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RESEARCH

Physical and Psychological Effects of Aquatic Therapy in Participants After Hip-Joint Replacement: A Pilot Study

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The purpose was to measure the outcome effects of a hydrotherapy program lasting 12 sessions on the rehabilitation of participants after joint replacement because of arthritis-related conditions. Sixteen volunteers at a postrehabilitation stage (15 women and 1 man, mean age 56.7 ± 6.5 y) participated in a quasi-experimental design with simple interrupted time series aimed at improving range of motion around the hip joints, mobility (Berg Balance Scale; BBS), walking velocity in the timed up-and-go test (TUG), and scores on a quality-of-life scale (SF-36). One-way ANOVA statistics showed a significant effect between the pre- and posttest outcomes without differences between baseline and pretest for the extension and abduction of the operated hip, the BBS, the TUG, and the summary measures of the SF-36 (general, physical, and mental health). Findings suggest significant effects of the proposed treatment across the variables measured in participants with joint transplantations.

Key Words: arthritis, quality of life, range of motion

The number of joint replacements performed annually has been steadily increasing. The Canadian Institute for Health Information (2002) reported a 34% increase in the number of total hip and total knee replacements between 1994 and 2000, nearly 150 per 100,000 toward the year 2000, depending on the province. The ultimate goal of the joint-replacement procedure is to ensure pain-free function of the joint so that the patient's quality of life will be improved (Berger et al., 2004). Persistent hip pain has been reported, however, as a frequent symptom in frail elderly individuals who have undergone hip replacements (Herrick et al., 2004). In addition, voluntary force production of the quadriceps femoris muscle in individuals after total knee replacement was considerably decreased compared with controls (Mizner, Stevens, & Snyder-Mackler, 2003). Exercise is generally recommended as one of the most effective means of treatment in the rehabilitation and postrehabilitation phases after joint replacements, suggesting improved mobility, increased knee-extensor power in knee replacement, and reduced pain

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(see Frost, Lamb, & Robertson, 2002). Most of the exercise modalities prescribed are weight-bearing activities that can provoke pain and impair joint stabilization (Berger et al.).

Aquatic therapy (also called hydrotherapy) is treatment in an environment that allows for exercising free of the negative effects of weight bearing on the joints (Korel, 1996). In the specific syndrome of rheumatic diseases, buoyancy offers the benefit of reducing pain and joint stiffness. The increased sensory transmission to the joint, created by turbulence, hydrodynamic pressure, and water temperature, stimulates the joint sensors to react to motion and posture. Muscles are relaxed, which allows for freedom of movement in the joint and a general reduction of compressibility and interarticular pressure (Danneskiold-Samsoe, Lyngberg, Risum, & Telling, 1987; Roxan, 1997; Templeton, Booth, & O'Kelly, 1996).

Most studies in the field of hydrotherapy and rheumatic diseases have been conducted on patients with rheumatoid arthritis and osteoarthritis disorders and directed at a wide spectrum of outcome effects. These studies have revealed significant evidence, mostly based on randomized controlled studies, with respect to gains in several domains: (a) range of motion (ROM) and relaxation (Bacon, Nicholson, Binder, & White, 1991; Danneskiold-Samsoe et al., 1987; Minor, Hewett, Webel, Anderson, & Kay, 1989; Roxan, 1997; Templeton et al., 1996; Wyatt, Milam, Manske, & Deere, 2001), (b) strength and aerobic capacity as a result of hydrotherapy (Foley, Halbert, Hewitt, & Crotty, 2003; Hall, Grant, Blake, Taylor, & Garbutt, 2004; Hall, Skevington, Maddison, & Chapman, 1996; Suomi & Collier, 2003; Wyatt et al.), and (c) activities of daily living and function (Foley et al.; Hall et al., 1996; Minor et al.). Some of the studies have compared hydrotherapy with land-based exercise and revealed at least similar results for participants exercising in the aquatic environment (Hall et al., 2004; Suomi & Collier; Wyatt et al.).

Joint failure caused by joint disease is a common reason for undergoing joint-transplant surgery. The main objectives of the surgery are pain reduction and improved joint functioning (Berger et al., 2004). Until now, individuals undergoing joint-replacement surgery have not been used as an exclusive sample designed for undergoing clinical trials examining the effectiveness of aquatic intervention. The purpose of the current study was to examine the impact of an aquatic therapy program on ROM, balance, walking speed, and health-related quality of life (HRQOL) during the postrehabilitation phase in individuals who have undergone hip-joint-replacement surgery. The clinical significance of positive findings might provide support for the effectiveness of aquatic therapy as a supplementary treatment. We hypothesized that aquatic intervention would produce significant changes in measures corresponding to important functional, activity, and participation outcomes represented in the *International Classification of Function and Disability* (ICF; WHO, 2001).

Method

Participants

In total, 16 participants (1 man and 15 women) age 43–65 years (mean age 56.75, *SD* 6.54) from "Steps" (a self-help organization for arthritis patients that assists its members before and after joint-replacement surgery) completed the study. In

order to be included in the study, participants had to meet the following criteria: They were diagnosed with arthritis, they had undergone a joint replacement in the hip at least 3 months before the study, they were age 40–65, they had no history of heart disease or high blood pressure, they signed an informed-consent form to participate in the study, they provided signed physician's consent to participate in the study, and they did not take any prescription medication.

Letters were sent to 72 members of the "Steps" organization. Forty members replied, and 28 met the criteria. Ten individuals dropped out before the start of the study because of technical difficulties (e.g., travel distance, etc.), and 2 dropped out during the study as a result of further surgery or other technical difficulties.

Instruments

Four instruments were used to measure criteria in all three domains of the ICF (World Health Organization, 2001). A ROM test was used to test functional level. Walking speed and balance tests measured activity level, and a QOL test measured participation level. Before administration of the tests, participants were asked to fill out a personal details and demographic questionnaire (e.g., sex, age, residence), including their medical treatment and medical history. The specific tests administered were as follows.

ROM.   According to the ICF, ROM is an indicator of "mobility of joint functions." Hip ROM is compromised for a long while after surgery in individuals who have undergone replacement (Berger et al., 2004; Herrick et al., 2004). An active ROM test was administered using a Saunders (1998) digital inclinometer. This device can be placed in any position. Three measures must be taken from the same angle, and the results are considered reliable only if there is a maximum of a 5° discrepancy among them.

Berg Balance Scale.   According to the ICF (World Health Organization, 2001), balance is considered "changing and maintaining basic body position." Balance is known to be compromised in individuals with arthritic conditions (Frost et al., 2002; Mizner et al., 2003). The Berg Balance Scale (BBS; Berg, Wood-Dauphinée, Williams, & Gayton, 1989) was administered by a physical therapist. The BBS is a functional balance scale developed for measuring balance in a clinical setting in the elderly and individuals with neurological injuries. The scale focuses on performance rather than the disorder. The BBS consists of 14 items graded by difficulty level. The items test functional skills relevant to daily activity, such as moving from a sitting to a standing position and extending the hand beyond one's base of support. The items are intended to examine an individual's ability to remain in position as the base decreases and to change positions. The activities are executed within a defined time frame or require that a position be maintained for a certain period of time. Items are marked on a scale from 1 to 4, with a maximum total of 56. A high score indicates a higher capacity to maintain balance. Test reliability is high ($r = .99$).

Timed Up-and-Go Test.   Walking is one of the most important functional daily activities. Walking performance is affected by arthritic conditions, and even after replacement surgery significant losses in speed and maneuverability can occur (Berger et al., 2004). The timed up-and-go test (TUG) was administered to measure

walking speed. The test was developed by Podsiadlo and Richardson (1991) to measure balance during task performance, including change of position and motion in space within a time limit, and is used to monitor fall risk among the elderly and individuals with disabilities (Shumway-Cook, Brauer, & Woollacott, 2000).

Participants are required to stand up from a sitting position on a standard chair, walk a 3-m distance, turn around in place, walk back, and return to a sitting position on the chair. Time is measured from the moment the individual gets up to the moment his or her buttocks are back on the chair. Test reliability is $r = .98–.99$. The test was found to be highly valid as a predictor of falls, because it correctly identified 13 out of 15 participants with a high falling incidence and 13 out of 15 participants who did not usually fall in community life. It should be noted that elderly individuals whose time on the TUG test is longer than 14 s are at high risk of falling. An earlier test found the cutoff line to be 30 s (Ware & Shelbourne, 1992).

HRQOL.   HRQOL refers to a multidimensional concept that focuses on the impact of disease and its treatment on an individual's well-being. Measures are expected to demonstrate perspectives of the patients' disease and treatment (Bowling et al., 2003). One of the most well-established measures of HRQOL is the SF-36 questionnaire developed by Ware and Shelbourne (1992) and translated by Lewin-Epstein, Sagiv-Schifter, Shabtai, and Shmueli (1998), reporting adequate validity and reliability. The SF-36 consists of 36 items: one closed item pertaining to changes in health (the extent of change in general health in 1 year) and 35 closed items divided into general physical health (21 questions) and general mental health (14 questions) in eight health areas. Specific health areas included physical and vocational functioning, physical pain, general health, vitality, social and mental functioning, and mental health.

Procedure

A quasi-experimental design was used with a simple interrupted time series (Thomas & Nelson, 1996). Each participant provided a letter of consent to take part in the study signed by the treating physician, as well as by the participant, after the aims of the study were explained. Data collection began after the necessary informed-consent forms had been signed. The schedule was as follows:

1. Six weeks before the start of the intervention schedule, the study and its aims were explained to the participants. They signed letters of consent, provided personal details, and completed HRQOL questionnaires. Once the questionnaire had been filled out, each participant was examined by a physiotherapist who measured ROM in the hip joint. Hip flexion was measured with participants in a supine position, hip extension was measured with participants in a prone position, and hip abduction was measured with participants in a vertical position. Hip flexion and extension were measured in both legs. After the ROM test, each participant underwent a BBS test to measure balance and a TUG test to measure walking speed.

2. One day before the start of the intervention program (6 weeks after the initial meeting) participants filled out an HRQOL questionnaire, and their ROM in the joints, walking speed, and balance were remeasured.

3. Participants took part in a 6-week aquatic intervention program, twice a week, 30–45 min per session. The program took place in a warm swimming pool with a 33.4 °C mean water temperature and a 31.7 °C mean air temperature. Water depth was at chest level. Exercises performed by participants were conducted by a trained aquatic therapist according to a structured program.

4. At the end of the intervention program, measures of ROM, BBS, and TUG were retaken, and participants again filled out the QOL questionnaire.

The Intervention Program

The intervention ran for 12 sessions over a 6-week period (two sessions per week). Adherence was almost perfect. For participants who missed one session an additional session was provided at the end of the intervention period, which led to attaining 100% participation. The intervention program included activity stimulation at the ankle, knee, and hip joints performed in buoyant prone, supine, and underwater positions, as well as in a vertically supported position, at waist to chest depth. Exercises were modified, and the number of repetitions in each joint was increased gradually from lesson to lesson. Emphasis was placed on all the joints, although not in every lesson. Exercises included use of the swimming-pool wall as a base of support for moving the trunk or body parts against water resistance. Other exercises were performed while walking or standing in the water, using flotation belts to increase buoyancy and kickboards to increase resistance. Every session began with walking in different directions, at various depths and patterns: forward, backward, sideways; on heels and on toes; and with the knee lifted (reaching 90° of flexion). Exercises were then performed at different stations: (a) lowering a kickboard to the bottom of the pool with the leg and continuing movement with the object on the floor to the other end of the pool, (b) walking across the pool width with ankle weights, (c) walking up and down the pool stairs, (d) sitting on a kickboard and performing bicycle movements in the water to the other end of the pool, and (e) walking on a cylinder in water. The session concluded with a cool-down of stretching and breathing activities.

Data Analysis

In our research design, the experimental group served as its own control ($O_1 - O_2 - x - O_3$), comparing participants' measures 6 weeks before the start of the therapy intervention (O_1) with those at the start of the therapy intervention (O_2) and at the end of the 6-week intervention (O_3).

Individual results of the male participant were close to the median of the range of results among the female participants on all measures. Similarly, in studies formerly conducted on arthritis patients, no gender differences were found. There was therefore no reason to exclude the male participant's results from the general sample.

Statistical analysis of the data was conducted by means of the following: Repeated-measures analyses of variance (ANOVA) were computed to identify changes in the outcome measures of ROM, BBS, TUG, and QOL across tests. Post hoc tests were employed in case of significant findings to distinguish between

time-related and intervention-related effects. Only if O_3 outcomes were significantly greater than O_2 and no effect was found between O_1 and O_2 did we conclude that there was a significant intervention effect.

Results

ROM

Table 1 presents descriptive and ANOVA statistics of ROM in the operated and nonoperated hips. As presented in Table 1, post hoc analyses confirmed significant intervention effects over time in hip-extension and -abduction ROM of the operated hip, $F(2, 24) = 13.746$, $p < .05$, and $F(2, 26) = 11.085$, $p < .05$, respectively. Effect sizes between pre- and posttests approached a 6° and 8° increase for flexion and abduction ROM, respectively. Significant differences for hip-extension and -abduction ROM of the nonoperated hip were observed, as well, $F(2, 16) = 10.481$, $p < .05$, and $F(2, 18) = 13.240$, $p < .05$, respectively, but post hoc analyses proved a continuous progression over time. No significant differences were found in hip flexion of both legs.

Dynamic Balance

Table 2 presents descriptive and ANOVA statistics of the BBS results. Results confirm a significant increase over time of nearly 4 points on a 56-point BBS between the pretest and the posttest, $F(2, 24) = 20.567$, $p < .05$; no significant differences were found between the baseline and pretest measurements (Table 2).

Table 2 also describes outcomes of the ANOVA statistics of the TUG measurements. Findings depict a significant reduction of more than 1.5 s between pre- and posttest, $F(2, 24) = 17.159$, $p < .05$, suggesting faster walking performance. No significant differences were found between baseline and pretest measurements.

Table 3 presents outcomes of the ANOVA statistics of the SF-36 responses. Results confirm significant changes of 7.5 points over time in the general QOL score, $F(2, 26) = 9.369$, $p < .05$, as well as in the subscales for general physical

Table 1   Scores ($M \pm SD$) and ANOVA Statistics of Range of Motion in the Operated (OH) and Nonoperated Hips (NOH) at the Three Test Intervals

Test	Baseline (1)	Pretest (2)	Posttest (3)	p	F	Post hoc analysis
OH						
flexion	75.51 ± 22.35	69.53 ± 14.77	71.82 ± 17.13	>.05	1.285	
extension	11.17 ± 8.51	12.02 ± 8.18	17.82 ± 6.81	<.05*	13.745	3 > 2
abduction	67.39 ± 19.14	74.54 ± 11.62	82.33 ± 12.56	<.05*	11.085	3 > 2
NOH						
flexion	75.33 ± 17.11	75.14 ± 14.22	74.77 ± 11.35	>.05	0.012	
extension	11.74 ± 4.14	15.36 ± 4.28	22.51± 9.19	<.05*	10.481	3 > 2 > 1
abduction	66.26 ± 15.78	74.26 ± 15.03	81.06 ± 1.03	<.05*	13.240	3 > 2 > 1

*Significant difference.

Table 2   Scores ($M \pm SD$) and ANOVA Statistics of the Berg Balance Scale (BBS) and the Timed Up-and-Go (TUG)

Test	Baseline (1)	Pretest (2)	Posttest (3)	p	F	Post hoc analysis
BBS	49 ± 5.4	50.61 ± 5.12	54.23 ± 2.68	<.05*	20.57	3 > 1, 2
TUG	10.75 ± 3.28	10.9 ± 3.76	9.24 ± 2.51	<.05*	17.159	3 < 1, 2

*Significant difference.

Table 3   Scores ($M \pm SD$) and ANOVA Statistics of Measures of Health-Related Quality of Life

Scale	Baseline (1)	Pretest (2)	Posttest (3)	p	F	Post hoc analysis
Quality of life	60.21 ± 14.9	64.78 ± 17.15	71.28 ± 15.75	<.05*	9.37	3 > 2
General physical health	52.28 ± 21.38	56.28 ± 21.91	62.28 ± 22.78	<.05*	5.3	3 > 2
Physical functioning	43.92 ± 27.53	47.85 ± 25.54	56.42 ± 26.34	<.05*	3.65	3 > 1
Vocational functioning	48.21 ± 38.56	51.75 ± 40.97	57.14 ± 39.74	>.05	0.81	
Bodily pain	49.92 ± 33.13	59.5 ± 29.53	68.35 ± 29.15	<.05*	6.23	3 > 2
General health	62 ± 26.29	59.78 ± 26.29	67.07 ± 22.34	>.05	1.66	
General mental health	67.92 ± 10.99	71.92 ± 12.42	77.5 ± 11.2	<.05*	7.61	3 > 2
Vitality	57.14 ± 16.83	62.5 ± 15.28	62.85 ± 14.63	>.05	1.41	
Social functioning	81.35 ± 22.77	85.85 ± 18.76	89.42 ± 14.57	>.05	1.18	
Mental functioning	73.85 ± 32.54	81 ± 31.25	92.85 ± 19.34	<.05*	3.36	3 > 1
Mental health	65.42 ± 22.66	70.85 ± 16.03	75.71 ± 11.03	<.05*	3.95	3 > 1

*Significant finding.

health, $F(2, 26) = 5.298$, $p < .05$, and general mental health, $F(2, 26) = 7.613$, $p < .05$, with increases of 9 and 6 points from pre- to posttest, respectively, where post hoc tests confirmed significant changes over time. In only one of the specific subscales, measuring bodily pain, a significant difference of 7 points was found between pre- and posttest scores $F(2, 26) = 6.229$, $p < .05$. In all other specific health areas either no significant difference or a difference between posttest and the baseline scores was found.

Discussion

The current quasi-experimental study investigated the effects of an aquatic therapy program on ROM at the hip joint, balance, walking speed, and QOL in individuals with rheumatoid disorders who had undergone joint replacement at least 3 months before program implementation. Findings confirmed significant improvements between pretest and posttest in (a) hip extension and abduction of the operated hip, (b) balance as measured by the BBS, (c) walking speed as measured by the TUG, and (d) physical pain and summary measures of the QOL scale. In all these measures no differences were found between baseline and pretest measurements.

Specifically, our findings with respect to ROM are supported by previous research on participants with rheumatoid disorders (Danneskiold-Samsoe et al., 1987; Roxan, 1997; Templeton et al., 1996). Authors have attributed the positive outcome effects to the type of exercises and the degree of resistance, which is related to equipment and performance speed; the number of exercise repetitions performed with each joint; ROM while performing the exercises; water temperature; motivation; and degree of pain perceived by participants (Berger et al., 2004). It is recommended that these variables be monitored during future investigations. In the nonoperated leg a significant difference was found among all three test periods, indicating a gradual change that apparently is derived from rehabilitation over a period of time, independent of the intervention. No significant differences were found in hip flexion after the intervention. This finding might be the result of the low emphasis placed on knee-flexion exercises during sessions. Aquatic exercises focusing on ROM and force in the knee flexors are recommended in future intervention programs, for example, walking backward in deep water over obstacles, walking backward in deep water with ankle weights, and holding a ball using the legs and pushing it backward and downward while lying with the back on a sponge noodle flotation device.

Our findings revealing a significant increase in balance and walking speed during the intervention period are supported by previous investigations, suggesting that aquatic therapy enables participants to perceive more proprioceptive feedback during a greater variety of dynamic balancing positions and movements (Geigle, Cheek, Gould, Hunt, & Shafiq, 1997; Hall et al., 1996, 2004). Turbulence, hydrostatic pressure, viscosity, and temperature of the water appear to increase the amount, variety, and velocity of feedback to the executive system, enabling better reactions to balance perturbation and thus increasing walking speed. A previous study with participants with osteoarthritic conditions revealed similar findings of improved walking speed in randomized hydrotherapy- and gym-exercise groups (Wyatt et al., 2001). The improvement in walking speed in our study is particularly significant, because it provides criteria for daily-activity performance and consequently can give participants a feeling of control when walking and lower their fear of falling. Decreasing fear of falling and injury appears to be a key factor in increased participation in daily motor tasks, as findings in the QOL area indicate.

Considering QOL outcomes, a significant reduction in perceived physical pain was observed. Many factors can contribute to pain reduction. The physical aspects of the aquatic environment in which the treatment was conducted, including turbulence and warmth, are known for pain reduction (Becker & Cole, 2004). The group-motivating atmosphere might be another factor. In the other physical and

mental health factors, no significant changes were observed that could be attributed to the intervention effect. A general trend for improvement over time was evident in the physical health subscales, and this might represent participants' normal recovery over time. Minimal change over time without any noticeable effect was observed in the mental health subscales, which could be attributed to a ceiling respecting the mean outcomes, which were within the normal range for unimpaired participants (Ware, Kosinski, & Keller, 1994).

The current study had certain limitations. The small number of participants and quasi-experimental design suggest a lower level of evidence and statistical power than would have occurred with randomized controlled group designs. Obviously, randomization in this small group was not possible. In addition, because of recruitment restrictions, it was not possible to exclude an intention-to-treat effect by "blinding" the participants. This was a preliminary study in a population of individuals with joint replacements who had not yet been studied as a unique group.

Conclusions

Our outcomes indicated a positive change during the intervention sessions in balance and walking speed, as well as hip-extension and -abduction ROM, which were significantly greater than the normal change over time traced during the preintervention baseline period. Therefore, aquatic therapy during the postrehabilitation period of individuals with hip-joint replacements appears effective, particularly in the activity domain of the ICF. In order to verify our findings, it is recommended that the procedure be replicated with a controlled group design and a larger sample to guarantee a larger effect size and statistical power. To demonstrate the links in the impact of functioning, activity, and participation measures, we propose that additional tests in functioning be incorporated, such as the effect of aquatic treatment on strength, muscle, and cardiovascular endurance. Furthermore, we propose that walking self-efficacy tests be included, which might reflect the objective measure of activity through the subjective measure of self-efficacy on participation in significant daily life, work, and leisure activities. To verify the effectiveness of the intervention, an additional follow-up test should be performed after a period with no intervention.

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