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Is the Aquatic Treadmill an Effective Therapy Tool for The Rehabilitation of Lower-Limb Amputees

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by

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IS THE AQUATIC TREADMILL AN EFFECTIVE THERAPY TOOL FOR THE REHABILITATION OF LOWER-LIMB AMPUTEES?

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The purpose of this study was to ascertain if an aquatic treadmill walking program is an effective therapy tool for adults with below-the-knee amputations. An Amputee Mobility Predictor (AMP) test was performed pre- and post- study to determine K-level. Two male participants (mean age = 61 yrs.) completed the eight-week study. Each week was comprised of three sessions, each session involving three repetitions of walking on the aquatic treadmill. The intensity and duration of each exercise bout was progressively increased over the 8 week time study. Following training, the AMP test was conducted to determine if the participants increased their insurance bracket level. Results of the study indicated that one participant raised his K-level from a K2 to a K3; the other participant remained at a K2 level. Thus, an aquatic treadmill walking program is a viable rehabilitation option for adults that have a single leg lower-limb amputation.

According to the *Archives of Physical Medicine and Rehabilitation*, almost two million people in the United States alone are living with a limb loss, the majority due to vascular disease (Ziegler-Graham et al., 2008). The high prevalence of amputations means insurance companies must outfit their clients with proper prosthetic limbs. However, amputee rehabilitation does not exclusively involve physical therapy associated with the use of the new prosthetic limb. Commonly, patients are prescribed a rehabilitation program that includes activities such as: “peer support, vocational rehabilitation, community reintegration, and sports and recreational activities” (Gerhards et al., 1984). These activities are implemented with the goal of improving the overall quality of life in all of the patients with lower-leg amputations.

A high level of functioning is imperative due to the fact that insurance companies are required to outfit their client with a prosthetic device that is consistent with the patient’s quality of life. Scandinavian medical scientists Dimenas, Dahlof, Jern, and

Wiklund (1990) propose that quality of life comprises three parts: subjective well-being, health, and welfare. The average person thinks of quality of life in terms of just overall health. However, health encompasses both the "physical and mental status" of the amputee (Dimenas et al., 1990). Quality of life must also include the person's opinion of their own life (subjective well-being) and the physical environment surrounding the person (welfare) (Dimenas et al. 1990).

Most insurance companies determine quality of life based on the Amputee Mobility Predictor Test (AMP). This test consists of twenty-one tasks involving variations of activities, such as: rising from a chair, standing balance, walking, and reaching. Each task is assigned a score ranging from zero to two. The scores are then summated, and the total number corresponds to a specific K-level. An amputee may be given a K-level score ranging from zero to four, zero being unable to perform daily activities of living and four being completely independent (inMotion, 2013). K-levels are then used by insurance companies to decide what type of prosthetic device should be provided and how much that insurance company will charge the patient (inMotion, 2013).

Rehabilitating and outfitting amputees with improved prosthetic devices is relevant because of the relatively small number of prosthetists who are qualified to fit and maintain prosthetic limbs. Each year, about 185,000 amputations are performed in the United States each year (Owings et al., 1998). These patients require prosthetics, and additional prosthetic limbs are required for those who have broken or worn down their current artificial limb. This combined need is causing a growth in the field of prosthetics and rehabilitation with amputations.

Because advanced prosthetic limbs cost more money to produce than basic prosthetics, insurance companies seek to provide clients the minimum level of prosthetic limbs based on the patient's original level of function. Therefore, if an amputee can prove that he or she has improved their quality of life, insurance companies are required to outfit their client with a newer, more advanced prosthetic limb. This study tests the efficacy of using an aquatic treadmill as a rehabilitation tool to improve a person's quality of life.

The aquatic treadmill and jet system was patented in 2014 by Anson Flake, Dominick Tucci, and Phillip Black (US8784278 B2, 2014). The system involves a motorized belt specifically built to withstand underwater use and has two chambers, one for entering the treadmill apparatus (foyer) and one for the actual treadmill tank. The user walks into the foyer chamber, the jet system fills the chamber with water from the treadmill chamber so that the water pressure is equalized between the two, and the user can then open the door and enter the treadmill chamber (US8784278 B2, 2014). Once the latch is secure, the jet system then redistributes the water out of the first chamber back into the treadmill area (US8784278 B2, 2014).

This study seeks to determine the efficacy of the aquatic treadmill as a rehabilitation tool in the therapy of lower-limb amputees. More specifically, this study seeks to determine if an aquatic treadmill walking program will improve independence in lower leg amputees. It was hypothesized that the eight-week study will result in an increase in the K-level of the participants.

Methodology

Participants

Lower-limb amputees (2 males; mean age = 61 yrs.) volunteered to contribute to this study. Their characteristics are listed in Table 1. Inclusion criteria for this study involved the amputees being originally assigned a K-level of 2 by their licensed prosthetist. Exclusion criteria for this study included the inability to walk on the aquatic treadmill without assistance. Written consent was required from both participants before commencement of the study.

Table 1: Participant Characteristics

Variable	Participant A	Participant B
Age (years)	62	60
Sex (male/female)	Male	Male
Height (m)	1.84	1.82
Body mass (kg)	92.9	84.3
Presence of physical aid (type)	Cane	No aid
Length of prosthesis (years)	2	3

Outcome Measures

The participants were tested using the AMP within one week of initiation into the eight-week study. A post-study AMP test was also performed following the conclusion of the eight-week aquatic walking program. The tests were performed in order to evaluate the initial score and then determine the amount of change that occured over the course of the study.

Sitting. Subjects sat in a chair with arms folded across the chest for 60 seconds, receiving a score of 0 or 1. The participants were instructed to lean forward to grab a ruler held 12 inches beyond the amputee's arm length, receiving a score of 0, 1, or 2.

Moving from chair. The subjects moved to a chair angled at 90°, receiving a score of 0, 1, or 2. Subjects were then asked to fold their arms across their chest and stand up, receiving a score of 0, 1, or 2. The number of attempts to rise from the chair was counted, and the amputee was given a score of 0, 1, or 2.

Standing balance. The subjects stood still for 30 seconds and were assigned a score of 0, 1, or 2. The subjects then stood on each limb (prosthetic and non-prosthetic) for 30 seconds. Each limb was assigned a score of 0, 1, or 2. Lastly, the subjects attempted to lean forward and grab a ruler held 12 inches beyond their arm length, receiving a score of 0, 1, or 2.

Unexpected activities. Subjects were asked to stand with their feet close together. The examiner then pushed lightly on the subject's sternum 3 times and assigned the amputee a score of 0, 1, or 2 based on their response. The subjects were also asked to stand with their eyes closed for 30 seconds, receiving a score of 0 or 1. Lastly, each subject picked up a pencil from the floor, positioned 12 inches from the middle of the body. They were then given a score of 0, 1, or 2.

Walking. The subjects were told to start walking, and they received a score of 0 or 1 based on how quickly they were able to begin. The step length and height was then observed for 12 ft. The prosthetic leg must move forward at least 12 inches and be completely lifted off of the floor. Two scores of 0 or 1 were assigned for both of these actions. The flow of each step was also rated a 0 or 1. Subjects were then asked to turn 180° and given a score of 0, 1, or 2. They were asked to walk 12 feet as quickly as they could for 4 repetitions. As a result, a score of 0, 1, or 2 was scored based upon the cadence of his walking.

Stepping. The subjects were tasked with stepping over a 4 inch box when walking, receiving a score of 0, 1, or 2. They were also asked to go up and down stairs without using a railing. Each subject was assigned a score of 0, 1, or 2 for both the ascending and the descending processes.

Assistance. Finally, the subjects received a score of 2 if they needed a walker, 3 if they needed crutches, 4 if they needed a cane, and 5 if they needed no additional help.

Total score. The scores were added together, and the final number corresponded with a specific K-level. A K0 has scores of 0-8. A K1 has scores of 9-20. A K2 has scores of 21-28. A K3 has scores of 29-36. Lastly, a K4 has scores of 37-43.

Protocol

Exercise intervention. Participants completed eight weeks of an aquatic walking program. Each week was comprised of three one-hour sessions. During each session, the participant walked on the aquatic treadmill for three bouts with a five-minute rest between walking repetitions. Progressive increases in exercise time and intensity occurred over the 8 week training period. Directly before and after a bout, subjects' heart rates were measured. This was done to ensure the participants were not exercising at too high of a level of intensity and could maintain the walking pace for the remainder of the session. After the 8-week study was completed, subjects were retested using the same format that insurance companies use to determine if any health insurance bracket level changes had occurred.

Statistical Analyses

Statistical analyses performed using the Statistical Package for Social Sciences (SPSS) version 24.0. A paired sample *t* test was used to determine pre and post underwater treadmill training differences between AMP test overall scores.

Results

Participant Compliance and Exercise-Related Injuries

Both participants completed (8 weeks x 3 sessions) all 24 one-hour aquatic treadmill sessions. No exercise-related injuries occurred. No further injuries outside of the kinesiology lab were reported.

Pre- and Post-Study Measures

The results indicated that there was a significant change in the individual K-level categories (see tables 2 and 3). An improvement of one K-level was also seen in one of the participants (1 AMP, $p = .02$) (see Table 4).

Table 2: Pre- and Post- Study AMP Results for Participant A

Measures	Pre- Study	Post- Study
Sitting balance	1	1
Sitting reach	2	2
Chair to chair transfer	2	2
Arises from a chair	1	2
Attempts to rise from a chair	1	2
Immediate standing balance	2	1
Standing balance	1	2
Single limb standing balance	1	1
Standing reach	1	2
Nudge test	2	2
Eyes closed	0	1
Pick up objects off the floor	1	2
Sitting down	1	2
Initiation of gait	0	1
Step length and height	1	1
Step continuity	1	1
Turning	1	2
Variable cadence	1	1
Stepping over an obstacle	1	1
Stairs	1	1
Assistive device selection	4	4

Table 3: Pre- and Post- Study AMP Results for Participant B

Measures	Pre- Study	Post- Study
Sitting balance	1	1
Sitting reach	2	2
Chair to chair transfer	2	2
Arises from a chair	1	2
Attempts to rise from a chair	1	1
Immediate standing balance	2	2
Standing balance	2	2
Single limb standing balance	1	1
Standing reach	2	2
Nudge test	1	2
Eyes closed	1	1
Pick up objects off the floor	2	2
Sitting down	2	2
Initiation of gait	1	0
Step length and height	1	1
Step continuity	1	1
Turning	1	1
Variable cadence	1	1
Stepping over an obstacle	1	1
Stairs	1	1
Assistive device selection	1	1

Table 4: Pre- and Post- Study K-levels

Participant	Pre-study K-level	Post-study K-level
A	K2	K3
B	K2	K2

Discussion

The purpose of this study was to determine the efficacy of the aquatic treadmill as a rehabilitation tool for lower-limb amputees. The results of the study indicate that the aquatic treadmill walking program can have positive results when it is used as a therapy tool for individuals with altered gait mechanics. However, before concluding these findings, it is imperative to consider each participant's individual experience.

Participant B was not able to raise his K-level score; however, he did experience improvements in his cardiorespiratory endurance. The participant was observed to heavily rely on his cane for walking and was unwilling to push himself during each bout of treadmill walking. The testers would frequently have to lower the treadmill belt speed in order to accommodate Participant B's level of participation. This reinforces the point that "factors related to function and confidence also alter an amputee's performance with prosthetics and can therefore influence outcomes" (Agrawal, 2016). If Participant B had more of an intrinsic view of the study's goals and wanted to have better results for himself, his K-level would probably have risen from a K2 to a K3.

Participant A was the perfect example of a subject completing the study. He pushed himself as hard as he possibly could and had a desire to fulfill the rehabilitation in order to increase his K-level. His final jump in K-level can be attributed to a successful aquatic treadmill rehabilitation routine and the proper mindset of a person wishing to better himself. The subjects' results reinforce the idea that rehabilitation can only be as successful as the intrinsic desires of the patients themselves. This can be attributed to positive psychology, the idea that there are outside factors that "enable individuals to confront challenges…" (Dunn, 2005). For example, Participant A had a low income and could not afford a more advanced prosthesis, and he worked diligently to improve his K-level so that he could qualify for a better prosthetic leg. Participant B was retired with a high income and could afford a higher grade prosthesis without having to raise his K-level. It is important to keep in mind that human-subject research studies will always have an aspect of positive psychology affecting the results.

The results show that the aquatic treadmill is a viable option when planning rehabilitation programs for lower-limb amputees. Although many facilities do not have an aquatic treadmill, this article hopes to increase awareness of an aquatic treadmill and encourage further research into the implementation of this exercise medium into rehabilitation programs.

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