more confidently on his involved leg and allowed it to bear more weight or forces. Reduction of the time to peak at step down by the uninvolved leg shows that this group functioned more similar to the normal individuals (i.e. the control group).

Comparing the treatment group with the control group on climbing up the stair on the two administrations of the test showed no significant differences. This finding suggests that patients' problem in activities involving eccentric contraction are more likely to manifest. The treatment conducted in this study also showed a significant effect in this function. GRF represents the distribution of the forces in the entire body and the gravity point which is dependent on the overall control and stability of the body (Anastasia et al., 2007). Therefore, any changes in the GRF would be indicative of the effectiveness of the intervention program on the entire body and not just on the knees.

**Conclusion**

The functioning of the ACLD patients significantly improved after participating in a ten-session perturbation training program. This improvement was observed in the form of a more natural ground reaction force in the involved leg. Therefore, a perturbation training program not only enhances the movement function of patients but it also approximates the ground reaction force of the patients to that of normal individuals.

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**REFERENCES**


