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The Effect of 12-Week Passive Aquatic Bodywork on Sympathovagal Balance of Obese Youth

Ertan Tufekcioglu[1], Mustafa Sait Erzeybek[2], Fatih Kaya[3], Goksel Ozan[4]

[1]Physical Education Department, King Fahd University of Petroleum & Minerals, Saudi Arabia

[2]Department of Physical Education and Sports, Dumlupinar University, Turkey

[3]Department of Physical Education and Sports, Faculty of Education, Erzincan University, Turkey

[4]ASFA Foundation for Education, Istanbul, Turkey

Correspondence: Mustafa Sait Erzeybek, Department of Physical Education and Sports, Dumlupinar University, Turkey.

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Abstract

Background: Obesity has been identified as a global epidemic that is associated with numerous comorbidities such as type 2 diabetes, hypertension, cancer, cardiovascular disease. We have investigated the effects of Watsu® therapy and Immersion on HRV parameters of obese male subjects.

Methods and Results: Volunteer 34 obese subjects with BMI above 30 without any other chronic health issues were included (age, 18.30±.31, height, 166.02±29.60, BMI, 36.54±5.96). Randomized controlled trial was conducted with Watsu and Immersion protocols whereas control group received no therapy in water or on land for 12 weeks. A baseline HRV was recorded 5 minutes in four different circumstances. Polar H7 heart rate sensor and digital standardized HRV signal processing software were used to record the R-R intervals in millisecond. The repeated measures were used to compare the conditions between the therapies. The HRV analyses were performed using three-way Mixed ANOVA. Multiple comparisons were done with a Bonferroni adjustment of the alpha level (0.05). The collective results of HF showed significant negative effect (13.01±1.36, 9.99±1.11) and HF laying supine value (20.62±2.22) was the highest ($p<0.05$).

Conclusion: A significant inverse correlation was found between HRV values and both therapeutic interventions. Counterintuitively, 12-week of watsu and immersion therapies decreased LF and HF.

Keywords: hearth rate variability, watsu, obesity, ımmersion, aquatic therapy

1. Introduction

Obesity has been identified as a global epidemic that is associated with numerous comorbidities such as type 2 diabetes, hypertension, cancer, cardiovascular disease (CVD) and sleep apnea (Eckel et al., 2004). The mechanisms that effect autonomic nervous system (ANS) functions of obese patients are not very clear (Hall et al 2002, Kalil & Haynes 2012, Smit & Minson 2012, Canale et al 2013).

ANS is a key factor in the regulation of energy balance glucose and adipose metabolisms, and body fat storage (Guariono et al 2017). In addition, obesity is considered as an independent risk factor for CVD and an important cause of ANS dysfunction (Poirier and Eckel, 2002). ANS dysfunction is considered an important mediator in the development of obesity-associated disease and insulin resistance (Hall et al. 2015).

ANS is a control system that acts largely unconsciously and regulates bodily functions such as heart rate, digestion, respiratory rate, pupillary response, urination, and sexual arousal (Kenney & Ganta 2014). The function of ANS can be assessed via a noninvasive Hearth Rate Variability (HRV) analyses (Task Force 1996). HRV is the variation of beat-to-beat R-R intervals recorded by an ECG (electro cardio gram) (Metelka 2014) and one of the most promising, amenable quantitative markers of the autonomic balance (Kamath 2015, Buchheit and Gindre 2006, Norris 2005). HRV has become very popular, as it opens a wide range of possibilities for the easy and noninvasive investigation of autonomic function in humans (Dong 2016, Mc Craty & Shaffer 2015, Thayer et al 2009). Alterations in HRV are predictive and associated with various cardiovascular diseases and pathological conditions, diagnosis of over-training, reflecting recovery status and aerobic performance (Ziegler et al 2006, Kluttig et al 2010, Adamson et al 2004, Al Haddad et al 2010). There is more correlation between body mass index (BMI) and HRV than regular physical activity (Rennie et al 2003). The controversial data on the associations between BMI and HRV could be the distribution of body fat (Windham et al. 2012). The excessive accumulation of fat tissue around the waist area leads to morphological changes in cardiac structure and function, even in the absence of other risks of heart disease (Poirier et al., 2004). HRV indices are displayed in time and frequency domain parameters (Shaffer & Gingsberg 2017, Task Force 1996). The frequency domain analysis permits the study of the sympathetic and parasympathetic contributions of autonomic control with some degree of separation (Hadase et al 2004). The selected frequency-domain measures in normalized units (n.u.) are (1) very low frequency power (VLFMS2) from 0.00 to 0.04 Hz; (2) low frequency power (LF) from 0.04 to 0.15 Hz; and (3) high frequency power (HF) from 0.15 to 0.40 Hz (Shaffer & Gingsberg 2017).

The findings of a number of studies (Schitter et al. 2015, Stan 2013, Kamioka et al. 2010, Becker 2009, Geytenbeek 2002) indicated that numerous psychological and physical benefits of aquatic physical therapy. Many pyschological and functional improvements can be achieved via aquatic therapies (Inoue 2013, Kesiktas et al 2004). The increased clinical implementation of watsu therapy in interdisciplinary treatment indicates a growing acceptance of this body-based complementary therapeutic intervention. Watsu® has been recognized and implemented as a relaxing therapy in many countries as a component in multimodal treatment settings focusing on posttraumatic stress disorder, and anxiety (Cole & Becker 2011, Dull 2008). The clear challenge in aquatic bodywork field especially in innovative watsu® therapy and its ramifications is the absence of studies with standardized protocols. Positive effects of manipulation and trigger points therapies on muscle relaxation and psychological state were observed (Zimmerman 2015, Bijari et al 2012, Sherman et al 2011, Björnsdotter et al 2010, Ditzen et al 2007, Moyer et al. 2004). In the preliminary studies, the positive effect of watsu® therapy on flexibility, relaxation and ANS activity was observed (Tufekcioglu and Hassanain 2016, Barbosa et al 2014, Tufekcioglu et al 2010). Watsu has been recommended for chronic pain and fibromyalgia (Faull 2005), depression (Maczkowiak et al 2007) and for patients with hemiparesis, multiple sclerosis, cerebral palsy, and spinal cord injury (Chon et al 2009).

Immersion may be beneficial in certain populations (Ronda 2014, Gruner 2009, Cider et al 2006] due to reduced gravitational forces and hydrodynamics. Chronic pain, cardiac conditions, hypothalamic-pituitary-adrenal axis activity to alleviate stress related disorders and obesity could be regarded as potential indications for immersion (Kelly and Kirschenbau 2011, Cider et al 2006, Kjellgren et al 2001). Water immersion triggers parasympathetic activity with colder temperatures likely to be more effective (Al Haddad 2010)

However, the effect of aquatic physiotherapeutic interventions including watsu therapy on cardiac autonomic modulation of the heart in obesity have not been investigated in a large-scale randomized trial. In our preliminary study, we hypothesized that Watsu® therapy has deeper effect on HRV of obese participants, compare to warm water immersion. HRV can reflect psychomotor state determining cardiac locomotor synchronization (CLS). To date, no aquatic therapy research has been done on the techniques that have potential improving effects on CLS. Therefore, purpose of this study was to assess and compare the effect of manipulative Watsu® therapy and passive immersion protocols on HRV parameters in steady, locomotor and non locomotor recordings.

2. Methods

We conducted the randomized controlled trial at the KFUPM college to investigate the effects of Watsu (W) and Immersion (I) in water on HRV parameters among obese peopling. Complete written and verbal information about the study were provided and written consent was obtained prior to participation. Volunteer 34 obese persons with BMI above 30 without any other chronic health issues, habit of smoking and alcohol were included. Participants with any disease histories that are known to affect the autonomic cardiac function, such as CV (cardio vascular) dysfunction, neurological diseases, or endocrine disorders, or if they are known to be taking medications were not involved in this study. The anthropometric values were collected using InBody 370, a body composition analyzer made by Biospace Co. in South Korea.

2.1 Experimental Design

Randomized controlled trial was conducted with Watsu and Immersion protocols whereas control group received no therapy in water or on land for 12 weeks. Collection of Data: We applied the following same procedure one day before and after the experimental therapy period. BP (blood pressure) was measured after 10 minutes rest in a silent room, right before HRV data recordings. A baseline HRV was recorded 5 minutes in each circumstances: 1. Laying supine (horizontal). 2. Sitting (vertical). 3. Walking (locomotor). 4. Cycling (non locomotor). All participants maintained food intake routine, avoided exercise and caffeine consumption during the previous 24 hours preceding the measurements. Participants consumed 500 mL of water 2 hours before the measurements. Polar H7 heart rate sensor and digital standardized HRV signal processing software called HRV+ were used to record the R-R intervals in millisecond. iPad-2 tablet pc that fully supports Bluetooth Smart (Bluetooth 4.0) were used for screening R-R intervals in ms. A Landice, model L-7 treadmill was used for locomotor HRV recordings at 4.5 km/hr walking speed. A Monark, model 686 cycle ergometer was used for non-locomotor HRV recordings at 50 W pedaling resistance and at 55 rpm. The obtained ECG data files were then transmitted to a personal computer as txt files. The frequency domain indices of HRV (VLFMS2, LF and HF N.U.) were calculated.

The measurements were initiated after participants confirmed positive feelings of four or more points on the 5-point scale. The following steps reinforced quality control of data collection: 1. Spectra 360 Electrode Gel was used on the skin before attaching the Polar H7 heart rate sensor for the continuity of precise signal detection. 2. Low power filter were performed in order to eliminate the noise in the recordings and then HRV indices in frequency domain were obtained using Kubios HRV 2.2 (bio-signal analyzing software)

2.2 Intervention Protocol

Each watsu therapy session started with a brief verbal description of the procedure. W.A.B.A. (Worldwide Aquatic Bodywork Association) certified professional watsu practitioner applied watsu-2 therapy protocol that includes stretches, trunk rotation, joint mobilization, vertebral traction/lengthening, deep breathing and pressure point work and rocking techniques in water. Immersion group spent the same time immersed without movement and/or receiving any therapy in shoulder depth warm water. Immersion and watsu therapies were performed for 30 minutes, twice a week for 12 weeks, between 5:00-7:00 pm in an indoor swimming pool. Temperatures of the pool water and air were 32 ℃ and 29 ℃. Post-intervention: The aforementioned procedure for the baseline data collection was performed one day after the experimental therapy protocol.

2.3 Statistical Analysis

The effect of watsu therapy and immersion were analyzed separately for each measurement in four positions (laying supine, sitting, walking, cycling respectively). The pretest and posttest time period including repeated measures were used to compare the conditions between the therapies. The frequency domain parameters (VLFMS2, LF, HF N.U.) were evaluated using three-way Mixed ANOVA (one between- and two within-subjects factors). Analyses were done with checks for sphericity. Multiple comparisons were performed with a Bonferroni adjustment of the alpha level (0.05). Mean and standart error were used for all the parameters. The level of significance was determined at $p \leq 0.05$ level. SPSS 20.0 computer program was used for all the statistical analyses.

3. Results

Table 1. Average anthropometric measurements and BMI values of the participants in each group (Mean ±SD)

Group	Age (year)	Height (cm)	Weight (kg)	BMI (w/h^2)
Watsu (n=13)	18.16 ±.27	171.31 ±6.54	108.05 ±20.52	36.58 ±5.58
Immersion (n=11)	18.34 ±.34	170.27 ±5.39	110.40 ±23.61	38.01 ±8.03
Control (n=10)	18.45 ±.26	154.46 ±53.96	102.16 ±15.17	34.86 ±3.34
Total (N=34)	18.30 ±.31	166.02 ±29.60	107.08 ±19.90	36.54 ±5.96

No significant differences ($p>0.05$) were seen in the baseline recordings of HF N.U. values of each groups (Watsu=11.99 ±1.68, Immersion=10.54 ±1.83, Control=11.99 ±1.92).

Considering the collective condition results of HF N.U. value (20.62 ±2.22), in laying supine (horizontal) are the highest ($p<0.05$) and decreased gradually in each following circumstances; sitting (vertical) 11.60 ±1.32, walking (locomotor) 7.27 ±0.92 and cycling (nonlocomotor) 6.52 ±0.66 (Figure 1). Findings are similar ($p>0.05$) to the HF N.U. value of each group (Figure 2).

The collective results of HF N.U. showed significant negative effect from pre to post test (13.01 ±1.36, 9.99 ±1.11, ($p<0.05$)). Significant decrease were also found in all groups results ($p>0.05$), which is contrary to our hypothesis (Figure 1).

In comparison of the groups, watsu group HF N.U. showed improvement only in the walking (locomotor) results, whereas immersion group improvement was only in cycling (nonlocomotor) results (Figure 2). However, the both group improvements are not significant ($p>0.05$). In addition, control group did not show any improvements in all condition results (see figure 2).

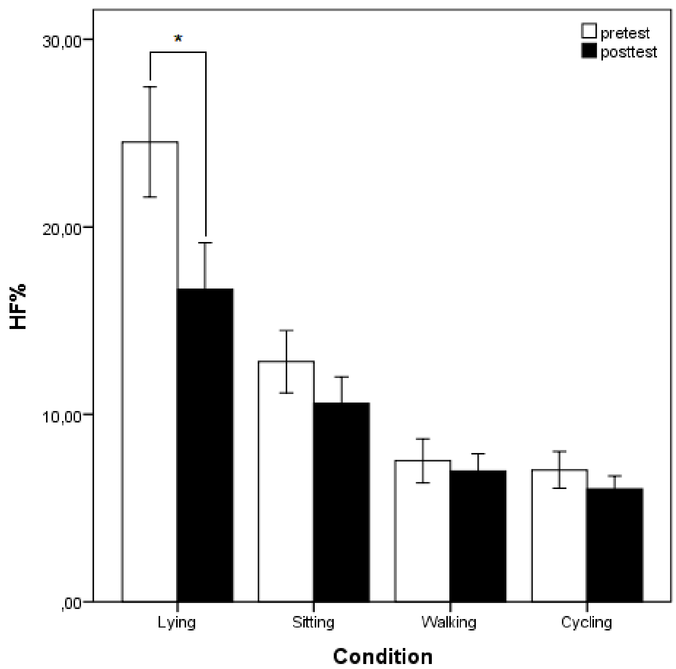

Figure 1. Collective HF N.U. recording results in all conditions (*p<.05), (+/-1 SE)

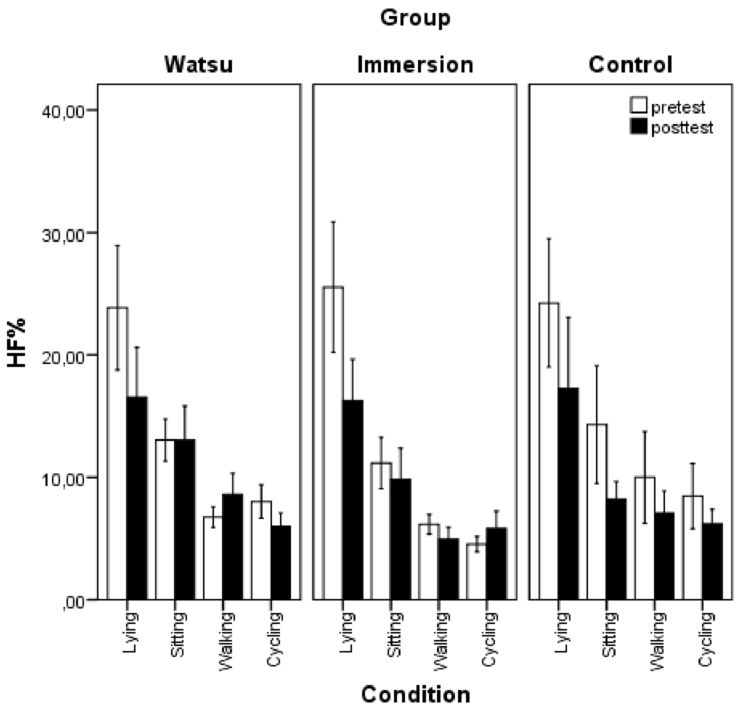

Figure 2. Groups HF N.U. average values in different recording conditions (+/-1 SE)

No significant differences were observed in LF N.U. of each group: Watsu=29.84±1.80, Immersion=31.63±1.96, control=30.35±2.05 (p>0.05). The LF value showed an insignificant increase in Immersion group cycling (non locomotor) and Control group laying supine (horizontal) position (p>0.05). The pre to posttest changes are similar for the groups in each circumstances (see Figure 3)

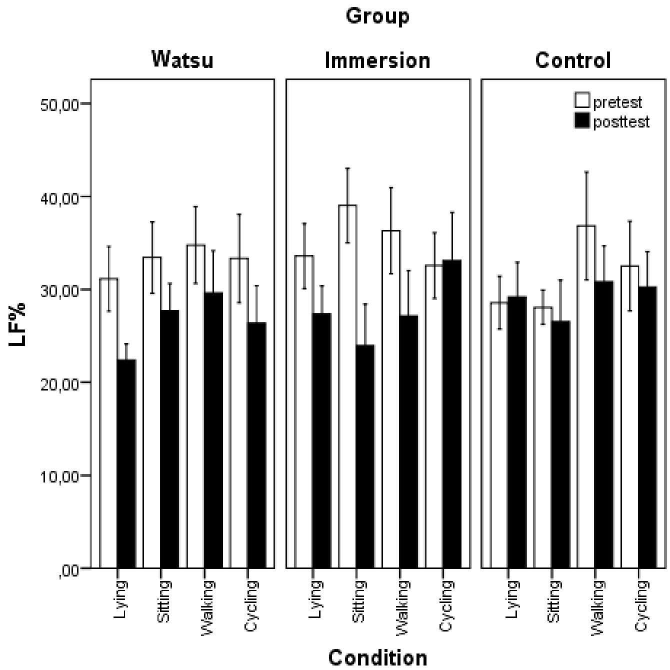

Figure 3. Groups LF N.U. average values in different recording conditions (+/-1 SE)

There was no difference between the groups VLF ms^2 (nu) values: Watsu®=58.13±2.71, Immersion=57.78±2.95, Control=57.72±3.09 ($p>0.05$). Collective result of VLF ms^2 (nu) increased from 53.65±2.06 to 62.09±1.90 ($p<0.05$). This is similar in each group ($p>0.05$). There was a gradual increase in order of four collective recording conditions VLF ms^2: 50.53±2.46, 58.56±1.84, 60.24±2.74, 62.16±2.53 respectively. The only significance was observed between horizontal and other recording conditions ($p<0.05$, Figure 4). These changes are similar in each group.

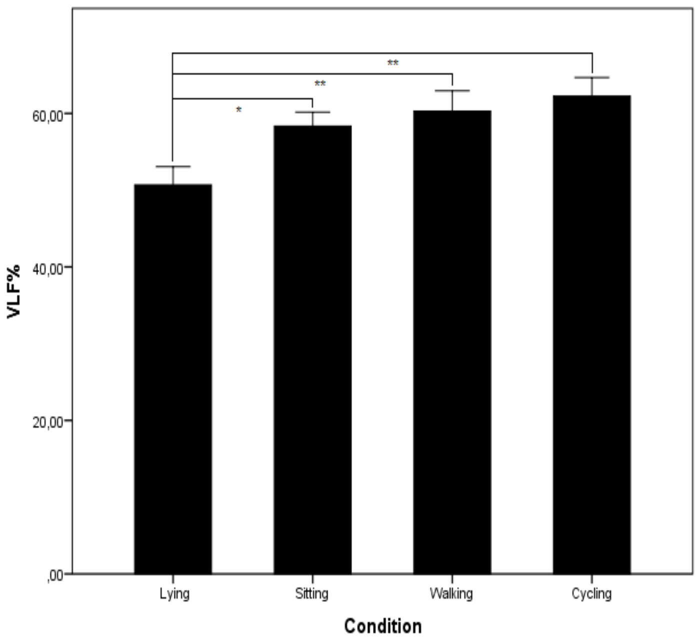

Figure 4. VLF ms^2 (nu) values in all conditions (*p<.05, **p<.01), (+/-1 SE)

VLF ms^2 result of each groups in each conditions are similar ($p>0.05$, Figure 5)

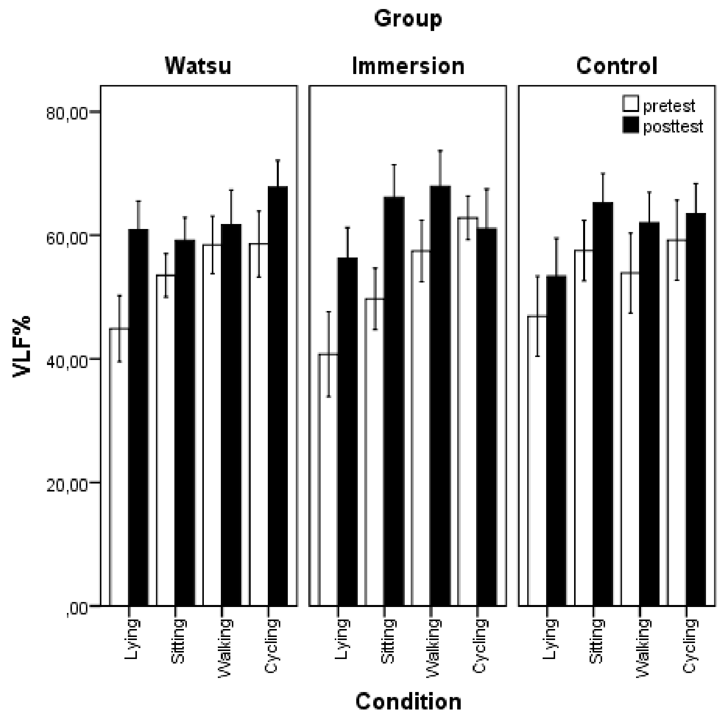

Figure 5. VLF ms^2 values in all groups (+/-1 SE)

4. Discussion

The correlation between relaxation and enhanced HRV indices especially in healthy people were revealed (Task Force 1996). However, many in vivo studies related to HRV resulted in unstable interpretation of the link between HRV, interventions and the interplay between ANS branches of different populations. The hyperthyroid patients' revealed significant differences compared to the controls in the HRV parameters (Chen et al 2006). The adaptive resources of ANS modulation is insufficient in fibromyalgia patients and in children with CP (Zamuner et al 2015, Kerppers et al 2009). Another study reported autonomic cardiac hypo responsivity to orthostatic stress in the obese group (Perini and Veicsteinas 2003).

Improved cardio vagal baroreflex sensitivity during water immersion increases PNS tone and HRV (Laurent et al 2008). Watsu is considered to be one of the promising method for acceleration in recovery, conservative and restorative functions and the activation of afferent C-tactile fibers (Schitter et al 2015). Mooventhan and Nivethitha (2014) suggested that balanced psychomotor state with increased sympathovagal balance and level of serotonin is due to the warmth and the massage effect of water.

Water immersion to shoulder-depth was shown to be PNS activator in many studies with colder temperatures to be likely more beneficial (Ottone 2014, Nagasawa et al 2001, Soni et al 2016, Kesiktas et al. 2004). In addition, passive immersion contributes to maximize muscle relaxation that is associated with a better vagal modulation i.e. enhanced HRV indices (Cider et al 2006, Schipke 2001, Petrofsky et al 2003). Watsu components may also lead to dampened muscle tone via vagal modulation as a side effect of vestibular system activation (Cole & Becker 2011).

The obese group presented higher BP and HR values at rest and autonomic impairment, characterized by a reduction in parasympathetic activity and relative predominance of sympathetic activity. The high value of the LFnu index and decrease in the obese group pointed to relative sympathetic predominance in these individuals (Rossi et al 2015).

The positive correlation between HF n.u. and LF n.u. shown by Goldstein et al (2011) was supported by our study. Del Paso et al. (2013) also showed LF as an indicator of PNS activity and Rossi et al. (2015) showed decreased LF value in obese group pointing sympathetic predominance which is in line with our study. We also confirm that LF component is no longer referred to a sympathetic index at all. Therefore, strong correlation found between HF n.u. and LF n.u. values in our study favors the abovementioned evidences for the current definitions of LF and VLF.

In our study, a significant inverse correlation was found between HRV values and both therapeutic interventions one of which included relaxing rotational stretches (Umphred 1995). Similar significant increase in VLF ms^2 after 12-week aquatic interventions was observed in line with another study (Becker 2009) suggesting warm water immersion significantly raises VLF ms^2.

In contrast to what preliminary studies showed in this first study with obese individuals, 12-week of watsu and immersion therapies decreased LF (n.u.) and HF n.u. Becker et al (2009) showed that exposure to warm water is associated with a significant decline in HF n.u. power in healthy individuals. In addition to that, in our study walking HF n.u. after watsu and cycling HF n.u. after immersion showed insignificant increase. Our findings illuminates the possible effect of aquatic interventions on psychomotor state in relation with CLS.

Due to the negative effects seen in all groups during the study period, we cannot infer causation from our study. Control group HF and LF n.u. decreased significantly (Figure 2, 3). Investigating the role that obesity plays in contributing to the etiology of ANS imbalance require also a bio-psychological perspective. These first findings of HRV on obese young individuals can encourage further studies of water therapies in different settings. Our study also favored using LF/HF ratio together with HF n.u. and LF n.u. due to the conflicting results. Researches addressing sympathovagal balance should include LF/HF ratio due to possible distortion of the estimation of LF and HF power in absolute units (ms2). We cannot infer direct positive link between the dysregulation of the autonomic nervous system and the water therapies in this first study. A more complete understanding of the role of warm water therapies and the SNS in obesity is necessary.

However, the inverse relation between ANS balance or HRV indices and both aquatic therapies could also be attributed to external factors such as having to fit the therapy sessions into daily schedule that may have played a role in. Such changes in perception can affect the emotions therefore ANS modulation.

To know the exact time of changes in HRV may help better understand of the possible variables effecting HRV. Additional recordings of HRV during the therapies and continues stress level questionnaires are recommended. In the light of these results, we also suggest synchronized multiple physiological recordings systems to be used in long-term studies. This first study showed that both therapies performed in water, in this population and setting was not effective in increasing HRV parameters. There is a substantial need for evidence-based research evaluating the specific effects of aquatic interventions on ANS activity in this population.

4. Limitations

The following limitations of this study need to be addressed. Measures of HRV by administering a 5-minute supine electrocardiogram is considered representative of 24-hour ambulatory recordings. Direct comparison with other studies is difficult, due to lack of standardized method for the frequency domain measures and therefore no universal unit. Both participants and assessors were not blinded. Possible influences of diet and energy intake were not examined in this study.

5. Conclusion

These findings suggest that multiple physiological recordings system should be a consideration in long-term HRV studies. In order to prescribe such therapies for obese population in warm water, longitudinal research with repetitive recordings to establish a specific therapy duration for obesity is required. Even though mechanistic and physiopathological studies strongly support aquatic interventions as promising approach, contrasting results in preliminary clinical trials exploring ANS modulation and aquatic interventions should be further investigated.

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