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Research Article

Effect of Hydrotherapy on Muscle Activities and Running Kinetics in Adult Males with Pronated Foot: A Randomized Clinical Trial

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ABSTRACT

The potential risk factor for injuries resulting from a pronated foot (PF) has been discussed. The water properties can be used to improve the biomechanics of the lower limb. Therefore, this study aimed to investigate hydrotherapy's effect on muscle activities and running kinetics in adult males with PF. This study was a randomized clinical trial type. Thirty adult males with PF were divided into two equally sized groups. Ground reaction forces (GRFs) were collected by a force plate on the runway. Muscle activities were recorded using a surface electromyography system. Statistical analysis was performed using repeated measures ANOVAs. The significance level was established at $p<0.05$. Significant main effects of "time" were found for first peak vertical GRF ($p=0.032$), first peak mediolateral GRF ($p=0.007$), last peak mediolateral GRF ($p=0.041$), first peak anterior-posterior GRF ($p=0.028$) and positive free moment ($p=0.003$). In the early stance phase of the experimental group, significantly larger tibialis anterior ($p=0.026$), gastrocnemius medialis ($p=0.002$), and gluteus medius ($p=0.004$) muscle activities were found after the test compared to before the test. Hydrotherapy changed the GRFs and muscular activities of the lower extremities in adult men with PF. More research is needed to understand this issue better.

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INTRODUCTION

The pronated foot (PF) has been a topic of discussion for decades, either as a potential risk factor for injuries or as the mechanism behind absorbing impact. The foremost common utilitarian foot abnormality is the PF, with a prevalence rate of 23%. People with PF experience pain and discomfort in the lower limb joints (Zhang & Vanwanseele, 2023). PF deformation can lead to lower limb injury and foot problems. PF defects contribute to tissue injury from lower limb movement. PF can be identified as a risk factor for postural stability (Beelen et al., 2020; Letafatkar et al., 2013). The primary movement of the ankle joint is plantar flexion and dorsiflexion. Conversely, inversion and eversion usually occur in the ankle. The muscles are primarily responsible for the movements of the foot. The foot is a complex system with different functions (Grey et al., 2013). Foot pronation determines the movement of the whole foot. It means that the foot can move in different ways to handle better the forces and movements of the body (Horwood & Chockalingam, 2017). Pronated feet may contribute to running-related injuries, such as shin splints and patellofemoral pain (Wu et al., 2022). When we run, the foot is the only part of our body that touches the ground. So, it helps to absorb and spread the ground reaction forces (GRFs) from stepping on the ground across the foot. There is proof that the way the subtalar joint works is connected to problems in the lower limbs, like having more significant peak medial GRF in the inner part of the foot when walking or running. An atypical medial arch may interfere with shock absorption and mitigation and place more stress on the foot (Jafarnezhadgero et al., 2019; Jafarnezhadgero et al., 2021) because problems in the foot can change kinetic components.

Rehabilitation involves a physical assessment of the subtalar joint. The therapist must comprehend the damaged structures. The fundamental components of rehabilitation are similar, despite therapists' differences in treatment protocols. The primary objective of treatment will be to manage aches and inflation and restore strength, normal function, and range of motion (Kirkby et al., 2020). It was hypothesized that training in the water would be related to an increase in the ankle range of motion and return to natural function (Mooventhan & Nivethitha, 2014). The physical properties of water would permit the therapist to use various exercise options to reestablish normal ankle range of motion. The hydrostatic pressure of the water on the joint and supple tissue would come about lower inflation by offsetting the propensity for the blood to pool in the lower extremities (Javorac, et al., 2020). The patient can do activities that involve weight bearing on their body in the water earlier than on land. This would help them return to normal activities (Ay & Yurtkuran, 2005). Hydrotherapy resistance exercises could be an effective way to improve lower extremity alignment in the form of greater shin mechanical axis angle, lower GRFs, and more significant muscle activities. Additionally, it can make your muscles work better. Resistance exercises can be done in different ways, like using the machines, own body mass, free weights, or hydrotherapy (LeVeau & Rogers 1980; Javorac, et al., 2020; Jafarnezhadgero, et al., 2021). Therefore, the biomechanics of human locomotion could be positively impacted by hydrotherapy.

To the authors' information, there is no randomized clinical trial accessible within the writing that inspected the impacts of hydrotherapy on muscle activities and kinetics during running in adult males with PF. Subsequently, the point of this study was to explore the effect of hydrotherapy on muscle activities and kinetics in adult males with PF. We hypothesized hydrotherapy results in changed muscle activities and running kinetics in adult males with PF.

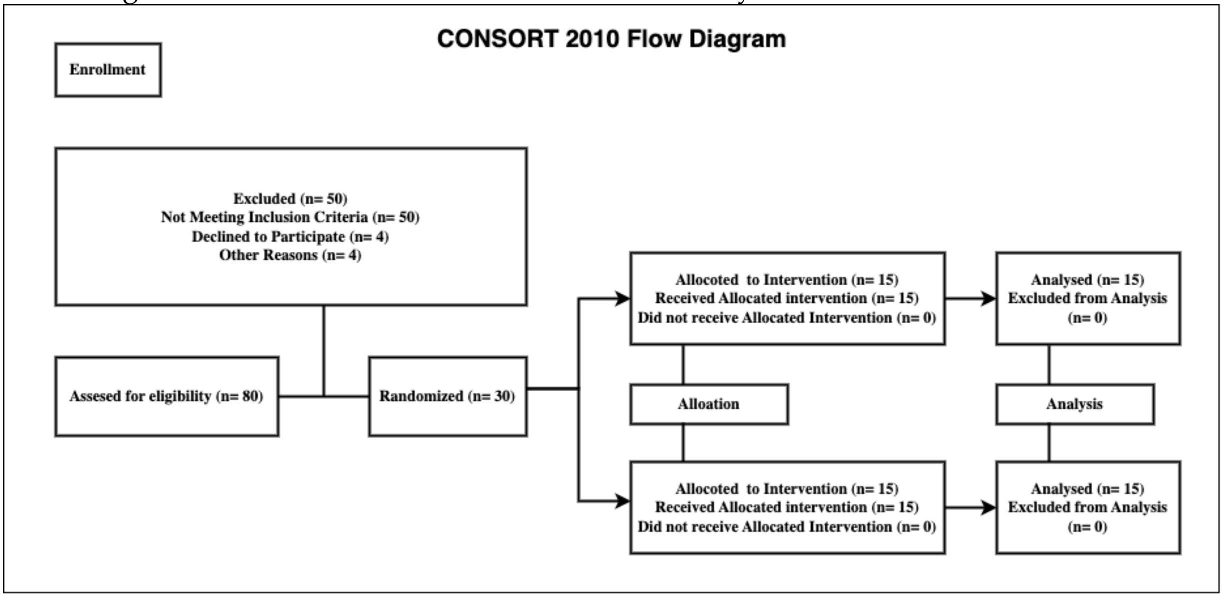
METHODS

Study Group

A randomized controlled design with equal group allocation was used (Figure 1). We used the G*Power software to compute a one-sided a priori power analysis with the F test family. The power analysis was calculated with an accepted Sort I error of 0.05, a Sort II error rate of 0.20, 2 tests, a correlation coefficient of 0.5, and an effect size of 0.80. The examination uncovered that 15 participants would be sufficient. Fifteen adult males with PF were in the control group, and fifteen adult males with PF were in the experimental group. Adult males with PF are eligible to participate in this study. They were utilized to guarantee the concealment of allotment. Each encompass contained a card showing to which group the subject was designated.

One analyst decided whether a participant was qualified for incorporation within the trial, whereas the other carried out gait investigations of the qualified participants. Both analysts and the participants were uninformed of group allotment. The research protocol was approved by the ethics committee of the Medical Sciences University of Mohaghegh Ardabibi Ardabil, Iran (IR.UMA.REC.1401.082), and it was registered with the Iranian Clinical Trial Organization (IRCT20191211045704N2). Before participants signed a paper agreeing to participate, they were given a clear explanation of what they needed to do in the experiment. This research was done following the latest rules of the Declaration of Helsinki. All individuals involved in the study gave their written permission before taking part.

Figure 1
Flow Diagram of Randomized Control Trial in This Study



Data Collection Process

Equity, diversity and inclusion

All assessors and educators were blinded for the group assignment. Inclusion criteria were: 1) young adult (18-30 age); 2) greater than 10 mm navicular drops; 3) a foot posture index of more than 10; 4) endorsement from a medical doctor to take part in this consideration. Within the current study, an altered form of the navicular drop depicted by Brody was utilized to decide the sagittal plane relocation of the navicular between the resting (situated) and stand-on-one-leg positions (Brody 1982). The foot posture index has six items that measure and categorize how feet are positioned. You can find a thorough explanation of the foot posture index somewhere else (Redmond et al., 2006). Individuals were taken out of the study if they had a difference in the length of their limbs that was more than 5mm, or if they said they had muscle spasms, nerve, and muscle disorders, bone and muscle-related illnesses, or had any surgery before on their legs and body. Significant differences in female and male biomechanical characteristics have been found (Bruening et al., 2015). To exclude this potential factor did not affect the study, only men were chosen to take part. Young adults were chosen because resistance training works well at this age, because of the hormones your body produces (Farrell et al., 2011). So, we thought that doing resistance training would make the muscles in the lower legs stronger and maybe even more significant. This could help individuals with PF run better. Everyone who participated in the test of kicking a ball had a right foot (Jafarnezhadgero et al., 2017).

Biomechanics assessment

A force plate was used to measure the GRFs of running. It recorded the data at a rate of 1000 Hz (Figure 2). The forces from the ground were low pass filtered at 20 Hz (4th order Butterworth filter, zero lag). The individual's gait characteristics (heel strike and toe off) were identified using the Bertec force plate. For this purpose, a 10 N threshold was used to detect the stance phase of the gait cycle. When running, certain GRFs are essential in understanding how specific running issues can cause problems. These GRFs include the time-to-peak (TTP) for the force to reach its highest point, how quickly the vertical loading rate, and the free moments (FM) to move within the body. These factors are most important in studying abnormal running patterns (Jafarnezhadgero et al., 2019). These are the variables we got from the GRFs data. The first vertical peak force (Fz_{HC}). The forces (Fy_{HC}) used to slow down (braking) and move forward (propulsion) were measured from the front-back force graph (Fy_{PO}). We found the highest point of the curve that goes from the middle to the side of the foot (Fx_{HC}). It happens right after the heel meets the ground. The GRF amplitudes were adjusted to account for body weight and expressed as a percentage. TTP is when the heel first touches the ground and when the force on the ground reaches its highest point. The loading rate means how fast the force increases between the heel contacting the ground and the point where the force reaches Fz_{HC} on the vertical force curve (Fz_{HC}; Jafarnezhadgero et al., 2018). The measurement of the foot's FM was calculated in the following way: $FM = Mz - (Fy \times COPx) + (Fx \times COPy)$.

Mz is the moment around the vertical axis, x and y are the horizontal components of the center of pressure (COP), and Fx and Fy are the horizontal GRF components. Additionally, FM amplitudes were normalized with regard to BW × height. The measurements for run variables were added together and then divided by three to find an average (Jafarnezhadgero et al., 2018).

A remote EMG with eight pairs of surface electrodes was utilized to record the activity of the vastus lateralis (VL), vastus medialis (VM), rectus femoris (RF), gastrocnemius medialis (Gas-M), tibialis anterior (TA), biceps femoris (BF), semitendinosus (ST), and gluteus medius (GM) muscles of the right leg following the SENIAM recommendation (Hermens et al., 1999). The GRFs and electromyography data were put together using Nexus software. After the running tests, MVIC tests were done on each muscle to normalize the EMG.

Figure 2
The Location of The Force Plate and the Surface Electrodes

Training protocols

The hydrotherapy group performed training in the water over eight weeks with three sessions per week. The intervention program was designed progressively. Every training session started with a ten10-minute warm-up program, including walking and submaximal running exercises and a dynamic stretching program. Finally, every session ended with a five5-minute cool-down. Taken together, the duration of a single training session lasted 90 minutes. All participants were taught the exercises before they started training. Table 1 and Figure. 3 provide more knowledge about the training programme. The control group did not receive any training program during eight weeks. All participants were told not to do any other kind of exercise while the study was happening.

Table 1
Exercise Protocol of the Intervention Group

Protocols	Range of motion (20 minutes)	Strength (35 minutes)	Proprioception (20 minutes)
Hydrotherapy	1. Active exercises involve moving your foot underwater using a small flotation device called a water wing. You should move your foot by pointing it downwards and upwards and turning it inwards and outwards. As you get better, you can use more significant flotation devices. 2. Easy exercises for your calf muscles: stretch by standing with your leg straight and then with your leg bent.	1. Walk from one end of the pool to the other (try to go faster each time to make it more complicated). 2. Move forward to jogging or running in deep water. 3. Heel raises involve lifting your heels off the ground using both legs first and then one leg at a time. 4. Flutter kicking means moving your legs up and down while you are in the pool's deep end. You hold onto the side of the pool while doing this. As you get better, you can do it for a longer time. 5. One or both feet jump on a flat surface and move forward to reach the stars.	1. Doing balance exercises in the water involves standing on one leg and practicing balancing. Participants do these exercises with their eyes open or closed. 2. Move forward to unstable positions with your eyes open and then with your eyes closed.

Figure 3
Exemplified Exercises of the Intervention in the Water

Note: 1: Going up and down the stairs; 2: squatting in the water; 3: step on the spot.

Data Analysis

After deciding on the ordinary dissemination of information utilizing the Shapiro-Wilk test, we carried out the statistical analysis using separate 2 (groups: control and hydrotherapy) x 2 (time: pre-test vs. post-test) repeated measures ANOVAs. Post hoc investigations were calculated utilizing Bonferroni-adjusted paired sample t-tests. Additionally, effect sizes were determined by converting partial eta-squared (η^2_p) to Cohen's d. According to Cohen, $d < 0.50$ demonstrate minor effects, $0.50 \leq d < 0.80$ demonstrate medium effects and $d \geq 0.80$ demonstrate significant effects. The significance level was set at $p < 0.05$. All examinations were performed utilizing the SPSS version 20.0.

RESULTS

Participant characteristics and all outcome variables at baseline are illustrated in Table 2. There were no significant differences between the groups at the beginning for all examined variables.

Table 2

Group-specific Baseline Values of All Reported Muscular Activity and Kinetic Result Factors

Variables		Control group	Experimental group	p-value
Participant characteristics	Age (years)	22.35±2.33	22.85±2.11	0.390
	Haigh (cm)	177.07±0.07	177.40±0.07	0.900
	Weight (kg)	80.53±9.83	79.73±8.86	0.817
	BMI (kg/m2)	25.81±3.79	25.45±3.50	0.791
Kinetics	Fz_{HC}	180.90±18.28	174.57±31.45	0.506
	Fx_{HC}	3.01±4.56	2.89±1.46	0.838
	Fx_{PO}	-13.93±3.37	-13.91±4.23	0.990
	Fy_{HC}	-2.84±0.97	-2.84±1.20	0.752
	Fy_{PO}	3.15±1.15	3.37±1.66	0.675
	$TTPFz_{HC}$	117.57±31.45	119.47±21.47	0.800
	FM (negative)	-019±0.11	-0.17±0.08	0.904
	FM (positive)	2.03±0.52	2.06±0.43	0.740
	LR	1.63±0.54	1.57±0.36	0.730
EMG (early stance phase)	TA	62.53±20.60	65.76±16.74	0.641
	Gas-M	25.95±7.73	28.28±14.89	0.594
	VL	66.53±15.77	61.19±29.61	0.543
	VM	62.35±22.79	58.47±19.32	0.619
	RF	49.69±19.01	45.91±23.13	0.628
	ST	33.47±9.70	34.34±12.08	0.831
	BF	46.04±10.98	43.03±16.41	0.560
	Glut-M	35.03±12.43	38.04±17.48	0.591
EMG (late stance phase)	TA	55.47±27.94	64.76±21.53	0.317
	Gas-M	157.61±36.92	163.12±50.03	0.734
	VL	123.62±24.41	118.90±38.54	0.733
	VM	119.29±24.41	122.01±38.28	0.818
	RF	38.18±23.20	41.64±23.68	0.689
	ST	50.60±23.60	48.65±20.04	0.809
	BF	41.29±20.29	38.10±17.93	0.652
	Glut-M	92.34±29.83	96.74±33.01	0.705

Note. Fx_{HC}: top lateral GRF during initial contact, Fx_{PO}: top medial GRF during propulsion, $Fz_{HC:}$ top vertical GRF during initial contact, Fy_{HC}: braking force, Fy_{PO}: propulsion force, TTP: time to peak, y: anterior-posterior course, z: vertical course, x: mediolateral course, LR: Loading rate, VL: vastus lateralis, VM: vastus medialis, RF: rectus femoris, TA: tibialis anterior, Gas-M: gastrocnemius medialis, BF: biceps femoris, ST: semitendinosus, GM: gluteus medius

Significant major effects of "time" were observed for FzHC, FxHC, FxPO, FyHC, and positive FM ($p<0.041$; Table 3). Pair-wise comparisons revealed significantly lower FzHC ($p=0.032$), FxHC ($p = 0.007$), FxPO ($p = 0.041$), FyHC ($p = 0.028$), and positive FM ($p = 0.003$) in the post-test compared with the pre-test (Table 3). In addition, we observed significant major effects of "group" for TTP FzHC and LR ($p < 0.029$; Table 3). Pair-wise comparisons revealed significantly longer TTP FzHC ($p = 0.002$) and lower loading rate ($p=0.029$) in the experimental group compared with the control group (Table 3). Finally, the statistical analysis showed significant group-by-time interactions for FxHC, FyPO, TTP FzHC, and LR ($p < 0.021$; Table 3). In the experimental group, significantly lower FxHC ($p = 0.000$), FyPO ($p = 0.021$), LR ($p = 0.009$), and longer TTP FzHC ($p = 0.008$) were observed during the hydrotherapy Protocol (Table 3).

The statistically significant major effects of "time" were observed for TA and Gas-M muscle activities during the early stance ($p < 0.032$; Table 4). Pair-wise comparisons revealed significantly larger TA ($p = 0.032$) and Gas-M ($p = 0.005$) muscle activities in the post-test compared with the pre-test (Table 4). The statistical analyses illustrate significant major effects of "group" for TA, Gas-M, and BF muscle activities during the early stance ($p < 0.032$; Table 4). Pair-wise comparisons revealed significantly larger TA ($p = 0.023$), Gas-M ($p = 0.006$), and BF ($p = 0.032$) muscle activities in the experimental group compared with the control group (Table 4). Finally, we observed significant group-by-time interactions for TA, Gas-M, and GM muscle activities during the early stance ($p < 0.026$; Table 4). In the experimental group but not the control group, significantly larger TA ($p = 0.026$), Gas-M ($p = 0.002$), and GM ($p = 0.004$) muscle activities were observed during hydrotherapy Protocol (Table 4).

No statistically significant major effects of "time" were observed for muscle activities during the late stance ($p>0.05$; Table 5). The statistical analyses illustrate the significant main effects of "group" for TA muscle activity during the late stance ($p<0.030$; Table 5). The pair-wise comparison revealed significantly larger TA ($p = 0.030$) muscle activity in the experimental group compared with the control group (Table 5).

Finally, we observed significant group-by-time interactions for TA muscle activity during the late stance ($p < 0.035$). In the experimental group but not the control group, significantly larger TA ($p = 0.035$) muscle activity was observed during the hydrotherapy Protocol (Table 5).

Table 3

Data are Means and Standard Deviations for GRFs During Hydrotherapy in Adult Males with PF

GRF	Control				Experimental				Sig. (Effect size)		
	Pre	Post	CI 95%	%Δ	Pre	Post	CI 95%	%Δ	Time	Group	Group x Time
Fz_{HC}	180.90±18.28	168.65±30.10	171.61,6.43	-6.77	174.57±31.45	167.64±28.19	174.27,6.43	-3.96	**0.032(0.154)**	0.772(0.003)	0.396(0.026)
Fx_{HC}	3.01±4.56	3.30±1.57	2.44,3.87	9.63	2.89±1.46	1.79±0.85	1.63,3.05	-38.06	**0.007(0.230)**	0.110(0.089)	**0.000(0.473)**
Fx_{PO}	-13.93±3.37	-12.40±4.31	-14.95,-11.12	-10.98	-13.91±4.23	-12.65±5.46	-15.96,-11.37	-9.05	**0.041(0.140)**	0.854(0.001)	0.714(0.005)
Fy_{HC}	-2.84±0.97	-2.29±0.82	-2.93,-2.07	-19.36	-2.84±1.20	-2.23±1.02	-2.96,-2.10	-21.47	**0.028(0.161)**	0.915(0.000)	0.670(0.007)
Fy_{PO}	3.15±1.15	3.26±1.05	2.67,3.73	3.49	3.37±1.66	2.23±0.83	2.27,3.32	-33.82	0.054(0.126)	0.277(0.042)	**0.021(0.175)**
TTP Fz_{HC}	117.57±31.45	93.14±21.27	98.11,112.45	-20.77	119.47±21.47	125.05±12.25	115.09,129.43	4.67	0.084(0.103)	**0.002(0.296)**	**0.008(0.226)**
FM (negative)	-0.19±0.11	-0.16±0.11	-0.21,-0.13	-15.78	-0.17±0.08	-0.15±0.05	-0.20,-0.12	-11.76	0.253(0.238)	0.656(0.007)	0.966(0.000)
FM (positive)	2.03±0.52	1.91±0.51	1.76,2.18	-5.91	2.06±0.43	1.56±0.40	1.60,2.02	-24.27	**0.003(0.282)**	0.265(0.044)	0.055(0.125)
LR	1.63±0.54	1.91±0.60	1.55,1.99	17.17	1.57±0.36	1.28±0.43	1.21,1.64	-18.47	0.986(0.000)	**0.029(0.159)**	**0.009(0.222)**

Note. Fy_{HC}: braking force; Fy_{PO}: propulsion force; Fz_{HC}: peak vertical GRF during initial contact; Fx_{HC}: peak lateral GRF during initial contact; Fx_{PO}: top medial GRF during propulsion; FM: free moment; TTP: time to peak; LR: Loading rate; CI: confidence interval

Table 4

Data are Means and Standard Deviations for Muscle Activity in the First Stance Phase (%MVIC) During Hydrotherapy in Adult Males with PF

Muscles	Control				Experimental				Sig. (Effect size)		
	Pre	Post	CI 95%	%Δ	Pre	Post	CI 95%	%Δ	Time	Group	Group x Time
TA	62.53±20.60	62.15±21.07	54.47,70.22	-0.60	65.76±16.74	85.10±16.29	67.56,83.31	29.40	**0.032(0.154)**	**0.023(0.171)**	**0.026(0.165)**
Gas-M	25.95±7.73	24.60±15.81	18.39,32.16	-5.20	28.28±14.89	50.22±22.28	32.37,46.14	77.58	**0.005(0.244)**	**0.006(0.236)**	**0.002(0.293)**
VL	66.53±15.77	63.61±22.20	54.74,75.41	-4.38	61.19±29.61	66.12±21.01	53.32,73.99	8.05	0.814(0.002)	0.844(0.001)	0.360(0.030)
VM	62.35±22.79	59.77±18.14	53.22,68.90	-4.13	58.47±19.32	45.22±21.10	44.01,59.69	-22.66	0.134(0.078)	0.100(0.094)	0.307(0.037)
RF	49.69±19.01	46.03±18.95	39.99,55.74	-7.36	45.91±23.13	45.23±15.44	37.69,53.45	-1.48	0.634(0.008)	0.676(0.006)	0.743(0.004)
BF	33.47±9.70	33.05±12.50	35.95,45.61	-1.25	34.34±12.08	47.22±16.38	28.44,38.09	37.50	0.072(0.111)	**0.032(0.154)**	0.055(0.125)
ST	46.04±10.98	40.67±13.25	36.51,50.19	-11.66	43.03±16.41	42.28±17.28	35.81,49.49	-1.74	0.241(0.049)	0.883(0.001)	0.373(0.028)
Glut-M	35.03±12.43	31.10±11.15	26.38,39.76	-11.21	38.04±17.48	50.57±16.20	37.61,51.00	32.93	0.111(0.088)	0.724(0.090)	**0.004(0.262)**

Note. TA: tibialis anterior; Gas-M: gastrocnemius medialis; VL: vastus lateralis; VM: vastus medialis; RF: rectus femoris; BF: biceps femoris; ST: semitendinosus; GM: gluteus medius

Table 5
Data are Means and Standard Deviations for Muscle Activity in the Late Stance Phase (%MVIC) During Hydrotherapy in Adult Males with PF

Muscles	Control				Experimental				Sig. (Effect size)		
	Pre	Post	CI 95%	%Δ	Pre	Post	CI 95%	%Δ	Time	Group	Group x Time
TA	55.47±27.94	50.23±28.81	41.03,64.66	-9.44	64.76±21.53	78.33±21.53	59.73,83.36	20.95	0.336(0.033)	**0.030(0.158)**	**0.035(0.149)**
Gas-M	157.61±36.92	153.51±82.13	132.10,179.02	-2.60	163.12±50.03	179.41±50.03	147.80,194.72	9.98	0.648(0.008)	0.341(0.032)	0.447(0.021)
VL	123.62±24.41	117.41±55.52	101.52,143.03	-5.02	118.90±38.54	125.65±38.54	99.76,141.27	5.67	0.967(0.000)	0.903(0.001)	0.320(0.035)
VM	119.29±24.41	116.95±39.25	101.49,134.75	-1.96	122.01±38.28	130.87±38.28	109.82,143.07	7.26	0.597(0.010)	0.474(0.018)	0.367(0.029)
RF	38.18±23.20	36.76±20.97	27.72,47.22	-3.71	41.64±23.68	44.11±23.68	33.13,52.63	5.93	0.917(0.000)	0.429(0.023)	0.698(0.005)
BF	50.60±23.60	52.62±20.66	40.21,59.05	3.99	48.65±20.04	50.60±20.04	42.19,61.03	4.01	0.637(0.008)	0.763(0.003)	0.993(0.000)
ST	41.29±20.29	45.53±23.82	34.27,52.55	10.26	38.10±17.93	42.54±17.93	31.18,49.47	11.65	0.261(0.045)	0.629(0.008)	0.978(0.000)
Glut-M	92.34±29.83	87.38±41.04	74.91,104.80	-5.37	96.74±33.01	98.29±33.54	82.57,112.46	1.60	0.817(0.002)	0.464(0.019)	0.658(0.007)

Note. TA: tibialis anterior; Gas-M: gastrocnemius medialis; VL: vastus lateralis; VM: vastus medialis; RF: rectus femoris; BF: biceps femoris; ST: semitendinosus; GM: gluteus medius

DISCUSSION

This research aimed to appraise the effect of hydrotherapy on muscle activities and running kinetics in adult males with PF. In this study, hydrotherapy persuaded significant reductions in the first top of lateral and straight GRFs during initial contact, along with reduced LR. Nevertheless, lower limb injuries can be predicted by more fabulous LR and top straight strike GRFs (Adams et al., 2018). For example, greater strike force and LR values can be linked to orthopedic injuries like stress fractures (Crowell et al., 2010). Our findings showed that hydrotherapy has the potential to lower top strike straight GRFs and LR during running in adult males with PF. In this manner, the applied training program may have an injury-preventive outcome. Future research should auscultate whether standard hydrotherapy indeed diminishes the injury event. Injuries to the knee and hip joints can be caused by both top mediolateral and straight GRFs (McLean et al., 2003). Our results illustrated that hydrotherapy reduced top mediolateral GRFs.

It is essential to consider the emphasis of the FM as an indicator of the rotational torque practical to the lower limb from a clinical perspective. The hazard components for PF-dependent injuries, especially for runners, are believed to be too much twisting force on the lower limb. A force plate can be used in a clinical setup to quicklyassess this torque easily and in this study peak positive free moment decreased during hydrotherapy in adult males with PF. Inducing ankle joint pronation in natural individuals should be considered because it focuses on the immediate impact on the natural position of the foot, not necessarily the long-term factors. In other research that was executed on runners, the researchers established significantly higher free-time parameters in individuals with a history of leg fractures. In conclusion, these studies were done while running, and according to previous research, water plays a big role in how our body moves and torque is transferred to the lower extremity (Milner et al. 2006; Yazdani et al.,2020).

To compensate for the PF pose, greater GRFs are expected to be created by lower limb muscles that back the medial longitudinal arch in adult males with PF. Hence, we adjudged that the TA muscle activity, which chips into backing the medial longitudinal arch, would be greater in individuals with PF (Zhang et al., 2017). This adjudge is corroborated by our results, which show a greater TA muscle activity in the experimental group than in the control group. However, a previous study by Angin et al. reported lower foot muscle activities in PF compared to normal foot (Angin et al., 2014). Although they too, examined asymptomatic individual with PF, a conceivable clarification for the nonattendance of indications in their populace could be due to inadequate introduction to loading. Therefore, the creators guess that physical dynamics within the adult males with PF might have adjusted to control foot pronation by expanding the TA muscle activity and hence anticipate themselves from creating overuse injuries. Assist investigation is required to affirm this. It has been archived that PF is related to an increment in muscle actuation of outward invertor muscles and a diminish in muscle actuation of outward evertor muscles (Zhang et al., 2017). One clarification for this is that the invertor muscles are constrained to greater levels of enactment to keep the already everted foot from everting assist. This is often the case, we would anticipate to see seeing an increment within the constrain producing capacities, and thus morphology, in those muscles. We found a difference in TA muscle activity between the experimental group and the control group.

After hydrotherapy, our results showed that there was larger GM muscle activity during the first stance phase. In adult males with PF, the knock knee is associated with hip adduction during the first stance phase, as illustrated by previous studies. The hip abductor muscle activities are increased in this condition, mainly because of the increased activity of the GM muscle (Park et al., 2010). In expansion, the GM muscles' infirmity may increase the chance of supporting injuries ascribed to intemperate lower leg joint pronation (Ukoha et al., 2012). While running, the GM muscle shrinks to preserve lower appendage from the pelvis to the foot (Farahpour et al., 2018). Be that as it may, the foot muscle activities essentialare additionally basic within the mid-stance for maintaining a strategic distance from over-pronation. A lessening in pronation might result in expanded GM muscle action, leading to modern lower extremity alignment and GM muscle activation. Following our research and past research, we hold forth that hydrotherapy may be a viable rehabilitative that implies lower extremity injuries due to creating greater muscle activities (Barrett et al., 1998).

Hydrotherapy also demonstrated significantly higher Gas-M muscle activity in the post-test compared to the pre-test. According to the research, no study has examined the effects of hydrotherapy on the muscular activities of PF individuals. Moore, (2016) discovered a significantly higher peak activation of the gastrocnemius muscle during the late stance phase, which involves plantar flexion of the ankle joint. Another study found that if the foot rolls too much eversion during gait, it can also cause the tibia to rotate too much inward. This can make hip rotate inward more than usual, which also increases how much hip moves towards the center of your body, and may affect the angle of your knee (Clark & Lucett, 2010). Subsequently, expanding the activity of GM muscle alongside Gas may be expanded the hip abduction and diminish the ankle eversion individually.

Limitations

With respect to the ponder confinements, we tried youthful men, as it were. Subsequently, our discoveries are particular to this cohort and cannot fundamentally be applied to females, distinctive ages, or quiet bunches. More inquiry is required in this zone with distinctive age or understanding bunches. In this consideration, we did not record kinematic information. This ought to be discovered to investigate merging kinematic, dynamic, and EMG information in the future. Confiscating extra muscles such as the peroneus longus would be beneficial.

CONCLUSION

The sequels can be credited to the truth that adult males with PF need more diverse muscles for hydrotherapy. In this manner, we can approve the potential of water as an unused preparing fabric when endeavoring to upgrade running capacities, especially the running mechanics in adult males with PF. The expanded hip and knee extension of movement amid running in adult males with PF can be incompletely ascribed to the expanded electromyography actuation of the Gas-M and GM muscles. Even though a total assessment and consideration are essential, ours can give analysts and clinicians experience to anticipate or treat wounds in adult males with PF, particularly when managing running-related injuries in these subjects.

PRACTICAL IMPLICATIONS

Training in the water resulted in lower GRFs and higher muscle activities during the first stance phase. This might mean changes in the way the muscles and nerves in the lower legs work when adult males with PF run. In PF adult males, having stronger lower limb muscles and more stability in the upper leg might help make up for less stability in the lower limb. Adult males with PF could return to normal function sooner if they could perform hydrotherapy. Hydrotherapy can help improve your running by using different muscles and reducing the forces when your feet hit the ground. It can also help with how quickly the body absorbs the impact and how much run it twists when running. More research is needed to understand better to understand this better to understand this matter better.

Authors' contributions

The first author contributed to the visualization, validation, methodology, investigation, formal analysis, data curation, writing – original draft, writing – review & editing. The second author contributed to the validation, methodology, investigation. The third author contributed to the visualization, validation, supervision, resources, project administration, methodology, investigation, formal analysis, conceptualization, funding acquisition, writing – original draft, writing – review & editing.

Declaration of conflict interest

No conflict of interest is declared by the authors.

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