Designing a sitting shower therapy with water temperature and pressure controller

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Submission date: 16-Feb-2023 10:12AM (UTC+0700)
Submission ID: 2015337399
File name: ower_therapy_with_water_temperature_and_pressure_controller.docx (396.22K)
Word count: 2858
Character count: 15547

Jurnal Health of Studies
Vol. 6, No. 1 (2022), pp. (9-16)
e-ISSN 2549-3353
10.31101/jhes.2436

Original Research Paper

Designing a sitting shower therapy with water temperature and pressure controller

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Submitted: March 4, 2022 Revised: March 16, 2022 Accepted: March 26, 2022

Abstract

The pressure and temperature of the water used when bathing using a shower has been presented to provide physiological changes to the body. However, the ideal water pressure and temperature for shower therapy has not been extensively discussed. Therefore, this research was conducted to design a shower therapy that meets the ideal specifications to obtain the most optimal therapeutic effect. Water pressure regulation was performed with a booster pump controlled by a dimmer circuit. Meanwhile, a linear motor was applied to drive the showerhead, which was controlled by Arduino. The results of the prototype test show that a series of shower therapy can be employed in both sitting and standing positions. The water temperature of 40-60 °C was achieved in 30 minutes of the heating process which indicates that the developed tool needs improvement in future research, to attain a shorter heating time and a more accurate shower head movement speed.

Keywords: therapeutic effect; shower head; shower therapy

Rancang bangun shower therapy duduk dengan pengatur suhu dan tekanan air

Abstrak

Tekanan dan suhu air yang digunakan saat mandi menggunakan shower terbukti dapat memberikan perubahan fisiologis tubuh. Namun demikian, tekanan dan suhu air yang ideal untuk *shower therapy* belum banyak dibahas. Oleh karena itu, penelitian ini dilakukan untuk merancang sebuah *shower therapy* yang memenuhi spesifikasi ideal untuk mendapatkan efek terapi yang paling optimal. Pengaturan tekanan air dilakukan dengan pompa pendorong yang di kendalikan dengan rangkaian dimmer. Sementara itu, motor linear diaplikasikan sebagai penggerak *shower head*, yang dikontrol dengan Arduino. Hasil pengujian prototipe menunjukkan bahwa rangkaian *shower therapy* dapat digunakan pada posisi duduk dan berdiri. Temperatur air 40-60 °C dicapai pada 30 menit proses pemanasan yang mengindikasikan bahwa alat yang dikembangkan perlu penyempurnaan pada riset berikutnya, untuk mendapatkan waktu pemanasan lebih pendek dan kecepatan gerakan shower head yang lebih akurat.

Kata Kunci: efek terapi; *shower head*; *shower therapy*

1. Introduction

The COVID-19 pandemic has caused negative lifestyle changes such as poor diet and sleep quality and lack of physical activity (Casagrande et al., 2020; Ingram et al., 2020; Zhou et al., 2020). Poor sleep quality and lack of physical activity are associated with mental health, which includes increased anxiety, stress and depression (Ingram et al., 2020; Silva et al., 2020). One alternative that can be implemented to improve health and fitness during the COVID-19 pandemic is water therapy (hydrotherapy). The simplest water therapy is a shower bath which can refresh and restore fitness.

The pressure of the water emitted by the shower into the head area and along the spine will have a good health effect, especially if given with certain temperatures, pressures, doses, and techniques

(Aryani et al., 2015). Water temperature and pressure in the hydrotherapy process are able to block nociceptors by acting on thermal receptors and mechanoreceptors and have a positive impact on the spinal segmentation mechanism, which is useful for pain reduction (Mooventhan & Nivethitha, 2014).

Several research results show that shower therapy can relieve pain, reduce fatigue and make the body more relaxed (Hsieh et al., 2017; Lee et al., 2012). However, data regarding pressure, temperature and ideal position in shower therapy for pain and fatigue reduction have not been widely discussed. Therefore, this research was conducted to redesign a shower therapy that is more optimal. Ideal water pressure and temperature are identified, and accurate shower head movement is electronically regulated to obtain appropriate movement for sitting and standing positions.

2. Research Method

This prototype shower therapy device was made to be used in a standing and sitting position. There are two main systems in this tool, which are: 1) water temperature controller with heater and temperature sensor, and 2) shower water pressure regulator. Work diagrams and important parts of the shower therapy prototype are presented in **Figure 1**. Water pressure regulation was performed with a booster pump which is controlled by a dimmer circuit. The shower head motor used a linear motor using a driver to control the torque and direction of motor movement. The control system employed Arduino as the main controller which controls all input and output devices.

Data retrieval was completed by testing the prototype automatic therapy shower, namely by measuring the temperature and pressure of the water produced. Users need to set the desired water temperature and pressure before using the shower. The analysis was performed by comparing the temperature and pressure produced by the therapeutic shower tool with the settings that have been implemented at the beginning and compared with measuring instruments, that were thermometers and pressure gauges.

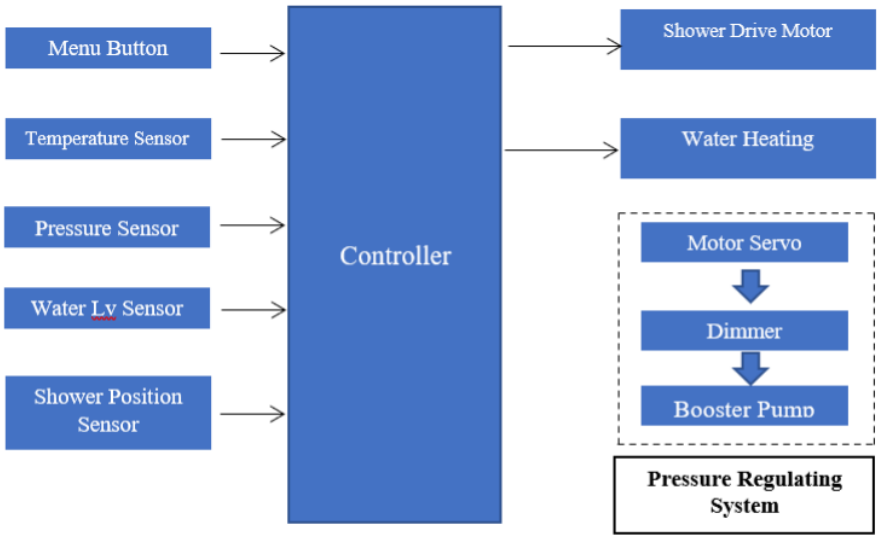

Figure 1. Work diagram of the shower therapy tool

3. Result and Discussion

3.1. Design Result

The prototype was successfully made and could function well as a shower therapy, in which water temperature and pressure work automatically by spraying water with vertical movements along the

user's spine. The height or length of the shower movement can be adjusted according to the user's height, as presented in **Figure 2**.

Figure 2. Photographic view of shower therapy trial

The shower head will move up and down with the number of cycles that can be set in the control panel. The distance or height of the shower head is limited by a limit switch as illustrated in **Figure 3**. The limit switch and the height can be adjusted according to the user's height. The dimmer circuit is employed in the water pressure regulator. The dimmer circuit is a series of voltage regulators on the water pump which plays a role in producing pressurized water. Water pressure is made in three options, namely low, medium, and high. For pressure measurement, two measuring instruments are used, that is a pressure sensor transducer connected to the control panel and can be monitored on the screen and a pressure gauge installed in the shower pipe as a comparison for measuring water pressure. The data on the results of the water pressure regulator test are displayed in **Tabel 1.**

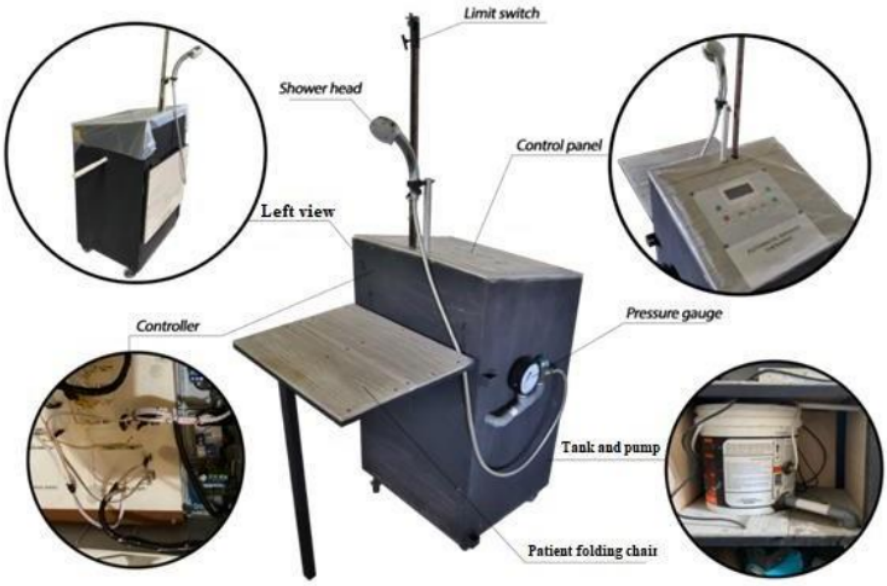

Figure 3. Automatic therapeutic shower prototype

Table 1. Water pressure regulator test results

Water pressure level	Measurement		
	Voltage water pump (V)	Pressure pressure transducer (Psi)	Pressure pressure gauge (Psi)
Low	140	10	10
Medium	175	12	13
High	213	14	15

In the water heating system, water is accommodated in the water tank and heated until it reaches the setting temperature. After the water temperature reaches the setting temperature, the new shower therapy system will run for therapy. The DS18B20 temperature sensor is installed in the water tank and as a comparison, a Krisbow brand infrared thermometer (thermo gun) is employed. For the analysis, measurements were made of the temperature of the water in the water tank and the temperature of the water that came out or sprayed the shower head. The water temperature test results are presented in Table 2.

Table 2. Water heating system test results

Setting temperature	Measurement results			
	Sensor DS18B20 In the water tank (°C)	Sensor DS18B20 In the shower head (°C)	Thermo gun Krisbow In the water tank (°C)	Thermo gun Krisbow In the shower head (°C)
40	40	38	40.2	37.7
45	45	43	45.1	43.2
50	50	49	50.3	48.4
55	55	54	55.5	54.2

A 12V linear DC motor 75cm long is used to drive the shower head. This motor is able to support the movement of the shower head so that it can spray water along the user's spine. In the control panel, the user can set how long to take a shower therapy bath. An overview of the maximum and minimum positions of the shower head can be seen in **Figure 4**.

Figure 4. Maximum and minimum shower head position

Based on data on **Table 3**, the movement of the linear motor that drives the shower head moves slower when going backwards/downwards (to the minimum position) than when going up, so that for one cycle of spine spraying twice back and forth it takes about 3.5 minutes.

Table 3. Shower head movement time

Testing	Time measurement	
	Shower head up	Shower head down
1	1 minute 11 seconds	1 minute 11 seconds
2	1 minute 9 seconds	1 minute 9 seconds
3	1 minute 10 seconds	1 minute 10 seconds

3.2. Discussion

Water therapy is extensively used because it provides various conveniences and benefits, including: water is easy to obtain, has excellent solvency and viscosity; high heat capacity and thermal conductivity; The density of pure water is similar to the density of the average water in the human body (Torres-Ronda & Schelling I Del Alcázar, 2014). Research on water therapy, especially bathing, is mostly performed with soaking techniques (An et al., 2019; Goto et al., 2012, 2014; Parker et al., 2018; Shah et al., 2019). Bathing provides benefits, including improving sleep quality, reducing stress/anxiety and relieving fatigue (Goto et al., 2012, 2014; Hayashi et al., 2022). In addition to providing benefits, bath therapy with the soaking method should be implemented with caution, particularly in the elderly with cardiovascular disease, because hydrostatic pressure causes venous return which has an impact on increasing cardiac output (Goto et al., 2018). The safety of bathing is also considered lacking, it is related to the many cases of death when bathing in the elderly in Japan (Hori et al., 2013; Suzuki et al., 2019; Suzuki, Ikaga, et al., 2017; Suzuki, Shimbo, et al., 2017).

Thirty-three percent of the 4,799 bathing accidents were identified as bath-related cardiac arrest events. Most cardiac arrests occur in tubs filled with water with their faces submerged in water (Suzuki, Shimbo, et al., 2017). According to Suzuki, Ikaga, et al (2017), low air temperature is closely correlated with the occurrence of bath-related cardiac arrest. Similar results were also discovered in the study of Hori et al., (2013) where 53% of victims of bathing accidents had a heart attack and 25% had impaired consciousness. The average patient experiences a temporary loss of consciousness due to an increase in body temperature. The increased body temperature may occur due to a unique heat illness caused by high water temperatures (41-43 degrees °C) which mostly occurs in the elderly population (Hori et al., 2013; Suzuki, Ikaga, et al., 2017).

Shower bath therapy can be an alternative therapy that is safe and beneficial for all people and ages, besides being useful for the elderly, Hsieh et.al (2017) also discovered that shower therapy with warm water of 40 °C and 43 °C for approximately 20 minutes can reduce fatigue in postpartum mothers (Hsieh et al., 2017). However, the study was conducted with a regular shower and did not use special tools for shower therapy. This portable shower therapy tool is expected to make it easier for researchers who want to do further research on the benefits of shower therapy, because apart from being easy to move, there are also many other features designed for user safety and comfort.

The design of this shower therapy has been successfully made on a laboratory scale and its basic functions function well. This tool can be used sitting or standing, so it can be used as required. Shower therapy in a sitting position is very helpful for the elderly and patients with special needs such as patients with spinal cord injuries to feel safe and comfortable while bathing. The menu system on the control panel is also equipped with an LCD screen that can be employed to make many settings such as setting temperature, water pressure, and duration of therapy. Different temperatures and forms of water in therapy will produce different outcomes in different body systems (Mooventhan & Nivethitha, 2014).

Previous studies reported a relationship between age and sensitivity to hot water temperatures, where thermal sensitivity decreased with age (Tochihara et al., 2011).

Heat transfer on the surface of the skin during a shower will vary depending on how the shower water is sprayed onto the bathing person, especially on the distribution of the water being sprayed. Water spray intensity, distribution, and temperature loss have an impact on the quality of the shower experience, the duration of the shower and of course the volume of water used (Adeyeye et al., 2020).

The movement of the shower head with a linear motor in the shower therapy prototype is sufficient for the purposes of shower therapy, although there is a weakness in the motor which has different moving speeds when going forward and backward, causing the speed of the showerhead to be different when going up and down. The heating system is still not optimal to perform its functions. The decrease in water temperature is quite significant in the shower head, which is the temperature of the water that comes out tends to be lower than the temperature in the water tank or the temperature that is set. Heating time is still long enough for setting a temperature of 40-60 °C which takes more than 30 minutes. The water pressure control system works well with three pressure options, which are low, medium, and high. The dimmer system used is able to provide a choice of water pressure with three options, thus, users can choose how much water pressure they want for a therapeutic shower. The development of shower therapy tools needs to be conducted to improve the tools so that they can be used optimally.

4. Conclusion

The design of shower therapy can be used in a sitting and standing position. The menu system on the control panel is equipped with an LCD screen that can be employed to make many settings such as setting temperature, water pressure, and duration of therapy. The water temperature of 40-60 °C was achieved in 30 minutes of the heating process which indicates that the developed tool needs improvement in future research, to obtain a shorter heating time and a more accurate shower head movement speed.

Acknowledgment

The researchers would like to thank the Public Hospital (RSUD) of dr. Chasbullah Abdul Majid Bekasi City who has provided the opportunity to researchers to conduct research. The researcher also expresses gratitude for the contribution of the Directorate General of Research and Development, the Ministry of Research, Technology and Higher Education of the Republic of Indonesia as the research fund support, and the LPPM As-Syafiiyah Islamic University who always supports research activities within the university.

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