The significance of water rehabilitation in patients with anterior cruciate ligament reconstruction

Ariane Zamarioli1,2, Adriano Pezolato2, Evandro Mieli3, Antonio C. Shimano1
1 Department of Biomechanics, Medicine and Rehabilitation of the Locomotor Apparatus, Faculty of Medicine of Ribeirão Preto, University of São Paulo
2 School of Physiotherapy Barão de Mauá
3 Hospital Santa Casa de Misericórdia of Ribeirão Preto

Abstract:
The purpose of this study was to investigate the responses elicited during aquatic and land rehabilitation to establish the comparison among parameters such as, range of motion (ROM), muscle strength, circumference of muscle mass and swelling. Thirteen individuals with an anterior reconstruction ligament with a concomitant meniscal injury participated in the study who established 2 groups: the land rehabilitation (LR), patients who were followed by a land program and the water rehabilitation (WR) whose patients had an aquatic program. Clinical evaluations were applied in the 0, 3, 6 and 9 weeks measuring the parameters. The patients from the WR reached the best results for all parameters which were evaluated. We concluded the aquatic rehabilitation allowed earlier function recuperation than the land program.

Key words: rehabilitation, anterior cruciate ligament.

Introduction
The anterior cruciate ligament (ACL) is the most common completely torn ligament injury in the knee [1]. Actually, the optimal rehabilitation program after ACL reconstruction is still undetermined, and it has received a considerable and growing attention over the past 20 years [2].

Aquatic exercises have generally been recommended for their capacity to allow early active mobilization and to improve neuromuscular performance, especially during the initial phase of rehabilitation program. Reduced gravity and water buoyancy under decreases the detrimental effects of weight bearing and impact forces on joint structure [3]. Water pressure reduces injury swelling and increases blood circulation. Water hydrodynamic resistance force can be regulated during the exercise by controlling the instantaneous kinematical condition of the body and selecting appropriate resistive devices. Thus, underwater environment allows early dynamics strengthening. However, it was reported that electromyographic activity of under water exercises was decreased as compared to similar exercises performed on dry land [4-6].

Biscarini and Cerulli [7] by a biomechanical and hydrodynamic theoretical model concluded that aquatic exercises can be usefully and safely implemented in the ACL rehabilitation, and whenever it is important to avoid excessive shear joint forces that constrain the tibial plateau anterior translation with respect to femur.

In spite of having literature comparing the influence on the exercise either in water and on land in cardiorespiratory parameters [8, 9], there is a lack of studies comparing the musculoskeletal system.

Purpose
The purpose of this study was to investigate the responses elicited during aquatic and land rehabilitation to establish the weekly comparison between both programs according to pain, range of motion (ROM), muscle strength, circumference of muscle mass and swelling.

Material and methods
The study was approved by our Institutional Review Board, and all participants consented to randomization. Thirteen individuals (twelve men and one woman) with an ACL reconstruction with concomitant meniscal injury participated in the study. Inclusion criteria were: (1) individuals of both genders with age between 18 and 55 years old, (2) documented unilateral ACL lesion with concomitant medial meniscectomy without another torn ligament, except the medial collateral ligament (MCL), (3) positive responses to the pivot-shift, lachman and anterior drawer tests in preoperative, (4) reconstruction using autograft patellar tendon scheduled between 70 and 90 days from the injury and, (5) ROM among 0 and 130 degrees post-surgery. Exclusion criteria included (1) any prior ligamentous surgery on the index knee or a concomitant posterior cruciate, fibular collateral or posterolateral corner ligamentous knee injury. Concomitant MCL injuries of any grade were not exclusionary in both groups, and (2) individuals who missed three sessions of rehabilitation program.
Table 1. Data of outcome measures

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>LR baseline</th>
<th>9 Wk postsurgery</th>
<th>WR baseline</th>
<th>9 Wk postsurgery</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean</td>
<td>SD</td>
<td>mean</td>
<td>SD</td>
</tr>
<tr>
<td>Pain</td>
<td>4.2</td>
<td>1.6</td>
<td>1.8</td>
<td>2.4</td>
</tr>
<tr>
<td>ROM flexion</td>
<td>78.8</td>
<td>4.38</td>
<td>134.2</td>
<td>5.21</td>
</tr>
<tr>
<td>ROM extension</td>
<td>-12.8</td>
<td>4.8</td>
<td>0.2</td>
<td>0.4</td>
</tr>
<tr>
<td>Muscle strength flexion</td>
<td>3.6</td>
<td>0.9</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Muscle strength extension</td>
<td>3.6</td>
<td>0.5</td>
<td>4.8</td>
<td>0.4</td>
</tr>
<tr>
<td>Circumference swelling</td>
<td>41</td>
<td>1</td>
<td>39.7</td>
<td>1.7</td>
</tr>
<tr>
<td>Circumference muscle mass</td>
<td>60.2</td>
<td>8.3</td>
<td>63.3</td>
<td>8.5</td>
</tr>
</tbody>
</table>

The administration of the diclofenac 50 mg was performed to patients for 10 days. The same posology was taken to all patients.

Individuals were randomized in two groups; the land rehabilitation (LR) and water rehabilitation (WR). The LR performed acceleration rehabilitation with miscellaneous techniques, such as, open kinetic chain (OKC) and closed kinetic chain (CKC) exercises, neuromuscular training and stretching techniques. A specific aquatic protocol was applied at water rehabilitation group with same exercises performed at land. The ROM used in the exercises until two months post-surgery was 0-45 degrees for CKC and 45-90 for CKO in order to avoid ACL strain.

Clinical evaluations were applied in 0, 3, 6 and 9 weeks measuring the following parameters: pain, ROM, muscle strength by the manual muscle test, circumference of muscle mass and swelling. The pain was measured by the Numerical Rating Scales (NRS) that quantify subjectively the degree of pain with a single number, typically ranging from zero to ten. Descriptive anchors are usually provided for the extreme values, with zero corresponding to "no pain" and ten being "the worst pain ever experienced". The ROM was measured by means of a goniometer that is used to objectively assess joint movement. Circumference measurement has been used to document tight girth, thigh muscle atrophy and knee joint swelling. The measure was performed 5 cm above the patella superior margin to quantify the swelling and in proximal thigh to quantify muscle trophism. The muscle strength was measured by means of the manual muscle test that consist in six grades: 0 (no contractile activity is felt in the gravity-eliminated position), I (muscles are palpable while the patient is performing the action in the gravity-eliminated position), II (patient demonstrates movement all or partial range of motion in the gravity-eliminated position), III (patient tolerates no resistance but performs the movement through the full range of motion), IV (patient holds the position against maximum resistance throughout the complete range of motion) and V (patient holds the position against strong to moderate resistance and demonstrates full range of motion) [10].

These parameters were useful to quantify the evolution of the patients, taking into consideration the contralateral limb as "control measurements". The rehabilitation program followed a same protocol for both groups twice a week for fifty minutes each session during 9 weeks. After 9 weeks the patients were maintained in the rehabilitation center but data was not used in this research. Data were analyzed using analysis of covariance – ANOVA One Way Analysis of Variance to test the differences between groups. The level of significance was set at 5%.

Results

The results were based on 10 individuals (LR = WR = 5) who completed all testing and training requirements of the study. There were 3 dropouts during the course of the study because of three lacks.

The mean of pain reduction was 0.27 mark per week in LR and 0.46 in WR.

The mean of the flexion ROM increase was 5.8 degrees per week in LR and 6.2 in WR. The mean of the extension ROM increase was 1.4 and 1.46 degrees per week in LR and WR, respectively.

The mean of muscle strength increase during flexion of the knee was 0.15 in LR and 0.18 in WR. During extension the values were 0.13 in LR and 0.18 in WR.

The mean of swelling reduction around the knee was 0.15cm per week in LR and 0.25 in WR.

The mean of muscle mass circumference in the leg increase was 0.36 cm per week in LR and 0.39 in WR.

Despite our findings that showed the presented differences between the groups, these results were not statistically significant.

All results are summarized in Table 1.

Discussion

All surgeries were performed by the same team using the same autograft patellar tendon and inclusion criteria were followed to minimize the variability. There are in the literatures discussion about the best period to operate after the injury; more than 21 days [11], 40 days [12], 70 days [13] and no difference was found operating within 21 days or between 42 and 192 days [14]. Thus, we scheduled the surgeries between 70 and 90 days after the injury.

The rehabilitation programs were well tolerated, and no orthopedic injuries occurred during the exercise sessions in both group.
The aquatic rehabilitation provided a better reduction of the pain by the warm water properties. We used isothermal warm water with temperature ranging from 33-34°C (91.4-93.2°F). We evaluated the pain through the NRS that is an easy and economical method to administer in a written or verbal form. This scale has been demonstrated to be reliable and valid for measurements of acute and chronic pain [15].

Our findings show that the aquatic exercises provided an earlier motion recovery. This data is supported by studies which reported the aquatic exercises are important to avoid excessive shear loads that constrain the tibial plateau and the fibula [5, 16-17]. We used the goniometer to measure the range of motion of the patients. Goniometers are considered valid clinical tool to measure the ROM. High correlations were observed between goniometric and the X-ray measures supporting the validity of goniometry (r = 0.97-0.98) [15].

In spite of being reported that electromyographic activity under water exercises was decreased as compared to similar exercise performed on dry land [4-6], we found that the group rehabilitated in the water got higher results of muscle strength than the group performed on land. The circumference of muscle also showed better results in water than on land. This may be related to the earlier active mobilization and the buoyancy provided by the water that provides a resistance to the movements. Numerous methods have been developed to assess muscle strength, such as manual muscle testing, dynamometers and isokinetic testing. We used the manual muscle testing by virtue of its simplicity and convenience and it is a clinically useful tool with good reliability and validity [16, 17].

We also noticed that the group whose rehabilitation program was performed in the water had their swelling issue earlier solved. Our results are in accordance to Tovin [18] that performed a comparative study between a land-based rehabilitation program and a water-based rehabilitation. Their data showed the water-based program was more effective at reducing joint swelling. This happening is supported by Harrison and Bulstrode [3], who reported the water pressure significantly reduces injury swelling by means of buoyancy, one of the water properties. We used the knee circumference measurements for measure the swelling. Several studies support the use of knee circumference measurements as an indicator of postoperative swelling following ACL reconstruction. Intra-rater reliability girth measurement using a standard tape measure has been demonstrated to be highly reliable making it a suitable objective outcome measure in clinical practice and research studies [15].

Conclusion
The rehabilitation programs either on land or in water were well tolerated and allowed the recovery of the pain, range of motion, muscle strength and swelling of the individuals undergone to an anterior cruciate ligament reconstruction. Besides on the benefits provided by the rehabilitation in both places, we found that the water may provide better condition for an earlier recuperation.

References

[15] Shaw T., Chipchase L. S., Williams M. T. A users guide to outcome measurement following ACL recon-
The significance of water rehabilitation in patients with anterior cruciate ligament reconstruction

Ariane Zamarioli, Adriano Pezolato, Evandro Mieli, Antonio C. Shimano


Address for correspondence:
arianezamarioli@usp.br

Wpłynęło/Submitted: V 2008
Zatwierdzono/Accepted: VI 2008