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Analysis of HRV and Blood Pressure Variables of Obese Male Subjects After Aquatic Therapies

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***Abstract*— This paper describes and analyzes blood pressure variables and 2 Heart Rate Variability (HRV) variables, namely RMSSD and Mean RR, after treatment with either immersion in water or WATSU® therapies of 26 obese young males. The objective of this paper is to show that subjects have shown a near random relation between systolic and diastolic blood pressures, before aquatic therapy of 26 obese subjects, and that the relation was corrected after aquatic therapy, in the sense that it demonstrated a near linear correlation and that is what is shown in medical literature. Also, the paper shows a correction of the relation between RMSSD and Mean RR HRV variables. These corrections highlight the significance of aquatic therapies for obese subjects as demonstrated by the results and analysis.**

***Keywords*— Obesity, Analysis, Systolic and Diastolic Blood Pressures, Heart Rate Variabilty variables.**

I. Introduction

This paper demonstrates that water treatment of young obese individuals improves blood pressure and HRV parameters. Twenty-six obese subjects were divided into 2 groups. One group received aquatic WATSU® therapy and the second group received immersion in water, only. Four positions were considered: sitting, walking, cycling, and laying down. Two treatments were considered, separately, water immersion, or WATSU®. The treatment continued for 3 weeks. HRV and blood pressure parameters measured before and after either intervention were RMSSD, pNN50, mean RR, stdRR, HF power percentage, LF power percentage, VLF power percentage, in addition to systolic and diastolic blood pressures. After both aquatic interventions some HRV and blood pressure parameters showed improvement, and some did not. For a full elaboration on the experiments and their outcomes, including the statistical significance of all HRV and blood pressure parameter outcomes, the interested reader is referred to reference [1].

Although systolic pressure outcome showed improvement that is statistically significant, as shown in [1], diastolic pressure did not. In this paper, we explore the improvements in the relation between systolic and diastolic pressure, plus RMSSD and Mean RR. In a future, more complete work, we will explore and analyze the improvement of all 11 HRV parameters of obese individuals and all situations, after water treatment, compared to individuals that did not receive the treatment.

II. A Brief Overview of Literature

Diastole occurs when the heart contracts to pump blood out, and diastole occurs when the heart relaxes after contraction, as shown in Fig. 1. It has been shown in the literature [2] that the relationship between systolic and diastolic blood pressures is linear. A plot of such a relationship for 250,000 normal subjects is shown in Fig. 2, below. An inspection of Fig. 2 may conclude that the relationship is near the general mathematical y = x line, on average. The reason for this is that when the two pressures work with almost the same amount of time then there is harmony in the heart pumping of blood and that is a sign of normal heartbeat. This is also a sign of a healthy and active parasympathetic nervous system [1].

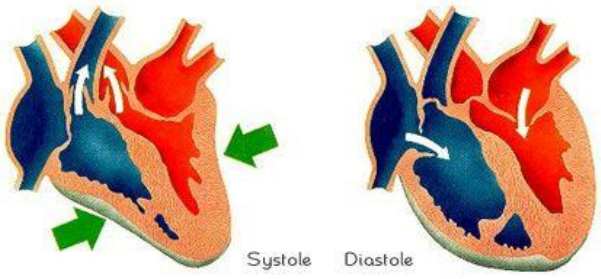


Fig. 1 Systolic and diastolic pressures of the heart.

RMSSD is measured in msec and is normally defined as the root mean square of successive RR interval

differences, while Mean RR is also measured in msec and is defined as the average (mean) of RR intervals. RR intervals are measures of the time between the R peaks of QRS complexes in a given ECG signal [1], [4]. Normal RMSSD and Mean RR functioning exhibit a near quadratic relation, as shown in [3]. Fig. 3 shows a plot of this relationship and Equ. 1 demonstrates the reason for the quadratic relationship, mathematically [5].

$$\text{RMSSD} = \langle (\Delta RR_i)^2 \rangle^{1/2} \quad \text{Equ. 1}$$

such that:

$\langle . \rangle$ is the mean symbol,

RR_i represents the ith value of the RR interval time series sampled at time intervals $t_i = [t_1, t_2, \cdots]$, where,

$RR_i = t_i - t_{i-1}$.

Therefore, RMSSD is a quadratic mean of values with exponent 2 in its root mean square.

It is worth mentioning that RMSSD and Mean RR are heart rate variability variables, while systolic and diastolic blood pressures are not.

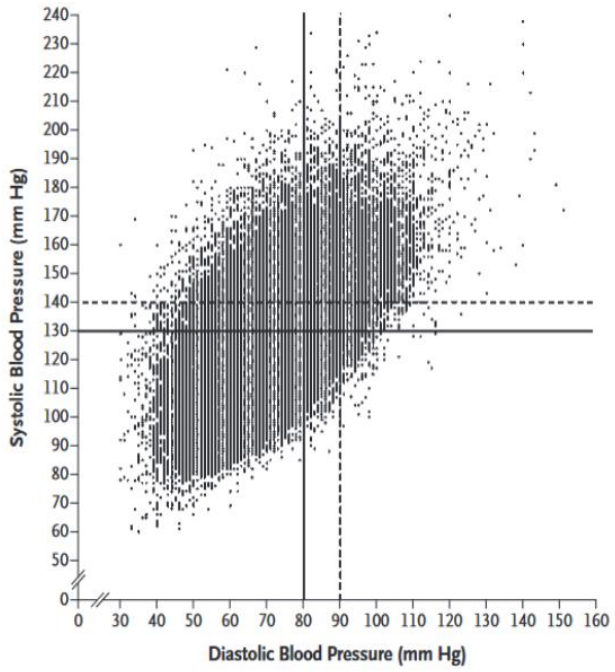


Fig. 2 The Relationship between Systolic and Diastolic Blood Pressures and Distribution of Blood-Pressure Measurements for 250,000 normal subjects (Reproduced from [2]).

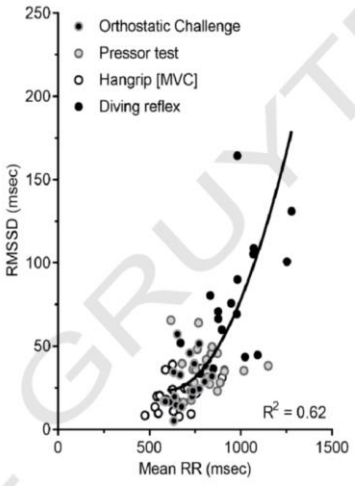


Fig. 3 The Relationship between RMSSD and Mean RR show a near quadratic relationship (Reproduced from [3]).

III. Results and Analysis

Upon exploring statistical correlation between systolic and diastolic blood pressure outcomes, the correlation improved from 0.42 to 0.73, after aquatic therapy [1]. Furthermore, a plot of systolic versus diastolic pressures before treatment demonstrates a near random pattern (Fig. 4). A plot of both pressures after aquatic treatment show a near linear relation (Fig. 5). A linear relation between systolic and diastolic pressures is the normal relation between the two pressures, as shown in medical reference [2]. It is worth noting that the although the relationship have been corrected but the curves mean line is not expected to go through the origin, like in Fig. 2, because Fig. 2 exhibits data for normal subjects while Figs. 4 and 5 exhibit data for obese subjects.

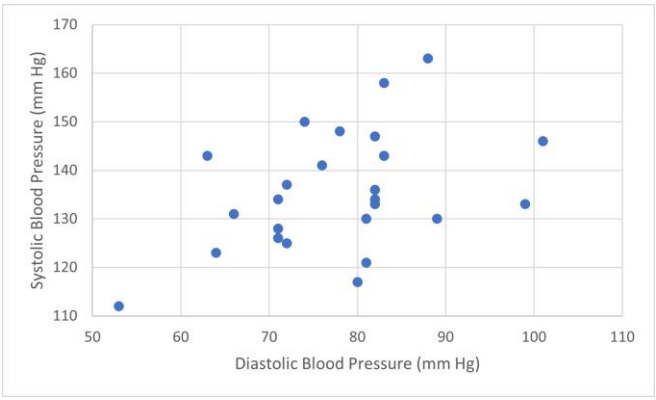


Fig. 4 Systolic versus Diastolic blood pressure results for obesity patients for the laying down position, before aquatic therapy, shows nearly random relationship

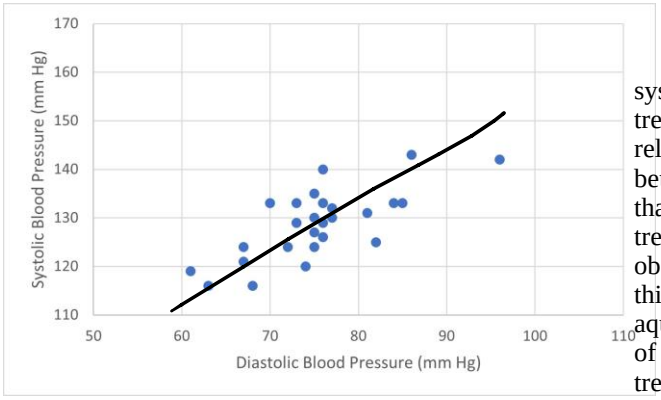


Fig. 5 Systolic versus Diastolic blood pressures results for obesity patients for the laying down position, after aquatic therapy, shows linear relationship

Plots of Mean RR and RMSSD data results are shown in Figs. 6 and 7, before and after aquatic therapy, respectively. Fig. 6 shows that the relationship between Mean RR and RMSSD is almost linear. It is clear that the aquatic therapy has corrected the relationship, compared to the literature [3], in the sense that the relationship between Mean RR and RMSSD have become quadratic, as shown in Fig. 7.

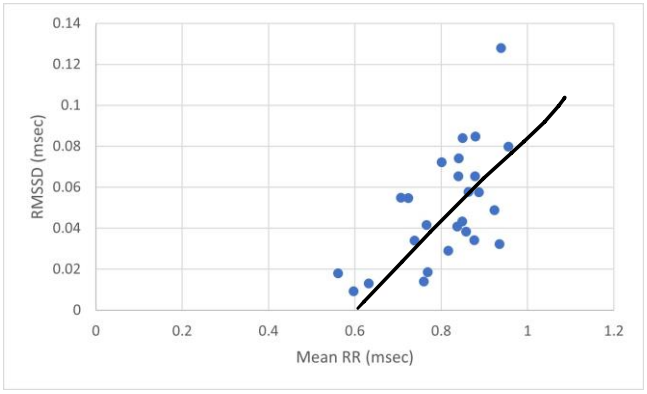


Fig. 6 Mean RR versus RMSSD results for obesity patients for the laying down position, before aquatic therapy, shows near linear relationship

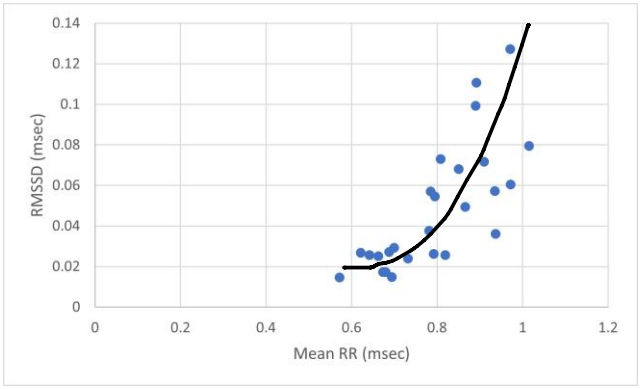


Fig. 7 Mean RR versus RMSSD pressure results for obesity patients for the laying down position, after aquatic therapy, shows quadratic relationship

IV. Conclusion

This analysis paper shows that the relation between systolic and diastolic pressures has improved after water treatment, in the sense that it has become a linear relationship. Furthermore, we have shown that the relation between Mean RR and RMSSD has improved, in the sense that it has become a quadratic relationship, post water treatment. Both experiments were performed for young obese subjects in the laying down position. All results in this paper are for a combination of immersion and Watsu aquatic therapies. These improvements for blood pressures of 2 HRV variables provide further evidence that water treatment improves blood pressure and HRV parameter results, which means that there is improvement in the parasympathetic nervous system and general heart health of the subjects.

V. Future Work

We plan to continue our analysis of the obesity dataset for all 4 situations, laying down, sitting, walking, and running, and to carry out experiments that analyze the possible differences between water treatment using Watsu versus water treatment using immersion only, and then, to compare the results to the combined water treatment methodology.

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