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Effects of sport education and teaching style on cardiovascular activation of HRV during physical and mental conditions in female students

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1 Problem presentation and state of knowledge

Musculoskeletal symptoms, strain sensation and physical implications are common medical conditions among computer workers. At present, however, more and more students experience musculoskeletal injuries and discomfort (Trimmel & Bachmann, 2004; Harris & Straker, 2000). The increase in number of students suffering from musculoskeletal pain is assumed to be related to increased computer and laptop usage in a school environment. Particularly, the implementation of laptop classes indicates higher laptop use among students. In school and at home, students are exposed to prolonged poor sitting positions which in terms lead to increased support work for trunk, neck and shoulder muscles. Furthermore, stress at school, increased workload, mental demands and inactivity may indicate supplementary discomfort. Physical activity is supposed to prevent musculoskeletal pain and has beneficial effects on the cardiovascular system which are well investigated (Jouven et al., 2005; Arai et al., 1989). The heart rate variability (HRV), which is also known as a global fitness parameter, is a well recognised indicator for cardiovascular activity. Investigations postulate that an increased HRV indicates health and fitness (Wecht et al., 2006). Particularly physical exercise programs involving the affected body parts seemed to be promising in reducing musculoskeletal symptoms (Bernaards, Ariens & Hildebrandt, 2006).

Rhythmic-musical physical education, also known as *rhythmic*, is becoming very popular in recent years. Teachers, students and rhythmic performers are convinced of the advantageous impacts of rhythmic exercises. At present, the effects of rhythmic on the human organism are generally based on theoretical assumptions. Empirical investigations of HRV and rhythmic were not available.

Therefore, the aim of the following study was to investigate the effects of sport education and teaching style on HRV parameters during mental and physical study conditions. It was focussed on the impacts of traditional physical education compared to rhythmic education. Furthermore, potential differences between laptop students and non laptop students in autonomic responses were evaluated. Supplementary, self-reported physical activity, body discomfort and computer use were measured by evaluating filled questionnaires.

1.1 Principles of cardiovascular activity and physiological origins

Cardiovascular psychophysiology examines the impact of psychological events and focus on the influence and complex relationship they have with biological processes. Brownley, Hurwitz and Schneiderman (2000) give a review about the basic anatomy and physiology of the cardiovascular system and introduce several techniques to measure cardiac function. They outline individual differences, response tendencies and psychosocial factors which affect the cardiovascular process and examine the nervous regulation and interactive nature of parasympathetic and sympathetic cardiac control during behavioural settings.

The cardiovascular system consists of the heart, the blood and the blood vessels. It interacts with the pulmonary system which transports oxygen and nutrients to the tissues, it removes waste products from the metabolism and distributes and even secrets some hormones itself (Levick, 1995). A measurement of cardiovascular activity is the heart rate (HR) which denotes the number of heart beats per minute. Porges and Byrne (1992) have proposed that the neurally controlled fluctuations and variability in the heart rate pattern reflect health, well-being and various mental states like stress, emotion and alertness. Equally according to exercise and physical activity, investigations highlighted a positive impact of sport on cardiovascular activity of HR. Wecht et al. (2006) report that a high HRV means good health and fitness. Hence, HRV measures may be considered a powerful tool to elaborate the relationship between psychological and physiological processes with regard to neural mediation of cardiovascular reactivity (Berntson et al., 1997). On this account, HRV is an indicator for the neurovegetative activity and autonomic function of the heart. It describes its capacity to adapt effectively to exogenic and endogenous influences (under resting conditions) and reflects the regulation of the whole Organism. Therefore, HRV is also referred to as a global fitness parameter (Hottenrott, 2002).

1.1.1 Electrical events of the cardiac cycle – The electrocardiogram (ECG)

Heart beat is initiated by an electrical system which is situated inside the heart and is composed of modified muscle cells. This electrical conduction system consists of the sinoatrial node (SA node), the atrioventricular node (AV node), the Bundle of His and the Purkinje system. The SA node is a small group of cells located on the posterior wall of the right atrium. Furthermore, the SA node is the primary pacemaker which intrinsically

determines the heart rate. These cells spontaneously depolarize and repolarize at a heart rate that exceeds the self-excitability rate of the other cardiac pacemakers. Hence, the SA node initiates an electrical impulse which spreads across the myocardium, activates the AV node and heads to fast-conducting fibres, the bundle of His and the Purkinje system, and causes the heart to contract (Brownley et al., 2000). The ECG records all electrical impulses that stimulate the heart and are obtained through electrodes from the skin surface. Potential changes of a single cardiac cycle are recorded in the ECG through three main deflections (waves and intervals) that mark their beginning and end (figure 1.1).

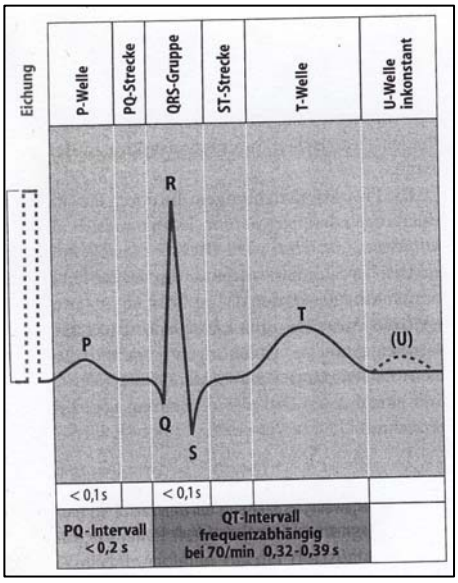


Figure 1.1: Exemplary electrocardiogram (ECG) recording (from Schmidt, Thews & Lang, 2005, p. 567)

Each wave and interval conveys explicit information regarding the electrical conduction system or the metabolic state of the heart. As a result, electrical activation and contraction of the atria (depolarization) is designated by the P-wave. Electrical stimulation of the ventricles corresponds to ventricular depolarization which is recorded as the QRS complex. Repolarization of the ventricles is represented by the T-wave. The interval between the beginning of the P-wave and the beginning of the QRS complex is called the PR interval. It represents the atrial depolarization time, the subsequent delay in the impulse transmission at the AV node, and the overall passage conduction time. In human ECG the PR interval usually lasts between 120 and 200ms. The ST segment arises at the "j-point" of the QRS complex, which indicates the end of the S-wave and the point designated by the return of the ECG tracing to its isoelectrical baseline. The beginning of the T-wave and its

completion of ventricular repolarization represents the end of the ST segment (Brownley et al., 2000; Levick, 1997).

The R-wave is used for time registration of a single heart beat because it's easier to identify. The time between heart beats is also referred to as heart period or RR interval. NN interval (normal to normal) is defined as all intervals between contiguous QRS complexes. Moreover, HRV is not only used as a term to describe the oscillation in the interval between successive heart beats (RR intervals) but also as the variation between consecutive instantaneous heart rates (Task Force, 1996).

A healthy adult's heart rate at rest normally has an average of 60 heart beats per minute. However, the rhythmic beating doesn't occur after every second or 1.000ms but varies considerable every heart beat episode (Hottenrott, 2002). Figure 1.2 demonstrates the naturally occurring beat-to-beat variations in heart rate at rest.

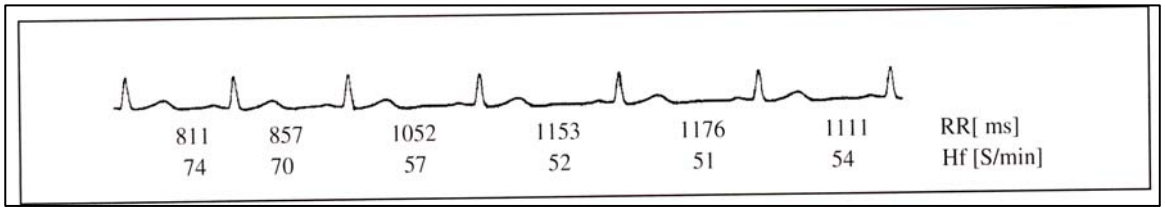


Figure 1.2: Exemplary illustration of six heart beats (RR-intervals) derived from the ECG (from Hottenrott, 2002, p. 10)

1.1.2 Nervous control of the heart rate – Parasympathetic vs. sympathetic activity

Since heart rate is neurally regulated, patterns of heart rate recordings indicate the activation status of the nervous system and, therefore, serve as a "window to the brain" (Porges & Byrne, 1992, p. 96). The irregular rhythmic, also known as arrhythmic beating and moment-to-moment variations in heart rate are the results of the continuous feedback between the central nervous system and autonomic responses (Porges & Byrne, 1992). The Institute of HeartMath (IHM), who conducted an overview of heart research, declares that this adaptability of the HR is due to the synergistic action of both the sympathetic and the parasympathetic divisions of the autonomic nervous system (ANS). While sympathetic fibres are the activating and mobilizing part of the autonomic nervous system, parasympathetic fibres act in more quiescent moments which have inhibitory functions and allow regeneration processes (Institute of HeartMaths Research Staff, n.d.). Similarly, the two antagonists control cardiac output. Sympathetic activity contributes to an increase in

HR and leads to lower variability in heart beats. The parasympathetic nervous system decreases HR and at the same time, shows an augmentation in irregular beat-to-beat fluctuations (Berntson et al, 1997). The inhibitory cardiac responses to parasympathetic activity, thus, modulate HR effectively at all frequencies between 0 and 0.5 Hertz (Hz). This mediation via the vagus nerve is due to acetylcholine release. On the contrary, cardiac responses to sympathetic activity modulate HR only below 0.1 Hz and is characterised by a pure time delay (about one or two seconds) which predominantly results from adrenalin and noradrenalin (Berntson et al., 1997). This is manifested by the slow HR gain with beginning physical activity and the comparatively fast lowering of HR immediately after exposure (Hottenrott, 2002).

However, most organs are stimulated from both branches of the ANS, and consequently they receive increasing and decreasing impulses simultaneously. Hence, depending on the net effect of the parasympathetic nerves and the sympathetic nerves at any moment, HR will either slow down or accelerate. These variations in heart rhythms are influenced by psychological states, physical exercise, age and gender (Institute of HeartMaths Research Staff, n.d.).

1.1.3 Measurement and methods of HRV

For the quantification and interpretation of HRV the length of the measurement is crucial. Consequently, analyses are strictly distinguished between short-term and long-term recordings. While short-term recordings incorporate ECG patterns of five minutes or less, long-term recordings illustrate analyses of entire twenty-four hours (Task Force, 1996). Most analytical methods are distribution-based on mathematical foundations. In this case NN intervals express variability as a set of temporally unordered data which can be evaluated by conventional statistical measures or by the geometric properties of histograms or other graphical representation (Malik, 1995, as cited in Berntson et al., 1997). These statistical and geometric measures are also referred to as time domain methods. Additionally, various spectral methods and different spectral components can be calculated and applied for the analysis of the tachogram.

1.1.3.1 Time-domain methods.

Time domain methods visualize both the change in heart beat rate for different points in time and determine intervals between successive normal QRS complexes in a continuous

ECG record. For general use in clinical studies examples of calculated time domain variables include the mean NN interval, the mean HR, the difference between the longest and the shortest NN interval and the difference between night and day HR. Variations in instantaneous HR secondary to respiration, or tilt can be used to describe differences in HR or circle length (Task Force, 1996). More complex statistical time domain measures can be calculated from one of the following: direct measurements of the NN intervals, instantaneous HR, and differences between NN intervals. These variables may be derived from analysis of the total ECG recording or, as recommended by the Task Force (1996), calculated by using smaller segments of the recording period which allows comparing HRV parameters under different conditions like rest, exercise or sleep. The most conventional measure of HRV is the standard deviation of all normal heart periods (SDNN) which reflects all the cyclic components responsible for variability within a recording epoch. Although SDNN estimators encompass short-term high-frequency variations as well as the lowest-frequency components it should be considered that the total variance of HRV increases depending on the length of the recording period and, therefore, it's not a well-defined statistical quantity (Saul, Albrecht, Berger & Cohen, 1987, as cited in Task Force 1996). The recommended estimate of short term variability (Task Force, 1996) is the square root of the mean squared differences between adjacent NN intervals (RMSSD). Other short term measures derived from interval differences include NN50, which is described as the number of pairs of successive NN intervals differing by more than 50 ms in the entire recording and pNN50, which represents the proportion derived by dividing NN50 by the total number of NN intervals (Task Force, 1996). Statistical quantities and geometric patterns can be constructed using NN interval histograms.

1.1.3.2 Frequency-domain methods.

For the analysis of the tachogram various methods of power spectral density (PSD) have been employed to obtain basic information of how the total variance (power) distributes as a function of frequency (Task Force, 1996). As specified in an assessment of autonomic function by Pomeranz et al. (1985) heart rate spectral analysis provide a powerful non-invasive tool for quantifying autonomic nervous system activity and cardiovascular regulation in health and disease. There are two methods most commonly used for spectral analysis which are based on the fast Fourier transform (FFT) and autoregressive (AR) modelling. The difference between FFT and AR approaches is the way in which data are

viewed. The spectrum resulting from the FFT is derived from all data present in a recording epoch whereby the analysis assumes that the time series contains only deterministic components. Furthermore, the FFT technique includes the entire signal variance, regardless of how well the data fit a model based on peaks in the spectral distribution. In contrast, the AR procedure treats data as a mix of deterministic and stochastic components and raw data (time domain) are used to identify a best-fit model from which the final spectrum and a variable number of peaks are derived. The components of the signal not fitting the model are treated as noise and on this account excluded (Berntson et al., 1997). Parati, Saul, Di Rienco and Mancia (1995) recommend the AR methods, especially when attention is focused only in heart rate rhythmic fluctuations driven by a fixed-rate oscillator. AR methods are able to identify the central frequency of the oscillation in an analytic way and therefore, are best suited when only a small number of samples are available for the analysis. In contrast to the FFT method which is dependent on the length of the recording the frequency resolution of the AR-derived spectrum is more stable concerning the duration of the ECG signal.

Spectrum components calculated from short-term recordings include very low frequency (VLF) components, low frequency (LF) components and high frequency (HF) components. Moreover, a variable of 5-minute total power (TP) can be analysed, which illustrates the variance of NN intervals over the temporal segments. Long term recordings analyse the sequence of NN intervals of an entire 24-hour period. Ultra low frequency (ULF) components and the slope of the linear interpolated spectrum in a log-log scale (α) can be assessed in addition to the aforementioned components (VLF, LF, HF, and TP) (Task Force, 1996). Power components are usually expressed as absolute values of power (milliseconds squared, ms^2). Additionally, LF and HF components may be expressed in normalized units (nu) which is illustrated in table 1.1.

Table 1.1: Normalized units description of low- and high- frequency components (from Task Force, 1996)

LF nu = LF ms^2 / (TP ms^2 -VLF ms^2) x 100
HF nu = HF ms^2 / (TP ms^2 -VLF ms^2) x 100

The normalization procedure consists of dividing the power of a given spectral component by the total variance diminished by the power of the VLF (below 0.03 Hz)

component, when present, multiplied by 100. The use of the normalized units facilitates comparison between spectra with large differences in total variance. Moreover, normalized units emphasize the controlled and balanced behaviour of the two branches of the autonomic nervous system (Task Force, 1996).

1.2 Effects of physical activity on human organism

1.2.1 Associations between physical activity and health

Beneficial impacts of regularly performed exercise are well investigated and research supports the popular belief that physical activity and health sports are associated with various components of well-being and psychological health. In their meta-analysis Netz, Wu, Becker and Tenenbaum (2005) examined the effect of exercise on well-being in older adults without clinical disorders. Comparative data indicated a positive relationship of physical activity and overall well-being, self-efficacy and view of self. Moreover, they observed a significant moderating effect of improvements in cardiovascular capacity and strength, especially in daily functioning. Essential health gains can already be obtained through moderate leisure and recreational sports as well as enjoyable body movements. This is also maintained by Netz et al. (2005) whose findings indicate that older adult's physiological well-being benefits most from moderate exercise. In accordance with the previous results Galper, Trivedi, Barlow, Dunn and Kampert (2006) suggest modest volumes of weekly physical activity to gain greater emotional well-being. In their study they used an objective marker of habitual physical activity by measuring cardiorespiratory (CR) fitness with a standardized maximal treadmill test. Their data indicated a positive dose-response association between physical activity, maximal CR fitness and emotional well-being. Additionally, they observed an inverse association of habitual physical activity and depressive symptomatology.

1.2.2 Advantageous impacts of exercise and training on autonomic processes

Further investigations also deal with the effects of physiological correlates on physical activity with respect to autonomous nervous system responses. Although improvements of cardiovascular activity regarding exercise and fitness could be demonstrated, the impact of training induced changes on the relative role of sympathetic and parasympathetic influences, however, is still inconsistent. Fluctuations of heart rate at frequencies above 0.15 Hz are

considered as the HF component. The HF band is mediated almost entirely by the vagus and is usually directly associated with respiratory activity. In consideration of impacts with respiration inputs Arai et al. (1989) demonstrated changes in autonomic tone during recovery and from exercise by using short data records of 64 seconds for spectral analysis. They found a 90% reduction in respiratory sinus arrhythmia (RSA) which shows a decline in HF power from rest phase to peak exercise. This indicates a dramatic fall in parasympathetic activation during exercise. Concerning the recovery phase, HF power showed higher rebound levels during early recovery compared to late recovery levels. Arai et al. (1989) suggested that this effect might be caused by increased respiratory tidal volume during early recovery. In contrast, the normalized HF component demonstrated a smooth increase until the end of measurement. By analysing LF power they observed a similar trend to that in the HF power analysis, namely a marked reduction in LF during exercise with a rebound during early recovery (Arai et al., 1989). In concordance with Akselrod et al. (1981) and Pomeranz et al. (1985) it is assumed that LF heart rate fluctuations reflect both sympathetic activity and parasympathetic activity. According to Hoos (2006) a general change in autonomic regulation of heart rate during moderate exercise results in increased sympathetic activity and reduced parasympathetic influences. This effect mainly depends on the intensity of exposure but reflections in the HRV power spectrum are unpredictable. Arai et al. (1989) concluded that the combination of parasympathetic withdrawal and sympathetic activation and the rise in heart rate during exercise is caused by the large decrease in HF power which at the same time led to reductions in LF power. This mechanism maintains a sympathetic-parasympathetic balance. Hoos (2006) postulated that also the total power variability dramatically reduces with exercise which results in modulation of both spectral bands. That is the high-frequency as well as the low-frequency component. However, research according to the relative role of vagal activation and sympathetic activation under exposure is still inconsistent.

Pagani et al. (1986) tested the hypothesis that spectral analysis of HRV could provide an assessment of sympathetic tone and found a large increase in LF power during upright posture. Furthermore, they found a reduction in LF/HF ratio at rest and an increase during tilt (orthostatic stress). They suggest that the LF variable, expressed in normalised units, and the ratio between LF and HF heart rate power (LF/HF), expressed in percent, indicate sympathetic activity. Further observations by Malliani, Pagani, Lombardi and Cerutti (1991,

as cited in Task Force 1996) designate that LF heart rate rhythms reflect mainly sympathetic outflow when expressed in a normalized unit and hence, can be considered as a marker of sympathetic modulation. Regarding inconsistent interpretation Arai et al. (1989) suggest that frequency fluctuations associated with the LF component may also be related to baroreflex activity, temperature regulation and maintenance of homeostasis during various cardiovascular stresses. Seeing that, La Rovere et al. (1992) tested the effectiveness of physical activity on autonomic balance in subjects with a first and recent myocardial infarction. They analyzed spectral HRV components at rest and during 70° head up tilt before and after a 4-week exercise training. Significant changes were observed in the tilt condition after physical exercise. Trained participants show an increase in the LF component and a decrease in the HF component in the spectral profile. The authors reported that these findings indicate a potential improvement of the autonomic balance. Although no changes were found in untrained patients as well as in the resting condition in both groups, La Rovere et al. (1992) suggest that physical training may induce higher parasympathetic activity, which can be demonstrated through increased baroreflex activity. Furthermore, the rise in the LF component of HRV after orthostatic test indicates a wider sympathetic reactivity as well. Nevertheless, disagreement and controversial outcomes persist in the interpretation of the LF component.

1.2.3 Autonomic recovery and physical activity

In view of the recovery period after exercise, heart rate is known to decrease and reflects both sympathetic withdrawal and parasympathetic reactivation. Current research was conducted by Cole, Blackstone, Pashkow, Snader and Lauer (1999) who have shown that a delayed fall in heart rate after exercise is a marker of depressed vagal activity and, therefore, is associated with an increased mortality. Supporting evidence with this contention was provided by Jouven et al. (2005), who proposed that the presence of autonomic imbalance and abnormal heart rate profiles during exercise and recovery constitute a predictor of sudden death among apparently healthy persons. The conclusion of Jouven and his collaborators were based on the observations of Kannankeril and Goldberger (2002) whose data suggest that depressed parasympathetic tone during exercise or reduced recovery vagal activity after exercise are important factors regarding an increased risk of sudden death. Moreover, they concluded that the presence of parasympathetic tone provides cardiac protection which leads to the adverse prognosis of diminished vagal activity and increased

mortality. In addition, also Jouven et al. (2005) recommend regular exercise programs because training could shift the autonomic balance through an adequate rise in vagal activity and therefore, improve long-term prognosis. Supplementary confirmation to the positive impact of physical activity has been provided by the recent study of Wecht et al. (2006). They analysed differences in cardiac autonomic control in fit and unfit subjects with paraplegia and were able to demonstrate that fitness come along with increased vagal activity in the recovery condition reflected through the HF component of HRV. Additionally, they observed an equal trend concerning the sympathovagal balance by demonstrating reduced recovery LF/HF in the fit individuals. This indicates depressed vagal activity and presumably increased sympathetic activity during the recovery period. However, no significant differences in resting HRV are observed between the groups (Wecht et al., 2006).

1.2.4 Rhythmic education

Rhythmic-musical education, also known as rhythmic, is recognised as a special form of pedagogic work and emphasises on self-development with respect to motor skills, emotional and social abilities and cognitive competence. Rhythmic is based on the assumption that humans have an inner need for movement. The sense and feeling of rhythm are more or less latent inside every human being and can be awakened and developed by using educational means like music, voice and materials combined with physical movement. All these means interact with each other and thus, situations arise in which learning processes will start. Besides sensitizing body experience and body awareness, attention, concentration and will-power may be developed due to the combination of rhythm perception and muscular movement (Witoszynskyj, Schindler & Schneider, 1996). In the early years of the twentieth century Emile Jaques-Dalcroze, a Swiss music pedagogue, developed a new approach to music education. Based on the premise that the human body is the source of all musical ideas, he combined human movement and musical rhythm. Due to the interaction between musical and physical rhythm he realised that musical elements and rhythmic sense influences movement techniques. Simultaneously, human movement affects musical perception (Dalcroze Australia Inc., n.d.). Jaques-Dalcroze called his kind of music *Eurhythmics*. Dalcroze's Eurhythmics emphasises on educating people in exploring a practical and physical experience of music. Dalcroze's students, Elfriede Feudel and Maria Scheiblauer, developed the idea further and extended Dalcroze's Eurhythmics

towards personality development. Today, rhythmic-music education is applied to various areas such as pre-school training, musical and dance education, adult education as well as special needs education and therapeutic pedagogy (Frohne, 1981).

1.2.4.1 Health-promoting influences of rhythmic education

Rhythmic uses human movements for educational means which results in better sensitivity for one's own body and body consciousness. Muscular and mental tension can be released by physical exercise. Furthermore, rhythmic practises fine motor skills, stabilises the balance and strengthens the musculature (Witoszynskyj, Schindler & Schneider, 1996). Music is applied as a further tool in rhythmic education. Dalcroze's student Maria (Mimi) Scheiblauer (as cited in Witoszynskyj, Schindler & Schneider, 1996) points out that listening to music suffice to initiate imaginations of motion. If the possibility exists to listen and move at the same time, then motor skills and sensory ability will be developed. Consequently, music and movement are assumed to be related to human experience (Frohne, 1981). Music used as an educational tool enables listeners either to relax or to stimulate. Therefore, music deepens the capacity for gaining experience, activates mental ideas and associations, inspires movement imaginations, initiates physical activity, and releases emotional tension (Witoszynskyj, Schindler & Schneider, 1996).

The combination of a rhythmic-music physical education will not only be beneficial to young adult's health but will also strengthen individual initiative and self-reliance of their own health. Besides, music-, exercise- and social – educational aspects foster self-confidence and decision-making ability. Simultaneously, the locomotor system will be mobilized, stretched and strengthened. Personality and social competence development as well as concentration, awareness and coordination will be supported due to the constitution of social learning and group processes (Österreichischer Berufsverband für Rhythmik/Musik und Bewegungspädagogik, n.d.; Hölzle-Schultze & Schultze, n.d.).

1.2.4.2 Rhythmic and the interaction of body and mind

Rhythmic-music education appeals to all senses and to motor activity. In her diploma thesis Witoszynskyj (1987) referred to investigations regarding the relationship of music and physical movement. She cited that muscle activity will be released if "pure" areas of the sensory cortex are stimulated. Therefore, motor skills and sensory awareness cannot be

strictly distinguished. This may be an explanation why children less than two years respond with motor reaction when listening to music.

Rhythmic exercises foster human bodies to obtain a physical memory of moving to music. This body memory is due to the continuous interaction between time, space and energy in music and movement. Body movement indicates a complex medium of internal and external activity. Information exchange exists inside every human organism apart from processing environmental stimuli. The internal communication provides us with information about one self such as the current position in time and space, the actual posture and postural change, and variances in muscular tension. It is assumed that awareness of the own body and sensory awareness form the basis for self-development and autonomous actions (Witoszynskyj, 1987).

Research in the field of rhythmic education is rare in respect to psycho-physiological coordination of brain, nerve-pathways and muscles. But in order to experience rhythm it seems probably beneficial to create a balance of the functions of the sympathetic and parasympathetic nervous system. In 1915, Dalcroze already emphasised that repetitive performed physical exercise can create corresponding images in the brain. A well trained body is able to carry out rhythmic ideas and mental representations. Reciprocally, it is also important to train sensory and rhythmic awareness. Then, a rapid and regular communication between the mind and the body is created with the help of rhythmic. Due to this information process it is assumed that a feedback mechanism of the nervous system is stimulated. According to Dalcroze (1915) differences between rhythmic education and traditional physical education are due to the development of a balance between the mental picture of a movement and its performance by the body. Therefore, a thorough and purposeful rhythmic training is necessary to develop a body image and to feel the effects of rhythm.

Potential effects of rhythmic education on psycho-physiological parameters and psychological indicators are investigated in Krepcik's and Heigl's (in prep.) experiment. Krepcik (B. Krepcik, personal communication, December 21, 2008) evaluated various psychological indicators before and after rhythmic education was performed. She found out, that variables such as mood, well-being and self-confidence showed significant higher values immediately after termination of the rhythmic program. Krepcik's rhythmic education is based on Professor Mag. Phil. Eleonore Witoszynskyj, who constructs

rhythmic exercises on “five pillars of rhythmic”: music, physical movement, social and group processes, creativity, and sensory perception.

1.3 Computer work and stress-induced effects on human organism

The use of information and communication technology is rapidly increasing. Computers and laptops in particular have become an indispensable part within the work and school environments. However, musculoskeletal symptoms and pain are frequently reported among computer users. Additional influences may be poor ergonomic working conditions, high workload, insufficient breaks, stress, and a lack of motion and a lack of physical exercise. All these factors may result in physical discomfort, strain sensation, fatigue and reduction of concentration.

The following chapter outlines recent research which focuses on the introduction of laptop classes and points out potential effects on health and well-being. Furthermore, influences of mental stress are illustrated.

1.3.1 Laptop vs. non laptop classrooms

The use of portable computers like laptops is increasing. The presence and application of laptop computers have become a matter of course particularly in the school environment. The introduction of so called “laptop classes” will foster media skills and information management and, moreover, help students to gain additional ability with an electronic working and learning tool. Several studies promote many benefits related to laptop use. Besides portability and greater flexibility of learning environments, advantages accrue from positive impacts on school attendance and learning interest, increased learning- and problem-solving strategies and additional team and cooperation skills (Schaumburg & Issing, 2002). Nevertheless, recent studies reported an increase in students suffering from musculoskeletal injuries and discomfort. Harris and Straker (2000) investigated potential physical implications of laptop use by undergraduate students and identified body discomfort especially on locations such as head, eyes, neck, shoulder, back and arms. The study indicated that physical load is caused by carrying laptop computers and, furthermore, because of prolonged poor postures with laptop use. Supplementary findings are demonstrated by Pekovics (2003) who reported discomfort like dry or itchy eyes. Besides, musculoskeletal symptoms on neck and upper limp are assumed to be related to increased laptop application. Therefore, Pekovics (2003) explicitly points out to introduce regular

breaks and to adapt relaxation techniques and special exercise training in the school environment. Otherwise, physical discomfort and emotional distress, like stress and lack of concentration may occur frequently among laptop students. Trimmel and Bachmann (2004) also consider potential health risks due to permanent laptop use. Long working hours on laptops lead to increased visual and posture requirements which may result in typical injuries and discomfort, such as head, musculoskeletal system and psychological strain. This is not only based on general continuous screen handling but also due to inflexible forced postures and unilateral musculoskeletal strain combined with mental activity. Poor and wrong sitting habits induce increased support work for trunk, neck and shoulder muscles which in terms may result in long-term muscle tension and hardening (Pekovics, 2003). Interventions and preventions are possible by adjusting the workplace properly and paying more attention to the body posture. Furthermore, investigations by Tsauo, Lee, Hsu, Chen and Chen (2004, as cited in Bernaards, Ariens & Hildebrandt, 2006) showed that the implementation of regular breaks and special exercise programs had positive effects on the reduction of neck and shoulder symptoms.

1.3.2 Effects of mental stress and computer work on HRV

Increased computer and laptop work induces high visual and cognitive requirements. Prolonged computer application in combination with cognitive and mental demands often results in physical discomfort and musculoskeletal symptoms. Additional psychological stress may increase strain sensation and feelings of uneasiness. Belik et al. (2000, as cited in Hjortskov et al., 2004) postulate in an epidemiological study, that psychological stress can be a risk factor for cardiovascular disorders. Investigated psycho-physiological effects of computer work and mental stress revealed inconsistent results depending on different cognitive demands and psychological stressors used. Pagani et al. (1995) evaluated changes in HRV by conducting two different mental tasks. On the one hand, they used a reaction time task, which implicated an error rate of 50%. On the other hand, subjects had to complete a mental calculating exercise in which they had to subtract as fast as possible single figure or two-figure numbers from four-figure sums. The subjects were left alone in the reaction time task and an instructor was present during the mental maths test. The attendance of a person during the mental calculating task is assumed to be an additional influence on HRV changes. Pagani et al. (1995) used LF and HF in normalized units to analyze their results and found out that the LF components increased according to the

frequency spectral distribution in both stress tasks. This increased sympathetic activity was higher in the mental calculating task than in the reaction time task, meaning that an attending person influences stress sensation in terms of a rise in the LF parameter of the HRV.

Hjortskov et al. (2004) tested the hypothesis that the combination of cognitive and emotional stressors influences mental stress which results in decreased HRV. They observed a reduction in the HF component and a rise in the LF/HF ratio variable during the stress session. No differences between the mental stress group and the control group could be detected in the LF component. Similar findings were described by Garde, Laursen, Jørgensen & Jensen (2002), who reported that the effects of a cognitive mental demand may be too small to detect significant changes in HRV variables. In their study they revealed an increase in sympathetic activity and a simultaneous decrease in parasympathetic activity during a physically demanding computer task. Garde and her collaborators used normalized LF and normalized HF components as indices for sympathetic and parasympathetic activation. No further effects could be detected by adding a cognitive mental stress task.

1.4 Hypothesis and research question

The latest state of research reveals comparatively good investigated effects of physical activity on HRV components, which are delineated in the previous section.

In general, the cardiovascular system benefits from long-lasting moderate exercise and daily activity which results in increased HRV. However, there are no studies concerning the effects of rhythmic education on HRV parameters. Influences of rhythmic exercises are mainly based on theoretical assumptions, although various observations during rhythmic classes and experienced rhythmic teachers consider positive impacts in well-being and cardiovascular health. Indications of potential effects on cardiovascular activity demonstrate the special pedagogical work of rhythmic which means that sensory awareness and mental representations are trained through rhythmic perception. At the same time, the body is prepared through physical activity by transforming those mental images into rhythmic movements which may be aimed at preventing muscles tension and physical discomfort. Hence the primary goal of the study was to determine whether rhythmic education compared to physical education would evoke changes in cardiovascular activity.

Due to favourable theoretical assumption of *rhythmic* beneficial effects on the autonomous nervous system can be expected.

Furthermore, the number of self-reported musculoskeletal injuries and pain increases and many research studies point out that this increase is related to student's increased use of computers. Additional influences on HRV variables implicate psychological stressors which are assumed to be a risk factor for cardiovascular imbalance and musculoskeletal pain. On this account potential implications of different kinds of teaching styles on autonomic processes were evaluated. Additionally, differences between laptop students and non laptop students in perceived mental stress and body discomfort were fields of interest.

Previous studies indicate relationships between personal and psychological aspects and autonomic activity. In particular BMI, physical discomfort, exercise behaviour, and computer use, were examined.

2 Method

2.1 Study design

The present empirical study gathered data in a quasi-experimental field research design, in which already existing groups were investigated within their natural environments. The multi-factorial model included an intervention group, consisting of a laptop class (LT) and a non-laptop class (NLT), and a control group, consisting of a laptop class (LT) and a non-laptop (NLT), respectively. The intervention group received rhythmic education (RE) which lasted fifty minutes per lesson and had six group meetings in a four month period (one school term). The RE was held during the gym lessons every second week (except off-school days and holidays) and took place under the supervision of a student rhythmic trainer. ECG recordings and questionnaires were examined at the beginning of the term before the rhythmic intervention started and in the end of the term after six lessons. In addition, HRV was recorded on several conditions (physical and mental demands) using a self-administered time protocol (see table 2.3 and section "procedure" for detailed information). On this account a multi-factorial study design with repeated measurements was applied (table 2.1).

Table 2.1: Multi-factorial study design with repeated measure. Factors are: sport education (PE and RE) and class teaching style (LT and NLT). Repeated measure signifies time on task (TOT) for pre-test and post-test.

Factors		**TOT**	
		Pre-Test	**Post-Test**
RE	LT	n = 17	n = 17
	NLT	n = 11	n = 11
PE	LT	n = 9	n = 9
	NLT	n = 12	n = 12

Baseline condition

First, data for baseline HRV across the sport education groups (rhythmic education, RE and physical education, PE), class teaching style (laptop, LT and non-laptop, NLT) and time on task (TOT) for pre-test and post-test recordings were obtained and analysed in five-minute-segments. The baseline condition investigated differences in HRV components between the sport education groups, the teaching style and across TOT for pre-and post-test recordings. The dependent variables of HRV (time- and frequency domain) were compared with the factors sport education (PE and RE) and class teaching style (LT and NLT classes) and the repeated factor time on task (TOT) pre- and post-test using a (2x2x2) 3-way analyses of variance (ANOVA).

Physical fitness condition

Secondly, the effect of cardiovascular fitness across the sport education groups, class teaching style, TOT (pre-and post-test) and TOT fitness condition (baseline, exercise for knee bending and recovery in sitting position) were evaluated. The time segments for the fitness condition were recorded and analysed in one-minute steps. Table 2.2 shows the study design for the complex experiment to assess cardiovascular fitness.

Table 2.2: Two-factorial study design with two repeated measures. Factors are: sport education groups (RE and PE) and class teaching style (LT and NLT). Repeated factors are time on task (TOT) for pre-test and post-test and TOT_condition (11) which signifies the TOT fitness condition over eleven measurements: BL = baseline, KB = knee bending, SR = sitting recovery.

		TOT_condition (11)	
		BL KB SR 12345 1 12345	**BL KB SR** 12345 1 12345
		Pre-Test	**Post-Test**
RE	**LT**	N = 17	N = 17
	NLT	N = 11	N = 11
PE	**LT**	n = 9	n = 9
	NLT	N = 12	N = 12

This experiment investigated potential differences between the RE group and the PE group, as well as differences between the teaching style of LT and NLT class regarding their cardiovascular fitness. Moreover, to explore potential impacts of time across the sport groups and classes differences between pre-and post-test were analysed. Therefore, a (2x2x2x11) 4-way ANOVA including the factors sport education (RE and PE), teaching style (LT and NLT classes) and the two repeated factors TOT pre-test and post-test and TOT fitness condition (5x 1-min BL, 1min KB, 5x 1-min SR) were applied.

Mental stress condition

The effect of mental stress (MS) on HRV variables was evaluated by comparing 11 NLT students to 17 LT students. Due to lack of time HRV evaluation during the mental stress task was only available for the rhythmic education group. A (2x2) 2-way repeated measures ANOVA was conducted to investigate the impact of the factor class teaching style (LT and NLT) and the repeated factor TOT (pre-test and post-test) on HRV parameters during a mental stress task.

Personal and psychological data

Finally, scores and indices were analysed from a questionnaire. Potential differences of body discomfort locations across the class teaching style were evaluated. For the analyses of the dependent variables of body discomfort locations a multivariate analysis of variance (MANOVA) was applied with the factor class teaching style (LT and NLT). Pearson's correlation matrix was conducted to test the assumptions of associations between self-

reported psychological indicators (body discomfort, BMI, extent of physical activity (Lüdenscheider Aktivitätsfragebogen following Höltke & Jakob, 2002), and computer use) and HRV components.

2.1.1 Variables

For most analyses, independent variables were defined as sport group factors (rhythmic education group, RE, or physical education group, PE) as well as class teaching style (laptop class, LT, or non-laptop class, NLT). Repeated factors were determined for pre-test and post-test, and for the following fitness conditions: baseline (BL), knee bending exercise (KB) and sitting recovery (SR). Dependent variables comply with physiological correlates of HRV: heart rate, SDNN, r-MSSD, pNN50, low frequency (LF), high frequency (HF), total power (TP), logarithmic LF/HF and atrial values (atrial mean and atrial median) (see tables 2.4 and 2.5 in section "data analysis" for detailed information).

Personal and psychological data

The "Lüdenscheider Aktivitätsfragebogen" (Höltke & Jakob, 2002) and additionally questions about sports and physical activities following Trimmel (in preparation) were applied to evaluate the extent of habitual exercise behaviour. The score "extent of physical activity" (Lüdenscheider Aktivitätsfragebogen) was assessed by declaration of hours and minutes. High scores indicate high exercise behaviour and therefore, a high score in the Lüdenscheider Aktivitätsfragebogen. In order to get information about computer application questions about the frequency of usage were asked. Body discomfort was evaluated by means of rated frequencies of different strain areas as well as an overall body discomfort index, composed of the sum of the rated frequencies like in Trimmel and Bachmann (2004).

2.1.2 Experiment control

The present study conducted a quasi-experimental design and participants couldn't be randomly assigned to different groups. Consequently, not considered variables could systematically affect the results. Therefore, significant differences in the present study might be due to other factors which also differed between the two sport groups and between the two classes. The following confounding variables couldn't be considered and may influence the experiment: condition, learning effects, boredom, motivation, arrhythmic

events and electrode inflicted error. Furthermore, noise, such as school bell ringing, and interference through unauthorized entry into the gym disturbed the experiment. However, these variables apply across all four classes and conditions and are considered as constant.

2.1.3 Research hypotheses

Due to the aforementioned theoretical assumptions and state of research, differences in sympathetic and parasympathetic responses of HRV between the two sport education groups (RE and PE) and the class teaching styles (LT and NLT) are anticipated. Sympathetic correlates such as heart rate, normalized LF and atrial values are well recognised indicators to analyse differences in stress sensation, activation and mobilization under different conditions. Parasympathetic correlates such as pNN50, r-MSSD and HF are well recognised indicators to assess differences in feelings of relaxation and recreation under different conditions. Additionally overall HRV indicators (SDNN, total power) and the sympathovagal balance (log LF/HF) were parameters of interest.

Questions regarding baseline differences at rest:
H1: The kind of sport education, teaching style and time of task has an impact on sympathetic activity of HRV in rest.
H1: The kind of sport education, teaching style and time of task has an impact on parasympathetic activity of HRV in rest.*

Question regarding differences in cardiovascular fitness during rest, exercise and recovery:
H1: The kind of sport education, teaching style and time of task has an impact on sympathetic activity of HRV during the fitness condition.
H1: The kind of sport education, teaching style and time of task has an impact on parasympathetic activity of HRV during the fitness condition.*

Question regarding differences during a mental stress task:
H1: The kind of teaching style and time of task has an impact on sympathetic activity on HRV during mental stress.
H1: The kind of teaching style and time of task has an impact on parasympathetic activity on HRV during mental stress.*

On the basis of previous research regarding associations of musculoskeletal risks and increased computer work, differences in body discomfort between the class teaching styles are awaited:

H1: The kind of teaching style and time of task has an impact on different areas of body discomfort.

2.2 Participants

The experiment was part of a sport education project in cooperation with the Vienna Business School, the Medical University of Vienna and the University of Music and Applied Arts, Institute of Rhythmic. Initially, 76 female students were recruited from the 9th and 10th grade. The school had previously participated in a former study by Trimmel and Bachmann (2004) in which group differences between laptop and non laptop students were evaluated. The quasi-experimental trial took place in the context of physical education, consequently only girls between 14 and 17 years of age participated in the study. Mean age was 15 years. Due to organisational restriction the four classes consisted of two laptop (LT) classes and two non laptop (NLT) classes. Nevertheless, precursory teaching impact is negligible, because all four classes had the same PE instructor. In order to detect potential group differences the four classes were divided into two intervention groups (rhythmic education, RE), which consists of one LT and one NLT class, and two control groups (physical education, PE), consisting of one LT and one NLT class, respectively. Figure 2.1 depicts the process of sample size and participant flow.

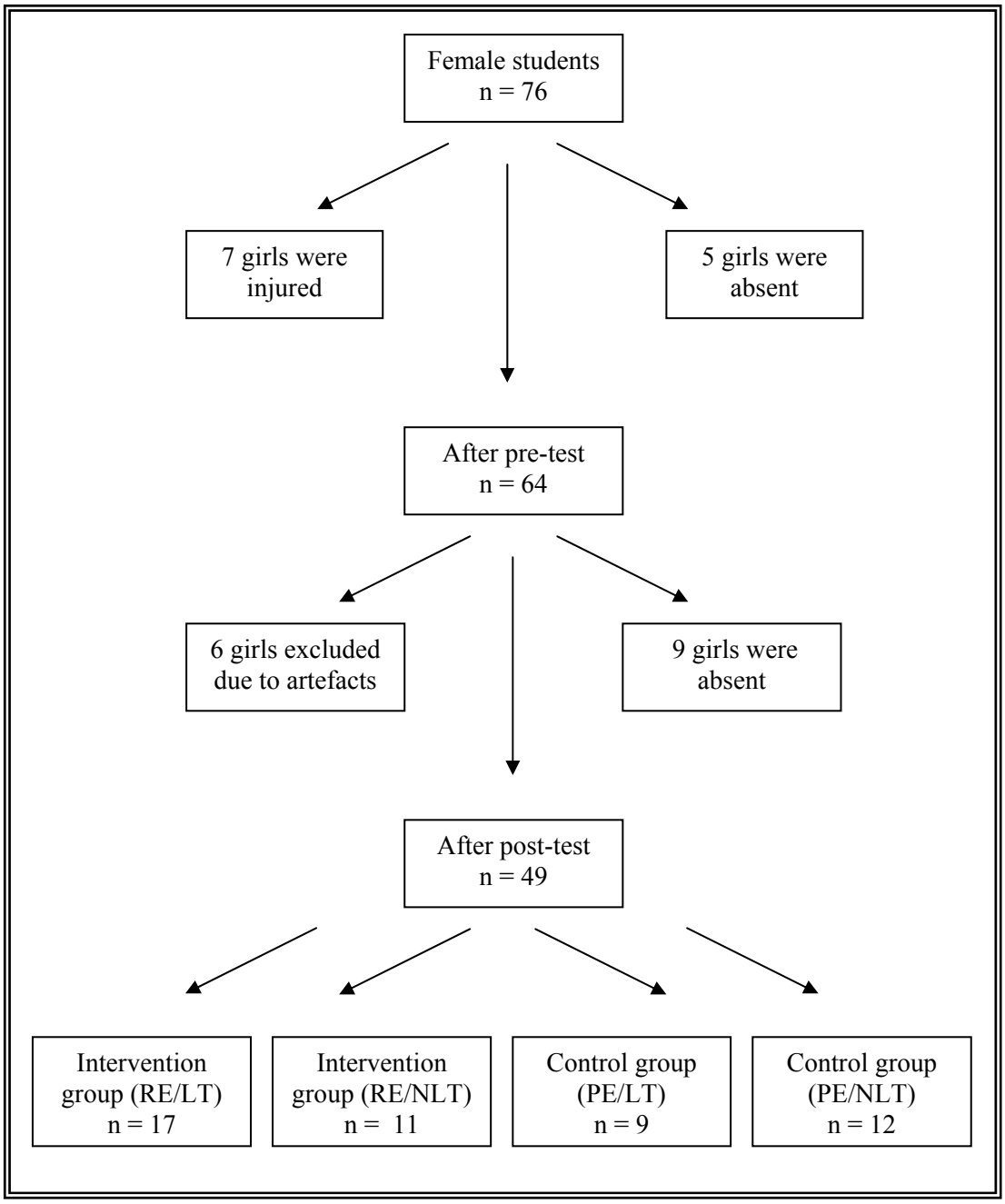


Figure 2.1: Participant flow chart

From the original sample of 76 students, 64 students participated in the pre-tests. Seven girls had been injured and, for this reason, were excluded from the study. Furthermore, five girls were absent or refused to participate. According to the post-tests, a total of 60 students cooperated in measurements. Nine girls were absent because of private or school matters. No data could be obtained for six subjects due to technical problems and artefacts.

In March, re-measurements were made due to high absence rate and lack of sample size in each single group. After all, complete data were available for 49 students (66.22%). The present analysis considered only those subjects who participated in both measurements. Therefore, HRV was analyzed from 17 students (34.7%) from the rhythmic education, laptop group (RE/LT), 11 students (22.4%) from the rhythmic education, non laptop group (RE/NLT), 9 students (18.4%) from the physical education, laptop group (PE/LT) and 12 students (24.5%) from the physical education, non laptop group (PE/NLT).

2.3 Material and apparatus

Data assessment is followed by collecting personal details and psychological indicators through different questionnaires. Apart from that, physiological correlates were assessed by recording ECG in various conditions using a special time protocol (see table 2.3 and section "procedure" for detailed information).

With regard to psychological indicators and personal data different questionnaires were computerized with the software "Sphinx" and presented on a pocket PC (PDA).

HRV was derived from the ECG equipment MedilogAR12 (Type designation AR12, company Oxford Instruments Ltd.) alias TOM. On the basis of a three-channel-deduction, TOM records all intervals of successive R-waves from the ECG. The derivation was recorded in digitalized form on a CompactFlash memory card. After cessation of the measurement, the data was sorted and saved on a PC. By means of the application software Medilog Darwin, which was made available at the Institute of Environmental Health, Medical University of Vienna, data was monitored and prepared for further processing.

In total, five electrodes were applied on each subject. The black one was fixed below the right collarbone and the red one was placed at the left side of the costal arch. The green electrode, which serves as electrical ground, was fixed in the middle above the chest. Additionally, two electrodes (left thenar and left upper arm) were applied to evaluate skin conductance. Finally, a laptop was used, in order to give the pace and rhythm for the breathing rate.

2.4 Procedure

Investigations took place from February to June 2008 during the PE lessons in the gym of the Vienna Business School. The PE lessons and RE interventions took place every Tuesday afternoon with fixed times for each class. Therefore, each class performed either the PE lesson or the RE at the same time over the course of the school term. Each subject was tested twice. Once, at the beginning of the school term before the RE and, the second time at the end of the term after the rhythmic intervention was finished. All four classes, the two RE classes as well as the PE control classes run through the same conditions regarding the time protocol.

PE lessons for the first class started at 11:40am. It was a control class without LT teaching. All subjects gathered together in the gym. Then the experimenter introduced herself and her assistances and explained the investigation. After instructions were made the ECG equipment TOM with the five electrodes were fixed on each subject and a thirty-minute PE lesson with the PE teacher was held. By doing this, the students had get used to the apparatus and technical problems were identified and eliminated before the actual time protocol was conducted. After the PE lesson all subjects were seated on wooden benches to start baseline recordings for five minutes. Then instructions for the respiration exercise were given and the application running on the laptop was started to give the pace and rhythm of the breathing rate. Five minutes with a “fast” breathing rate of twelve breathes per minute were recorded as well as five minutes with a “slow” breathing rate of six breathes per minute. Afterwards all students stood up and one minute knee bending was performed. Knees were bent to a 90 degree angle. Subsequently, a five minute recovery period started in seated position on the wooden benches. After that a mental stress situation was created by asking them to complete a calculating exercise for which they had five minutes time. Students continuously had to subtract the number 7 from a four-figure sum. The calculating sheet already had numerical series but errors were hidden. Participants had to find out the error, cross out the wrong number and check mark the right number (see appendix section 7.7 for detailed information). To complete an entire recording, students were asked to remain seated for five more minutes. Noise, especially the ringing of the school bell was noted in the protocol as well. Table 2.2 shows the study protocol for all four classes.

Table 2.3: Study protocol with chronological condition execution

Time Protocol	**Commencement**	**Cessation**
Start physiological recording (all ECG applied)		
30 min PE or rhythmic education		
5 min baseline		
Respiration exercise (instruction)		
5 min fast breathing (breathing rate: 12/min = respiratory rhythm of 5 sec)		
5 min slow breathing (breathing rate: 6/min = respiratory rhythm of 10 sec)		
Uprise before knee bending		
1 min knee bending (KB)		
5 min recovery (sitting)		
5 min mental stress (count down at a 7-pace)		
Approximately end of ECG-derivation		
School bell ringing		

The same procedure was conducted for the second PE control group and LT class, who performed the thirty minute PE lesson and the study protocol at 4:40pm.

The RE intervention groups completed the same study protocol in the same recording environment. However, a thirty minute RE lesson was recorded instead of the PE lesson. The NLT class started RE recording at 1:20pm and the LT class students performed their RE at 3:00pm. Both classes conducted the study protocol after the RE recording.

2.5 Data analysis

The software Medilog Darwin was used for the analysis of the selected HRV parameter. Standard configuration of the maximum interval increase and decrease was set to thirty percent in order to avoid artefacts. Furthermore, at least five successive correctly identified heart beats are needed to be included in the analysis. Only normal beats were included in the analysis, meaning that these configurations excluded identified artefacts. The minimum accepted heart rate was determined at 36 BpM whereas the maximum heart rate was fixed at a level of 220 BpM.

In this study following time domain parameters of HRV were used for the analysis:

Table 2.4: Description of HRV time domain parameters

Variable	Units	Description
Heart rate minimum	BpM	Average minimum heart rate within a 1- or 5-minute recording epoch
Heart rate mean	BpM	Average mean heart rate within a 1- or 5-minute recording epoch
Heart rate maximum	BpM	Average maximum heart rate within a 1- or 5-minute recording epoch
SDNN	Ms	Standard deviation of all normal heart periods within a 1-or 5-minute recording epoch
r-MSSD	Ms	Square root of the mean of the sum of the squares of differences between adjacent NN intervals
pNN50	%	Proportion of successive NN intervals differing by more than 50 ms in the entire recording

The AR Burg method was used to conduct spectral analysis for the assessment of frequency domain parameters. Finally, the window size was adjusted to 60 and 300 seconds because only short-term recordings of one- and five- minute segments were used.

In this study following frequency domain parameters of HRV were used for the analysis:

Table 2.5: Selected frequency range (Hz) in ms² and nu.

Parameter	Units	Frequency Range
Low frequency (LF)	ms² and nu (%)	0,04 – 0,15 Hz
High frequency (HF)	ms² and nu (%)	0,15 – 0,4 Hz
Total power (TP)	ms²	< 0,4 Hz
Log LF/HF (sympathovagal balance)	Ratio LF [ms²]/HF [ms²]	

Supplementary, atrial mean and atrial median (in ms) were evaluated in this study. It is believed that these parameters reflect sympathetic activity and contribute to stress-related influences.

Data assessment concerning the time protocol comprises the physical and mental stress conditions only. Hence, the breathing conditions were not included into statistical analysis.

Data during physiological recordings at knee bending exercise are biased because students from the non-laptop RE class showed unmotivated behaviour and exercise performance were delayed in time.

After the data were monitored and edited as required in Medilog Darwin, the parameters of interest were transported into Excel for further processing. A special macro helped to import the data into the statistics program SPSS 15.0 for Windows and Statistica 6.0. Statistical data processing was conducted and graphics were created. Physiological data is susceptible to artefacts and, therefore, data cleansing was performed to detect and correct inaccurate records and missing data. Besides, histograms and bar charts were created to check the data for outliers. After evaluating descriptive statistics and testing the assumption of normal distribution with the Kolmogorov-Smirnov-Test (K-S), different statistical tests were utilized to analyse the research question and set of hypothesis. Normal distribution violations, variance of homogeneity violations and significant effects were rechecked using the non parametric Mann-Whitney U-Test. The experiment-wide error was kept below 0.05. Confidence interval was 95% and a greenhouse-geisser adjustment to the degrees of freedom was performed.

3 Results

3.1 HRV at baseline condition

This chapter illustrates the results of the HRV parameters during rest which were analysed in 5-minute-segments. Relevant results are demonstrated first on the basis of their statistics with F-values and afterwards are described via graphs, which show the interactions between the two sport groups (PE and RE), class teaching style (LT versus NLT) and TOT, for pre- and post-test recordings.

In the following tables and figures abbreviations are used for easier illustration, such as SPORT for the type of sport education (RE or PE), CLASS, meaning teaching style, laptop (LT) or non laptop (NLT), and TOT, representing pre- and post-test measurements. The appropriate tables for mean values, standard errors and confidence intervals are inserted in the appendix (see tables 7.1 – 7.20).

All effects are reported as significant at $p < 0.05$.

If assumptions of normal distribution or variance homogeneity are violated the non-parametric Mann-Whitney U-test are conducted to check significant effects.

3.1.1 Time domain parameters

3.1.1.1 Minimum heart rate

Statistical analysis of the average minimum HR is illustrated in table 3.1. The results of the repeated measures ANOVA showed that, the minimum HR was not significantly affected by the time of task (TOT), $F(1,45) = 1.054$, $p > 0.05$. There was a significant main effect of the type of sport education examined during the term, $F(1,45) = 4.315$, $p < 0.05$ and a non-significant main effect according to the teaching style, on the average minimum HR across the baseline condition, $F(1,45)= 0.008$, $p > 0.05$.

Concerning the interactions, there was a significant effect between TOT, and the type of sport education performed, $F(1,45) = 6.391$, $p < 0.05$. Additionally, a significant interaction effect was found between sport education and teaching style, $F(1,45) = 6.380$, $p < 0.05$ but no significant effect are detected between TOT and teaching style, $F(1,45) = 1.895$, $p > 0.05$. Finally, the 3-way interaction between TOT, sport education and teaching style showed a significant effect, $F(1,45) = 11.923$, $p < 0.05$.

Table 3.1: Repeated measures ANOVA. Measure is average minimum heart rate at time on task (TOT) for pre-test and post-test recordings (= within-subjects variable). Between-subjects variables indicate sport education (SPORT) and teaching style (CLASS)

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	***P***
Intercept	595354.812	1	595354.812	1678.801	.000
SPORT	1530.147	1	1530.147	4.315	**.044**
CLASS	2.796	1	2.796	.008	.930
SPORT * CLASS	2262.372	1	2262.372	6.380	**.015**
Error	15958.393	45	354.631		
TOT	48.084	1	48.084	1.054	.310
TOT * SPORT	291.503	1	291.503	6.391	**.015**
TOT * CLASS	86.416	1	86.416	1.895	.175
TOT * SPORT * CLASS	543.774	1	543.774	11.923	**.001**
Error(TOT)	2052.377	45	45.608		

In figure 3.1 the significant interaction effects are depicted between pre- and post-test recording and sport education in LT students compared to NLT students. With respect to the LT class the graphs reveal higher average minimum HR in the PE group than in the RE group. While pre- and post-test recordings remained fairly steady in the PE group, a slight decrease in minimum HR are observed from pre-test to post-test in the RE group. As opposed to that trend NLT class students showed a remarkable rise in minimum HR from

pre- to post-test measurements in the RE group. However, in the PE group, a fall in HR is observed from pre-test to post-test.

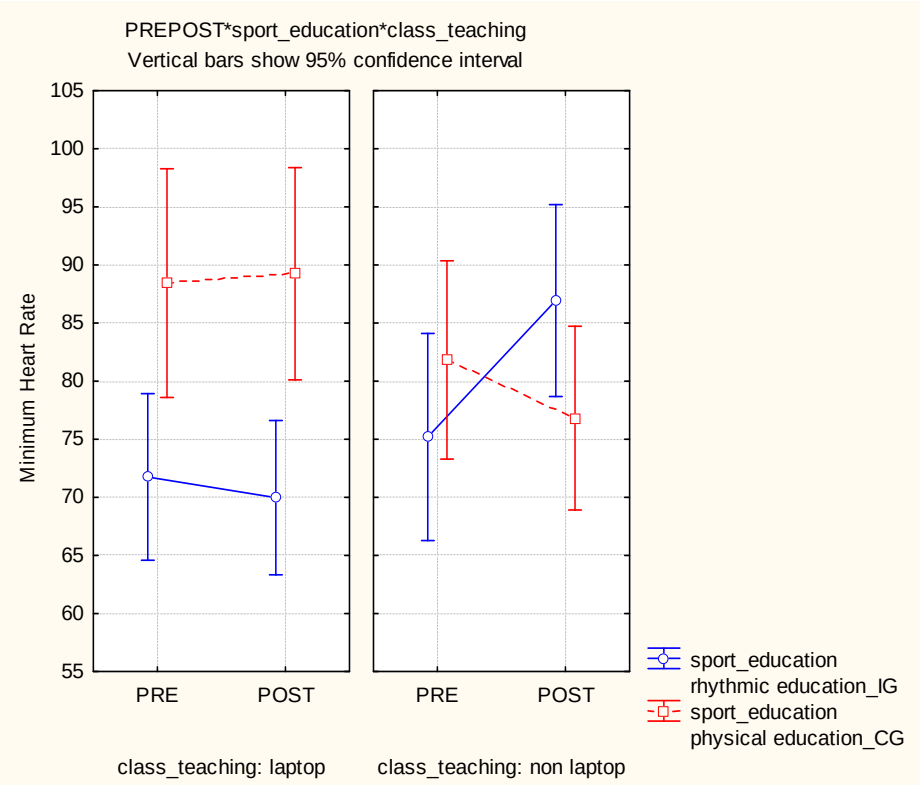


Figure 3.1: 3-way interaction between TOT * sport education * teaching style. Average minimum heart rate at pre- and post-test recordings for laptop and non laptop students demonstrated for the rhythmic education group (RE) and the physical education group (PE)

3.1.1.2 Mean heart rate

A similar trend is observed regarding the mean heart rate (table 3.2). There was a significant main effect of the type of sport education performed, $F(1,45) = 5.904$, $p < 0.05$. No significant main effects existed for teaching style, $F(1,45) = 1.250$, $p > 0.05$ and TOT, $F(1,45) = 1.879$, $p > 0.05$. Moreover, there was no significant interaction between sport education and teaching style, $F(1,45) = 3.396$, $p > 0.05$ as well as between TOT and teaching style, $F(1,45) = 0.561$, $p > 0.05$. Significant interaction effects are identified between TOT and sport education, $F(1,45) = 6.078$, $p < 0.05$ and between TOT, sport education and teaching style, $F(1,45) = 9.327$, $p < 0.05$.

Nonparametric post-hoc tests with the Mann-Whitney U-test revealed a significant effect in mean heart rate between LT and NLT students during post-test recording, $z = -2.063$, $p < 0.05$ (see appendix table 7.3).

Table 3.2: Repeated measures ANOVA. Measure is average mean heart rate at time on task (TOT) for pre-test and post-test recordings (= within-subjects variable). Between-subjects variables indicate sport education (SPORT) and teaching style (CLASS)

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	***P***
Intercept	907767.120	1	907767.120	3494.439	.000
SPORT	1533.590	1	1533.590	5.904	**.019**
CLASS	324.779	1	324.779	1.250	.269
SPORT * CLASS	882.266	1	882.266	3.396	.072
Error	11689.866	45	259.775		
TOT	95.538	1	95.538	1.879	.177
TOT * SPORT	309.004	1	309.004	6.078	**.018**
TOT * CLASS	28.509	1	28.509	.561	.458
TOT * SPORT * CLASS	474.150	1	474.150	9.327	**.004**
Error(TOT)	2287.691	45	50.838		

The interaction graphs (figure 3.2) reveal higher mean heart rates in the PE group as compared to the RE group. In the course of pre- and post-test recordings a fall in mean HR are observed in LT students who completed RE over the term, whereas LT students who performed PE showed an increase in mean HR. An inverse trend again existed in the NLT class. There, students who conducted RE showed a noticeable rise from pre-test to post-test, whereas students who performed PE a noticeable fall are identified.

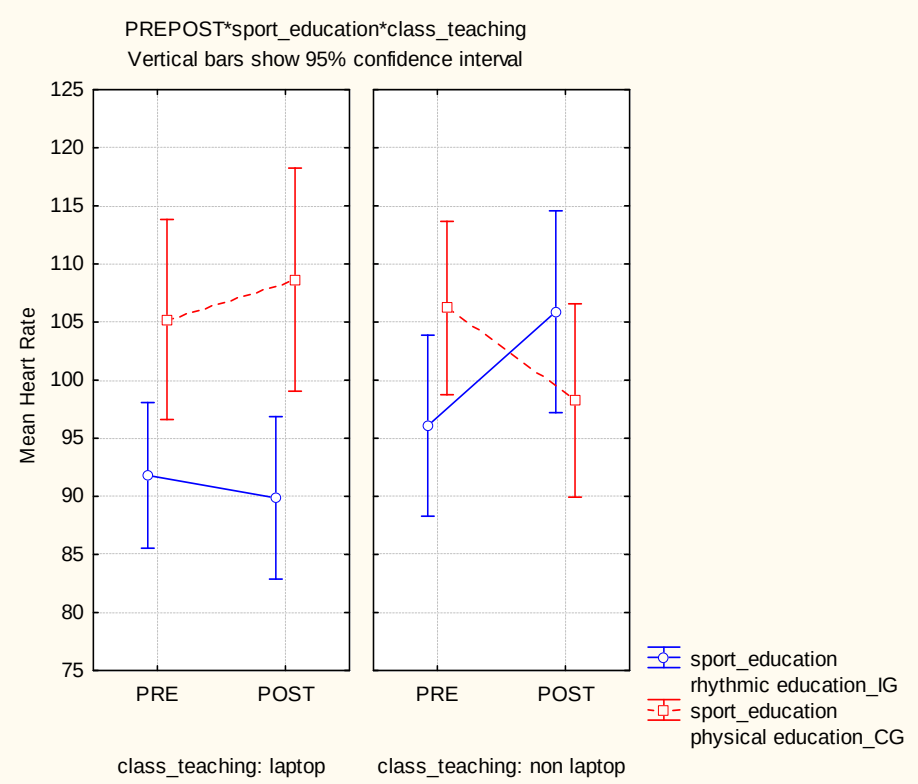


Figure 3.2: 3-way interaction between TOT * sport education * teaching style. Average mean heart rate at pre- and post-test recordings for laptop and non laptop students demonstrated for rhythmic education group (RE) and physical education (PE)

3.1.1.3 Maximum heart rate

Concerning the maximum HR (table 3.3), there were no significant main effects of sport education, $F(1,45) = 3.662$, $p > 0.05$, of teaching style, $F(1,45) = 1.869$, $p > 0.05$, and of TOT, when recordings were conducted, $F(1,45) = 0.130$, $p > 0.05$. Furthermore, no significant effects existed according to the interaction between sport education and teaching style, $F(1,45) = 1.925$, $p > 0.05$, between TOT and sport education, $F(1,45) = 2.539$, $p > 0.05$, and between TOT and teaching style, $F(1,45) = 0.012$, $p > 0.05$. Finally, there was a significant interaction effect between TOT, sport education and teaching style, $F(1,45) = 5.458$, $p < 0.05$.

Nonparametric post-hoc tests with the Mann-Whitney U-test revealed significant effects between RE and PE during pre-test recording for all three heart rates (minimum, mean and maximum), $p < 0.05$ (see appendix table 7.5).

Table 3.3: Repeated measures ANOVA. Measure is average maximum heart rate at time on task (TOT) for pre-test and post-test recordings (= within-subjects variable). Between-subjects variables indicate sport education (SPORT) and teaching style (CLASS)

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	***P***
Intercept	1382550.134	1	1382550.134	3873.346	.000
SPORT	1307.111	1	1307.111	3.662	.062
CLASS	666.979	1	666.979	1.869	.178
SPORT * CLASS	686.979	1	686.979	1.925	.172
Error	16062.278	45	356.940		
TOT	22.186	1	22.186	.130	.720
TOT * SPORT	434.505	1	434.505	2.539	.118
TOT * CLASS	2.137	1	2.137	.012	.912
TOT * SPORT * CLASS	934.094	1	934.094	5.458	**.024**
Error(TOT)	7701.245	45	171.139		

As previously observed, the maximum HR revealed a similar tendency (figure 3.3). An overall higher maximum HR existed in the PE group, with a remarkable decrease in HR in the NLT class and a minor increase of 1BpM in the LT class. In contrast, in the RE group, the LT class showed a decrease in maximum HR, while the NLT class demonstrated a remarkable rise of 10BpM from pre-test to post-test.

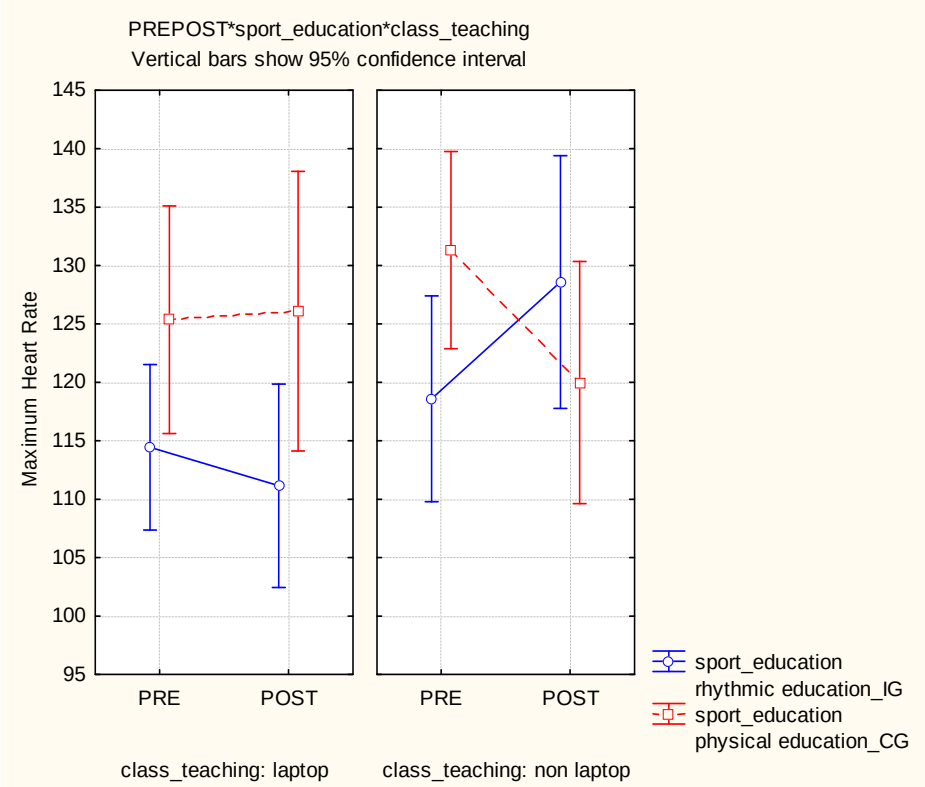


Figure 3.3: 3-way interaction between TOT * sport education * teaching style. Average maximum heart rate at pre- and post-test recordings for laptop and non laptop students demonstrated for rhythmic education group (RE) and physical education (PE).

3.1.1.4 SDNN

HRV evaluated through the SDNN parameter (table 3.4) showed a significant main effect regarding TOT, $F(1,45) = 6.228$, $p < 0.05$. Furthermore, there was a significant interaction effect between TOT and teaching style, $F(1,45) = 7.633$, $p < 0.05$. No significant main effects are detected for sport education, $F(1,45) = 3.951$, $p > 0.05$, and for teaching style, $F(1,45) = 0.011$, $p > 0.05$. Additionally, there were no significant effects between sport education and class teaching style, $F(1,45) = 2.047$, $p > 0.05$, between TOT and sport education, $F(1,45) = 3.618$, $p > 0.05$, and between the 3-way interaction TOT, sport education and teaching style, $F(1,45) = 3.430$, $p > 0.05$.

Table 3.4: Repeated measures ANOVA. Measure is average SDNN at time on task (TOT) for pre-test and post-test recordings (= within-subjects variable). Between-subjects variables indicate sport education (SPORT) and teaching style (CLASS)

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	***P***
Intercept	203685.997	1	203685.997	329.630	.000
SPORT	2441.309	1	2441.309	3.951	.053
CLASS	6.953	1	6.953	.011	.916
SPORT * CLASS	1264.618	1	1264.618	2.047	.159
Error	27806.550	45	617.923		
TOT	919.826	1	919.826	6.228	**.016**
TOT * SPORT	534.393	1	534.393	3.618	.064
TOT * CLASS	1127.337	1	1127.337	7.633	**.008**
TOT * SPORT * CLASS	506.574	1	506.574	3.430	.071
Error(TOT)	6646.214	45	147.694		

On average students in the PE group showed a lower mean SDNN than students in the RE group (figure 3.4). While students in the LT class remained fairly constant between pre- and post-test recordings in both sport groups, students in the NLT class showed a slight fall during post-test measurements in the PE group, but demonstrated a remarkable decrease in the RE group from pre-test to post-test recordings.

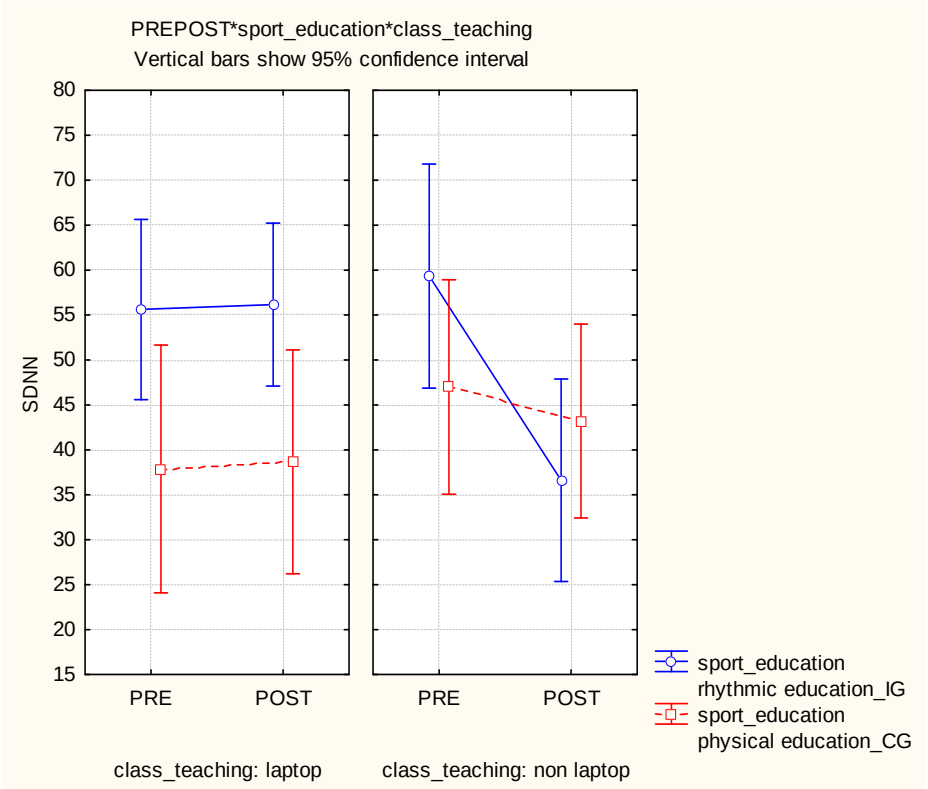


Figure 3.4: 3-way interaction between TOT * sport education * teaching style. SDNN at pre- and post-test recordings for laptop and non laptop students demonstrated for rhythmic education group (RE) and physical education (PE).

3.1.1.5 r-MSSD

HRV represented by the parameter r-MSSD (table 3.5) showed a significant main effect of sport education, $F(1,45) = 7.516$, $p < 0.05$. There were no significant main effects regarding teaching style, $F(1,45) = 0.577$, $p > 0.05$ and TOT, $F(1,45) = 0.665$, $p > 0.05$. Furthermore, no significant interaction effects existed between sport education and teaching style, $F(1,45) = 2.820$, $p > 0.05$, between TOT and sport education, $F(1,45) = 2.273$, $p > 0.05$, and between TOT and teaching style, $F(1,45) = 2.826$, $p > 0.05$. But a significant effect are detected regarding the 3-way-interaction between TOT, sport education and teaching style, $F(1,45) = 4.792$, $p < 0.05$.

Table 3.5: Repeated measures ANOVA. Measure is average r-MSSD at time on task (TOT) for pre-test and post-test recordings (= within-subjects variable). Between-subjects variables indicate sport education (SPORT) and teaching style (CLASS)

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	***P***
Intercept	65356.972	1	65356.972	220.250	.000
SPORT	2230.435	1	2230.435	7.516	**.009**
CLASS	171.146	1	171.146	.577	.452
SPORT * CLASS	836.669	1	836.669	2.820	.100
Error	13353.273	45	296.739		
TOT	68.881	1	68.881	.665	.419
TOT * SPORT	235.430	1	235.430	2.273	.139
TOT * CLASS	292.641	1	292.641	2.826	.100
TOT * SPORT * CLASS	496.227	1	496.227	4.792	**.034**
Error(TOT)	4660.258	45	103.561		

Figure 3.5 illustrates a lower HRV evaluated through the r-MSSD variable in the PE group compared to the RE group. With respect to the PE groups, r-MSSD remained fairly steady from pre- to post-test measurements in LT class students and showed a slight increase in NLT class students. In the RE groups however, LT students showed a rise in r-MSSD from pre-test to post-test, whereas in the NLT class a remarkable decrease from pre-test to post-test is observed.

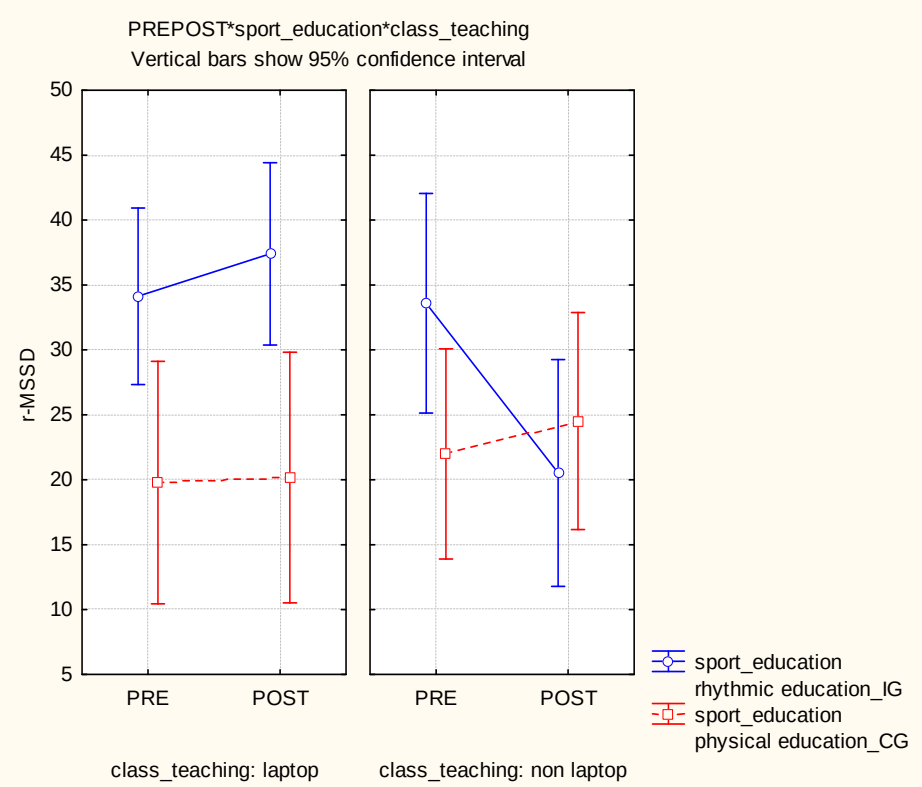


Figure 3.5: 3-way interaction between TOT * sport education * teaching style. R-MSSD at pre- and post-test recordings for laptop and non laptop students demonstrated for rhythmic education group (RE) and physical education (PE).

3.1.1.6 pNN50

Table 3.6 illustrates the results of the HRV as measured by pNN50. There was a significant main effect of sport education, $F(1,45) = 5.473$, $p < 0.05$. No significant main effects are detected for class teaching, $F(1,45) = 1.614$, $p > 0.05$, and TOT, $F(1,45) = .000$, $p > 0.05$. Besides, there were no significant interaction effects between TOT and sport education, $F(1,45) = 1.469$, $p > 0.05$, as well as between TOT and teaching style, $F(1,45) = 2.960$, $p > 0.05$. However, a significant interaction effect between TOT, sport education and teaching style is observed, $F(1,45) = 6.139$, $p > 0.05$.

Nonparametric post-hoc tests with the Mann-Whitney U-test revealed a significant effect between LT and NLT students at post-test recording, $z = -2.065$, $p < 0.05$, and a significant effect between RE and PE at pre-test recordings, $z = -2.647$, $p < 0.05$ (see appendix tables 7.9 and 7.10).

Table 3.6: Repeated measures ANOVA. Measure is average pNN50 at time on task (TOT) for pre-test and post-test recordings (= within-subjects variable). Between-subjects variables indicate sport education (SPORT) and teaching style (CLASS)

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	***P***
Intercept	7578.985	1	7578.985	51.957	.000
SPORT	798.418	1	798.418	5.473	**.024**
CLASS	235.439	1	235.439	1.614	.210
SPORT * CLASS	229.842	1	229.842	1.576	.216
Error	6564.196	45	145.871		
TOT	.002	1	.002	.000	.996
TOT * SPORT	92.334	1	92.334	1.469	.232
TOT * CLASS	186.010	1	186.010	2.960	.092
TOT * SPORT * CLASS	385.766	1	385.766	6.139	**.017**
Error(TOT)	2827.930	45	62.843		

Similar to the above the PE group showed a lower pNN50 than the RE group (figure 3.6). Students from the LT class showed a marginal rise from pre- to post-test recordings when performed PE, whereas LT students who performed RE demonstrated a higher rise in pNN50 from pre-test to post-test. With respect to the NLT class, the PE group showed a rise in pNN50 from pre-test to post-test, whereas in the RE group a remarkable fall could be observed from pre-test to post-test.

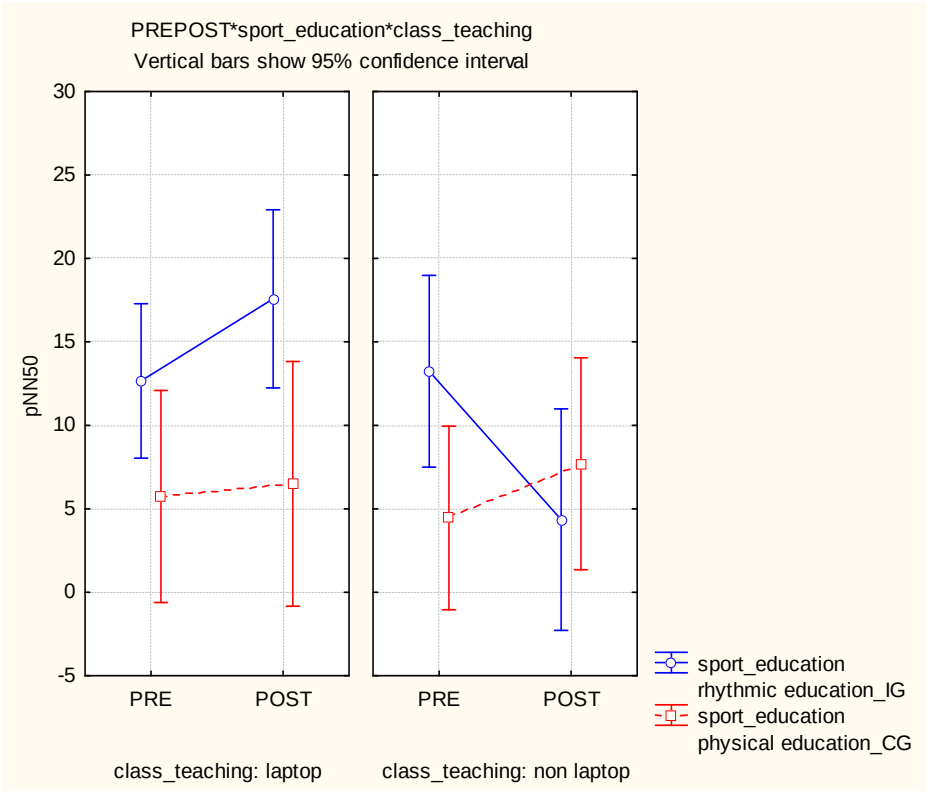


Figure 3.6: 3-way interaction between TOT * sport education * teaching style. pNN50 at pre- and post-test recordings for laptop and non laptop students demonstrated for rhythmic education group (RE) and physical education (PE).

3.1.2 Frequency domain parameters

3.1.2.1 LF Power

Statistical analysis for the LF power is shown in table 3.7. There was a significant main effect for sport education, $F(1,45) = 5.107$, $p < 0.05$, but the class main effect, $F(1,45) = 0.532$, $p > 0.05$, and the TOT main effect, $F(1,45) = 0.441$, $p > 0.05$, were both non-significant. Regarding the interaction effects, there was no significant interaction between sport education and teachings style, $F(1,45) = 1.645$, $p > 0.05$, between TOT and sport education, $F(1,45) = 3.082$, $p > 0.05$, and between TOT and teaching style, $F(1,45) = 1.498$, $p > 0.05$. Finally, there was a significant 3-way interaction effect between TOT, sport education and teaching style, $F(1,45) = 8.102$, $p < 0.05$.

Table 3.7: Repeated measures ANOVA. Measure is average low frequency power (LF) at time on task (TOT) for pre-test and post-test recordings (= within-subjects variable). Between-subjects variables indicate sport education (SPORT) and teaching style (CLASS)

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	***P***
Intercept	34283266.858	1	34283266.858	68.301	.000
SPORT	2563186.916	1	2563186.916	5.107	**.029**
CLASS	266884.078	1	266884.078	.532	.470
SPORT * CLASS	825756.433	1	825756.433	1.645	.206
Error	22587507.868	45	501944.619		
TOT	69298.754	1	69298.754	.441	.510
TOT * SPORT	484148.123	1	484148.123	3.082	.086
TOT * CLASS	235286.305	1	235286.305	1.498	.227
TOT * SPORT * CLASS	1272487.569	1	1272487.569	8.102	**.007**
Error(TOT)	7068014.620	45	157066.992		

Figure 3.7 reveals higher LF power in the RE group compared to the PE group. Furthermore, LT students performing RE during the term showed a faint decrease, whereas LT students conducting traditional PE demonstrated a higher decrease from pre-test to post-test. In the NLT class however, students who performed RE showed a fall of 350 ms from pre-test to post-test recordings, whereas students who conducted PE demonstrated a remarkable rise of over 400 ms from pre-test to post-test.

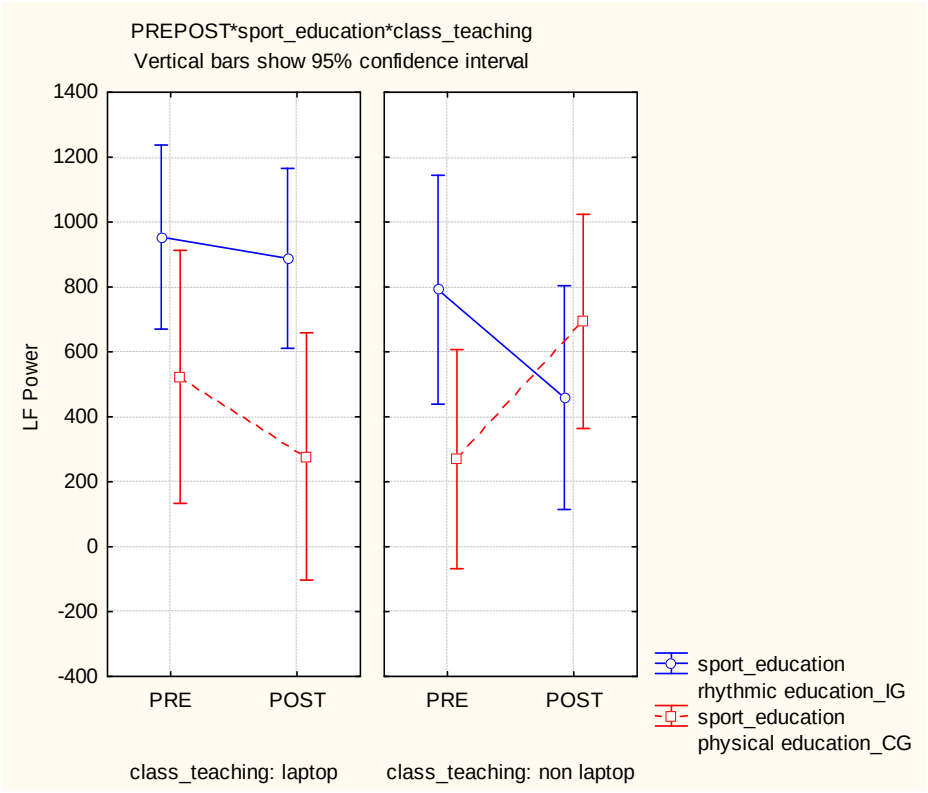


Figure 3.7: 3-way interaction between TOT * sport education * teaching style. Low frequency power at pre- and post-test recordings for laptop and non laptop students demonstrated for rhythmic education group (RE) and physical education (PE).

3.1.2.2 HF Power

The results of the HRV parameter HF power are illustrated in table 3.8. Statistical analysis identified a significant main effect of sport education, $F(1,45) = 9.869$, $p < 0.05$. All other main effects, as well as all interaction effects showed non-significant results with $p > 0.05$.

Nonparametric post hoc check-ups via Mann-Whitney U-test revealed a significant effect between the two sport groups at pre-test recording, $z = -3.334$, $p < 0.05$, and a significant effect between the two sport groups at post-test recording, $z = -2.626$, $p < 0.05$ (see appendix table 7.13).

Table 3.8: Repeated measures ANOVA. Measure is average high frequency power (HF) at time on task (TOT) for pre-test and post-test recordings (= within-subjects variable). Between-subjects variables indicate sport education (SPORT) and teaching style (CLASS)

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	***P***
Intercept	5057618.750	1	5057618.750	42.906	.000
SPORT	1163331.417	1	1163331.417	9.869	**.003**
CLASS	248178.945	1	248178.945	2.105	.154
SPORT * CLASS	478800.168	1	478800.168	4.062	.050
Error	5304416.016	45	117875.911		
TOT	285.090	1	285.090	.007	.934
TOT * SPORT	6444.319	1	6444.319	.156	.695
TOT * CLASS	289.147	1	289.147	.007	.934
TOT * SPORT * CLASS	142578.504	1	142578.504	3.445	.070
Error(TOT)	1862436.860	45	41387.486		

The graphs in figure 3.8 reveal an inverse trend between LT and NLT students according to the two sport groups. With respect to the LT class student, those who performed RE during the term showed an increase of HF power from pre-test to post-test. LT students who conducted traditional PE demonstrated a fall from pre-test to post-test recordings. NLT students however, showed a decrease in HF power if completed RE. In contrast, NLT students performing PE revealed an increase in HF power in terms of pre- and post-test measurements.

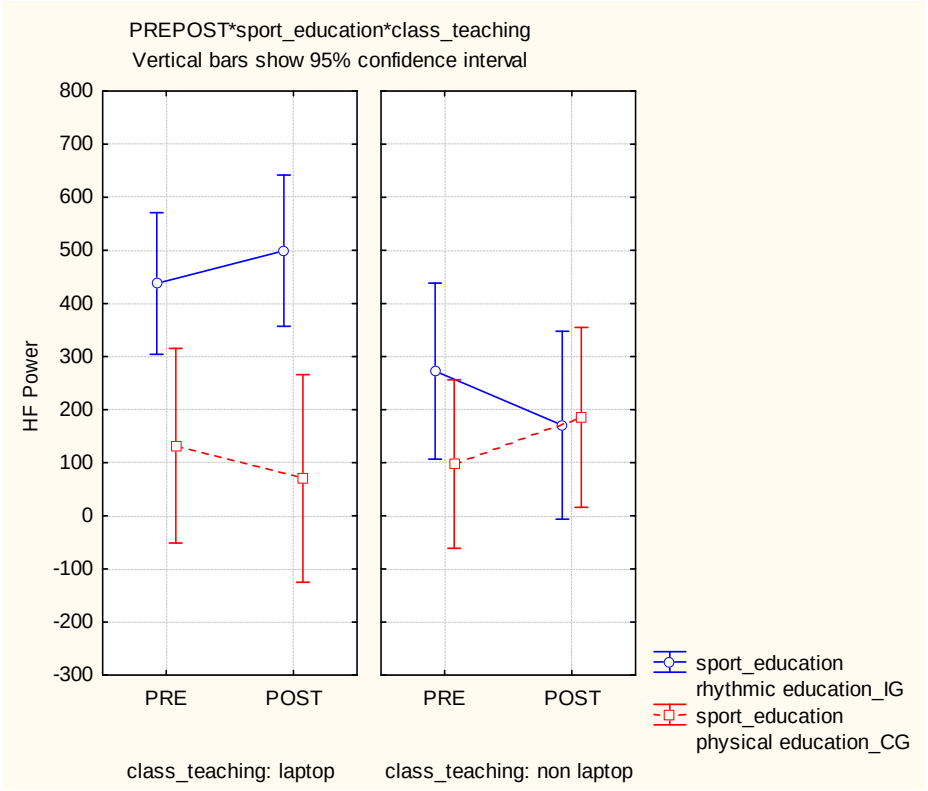


Figure 3.8: 3-way interaction between TOT * sport education * teaching style. High frequency power at pre- and post-test recordings for laptop and non laptop students demonstrated for rhythmic education group (RE) and physical education (PE).

3.1.2.3 Total Power

HRV which is represented by the parameter TP (table 3.9) shows a significant main effect of sport education, $F(1,45) = 8.129$, $p < 0.05$. There were no significant main effects concerning teaching style, $F(1,45) = 0.061$, $p > 0.05$, and TOT, $F(1,45) = 1.510$, $p > 0.05$. Moreover, non-significant interaction effects are detected between sport education and teaching style, $F(1,45) = 0.790$, $p > 0.05$, between TOT and sport education, $F(1,45) = 1.851$, $p > 0.05$, and between TOT, sport education and teaching style, $F(1,45) = 0.553$, $p > 0.05$. But a significant interaction effect is observed between TOT and teaching style, $F(1,45) = 4.594$, $p < 0.05$.

Nonparametric post hoc recheck via Mann-Whitney U-test revealed a significant effect between the two classes at post-test recording, $z = -2.264$, $p < 0.05$ (see appendix table 7.15).

Table 3.9: Repeated measures ANOVA. Measure is the average total power (TP) at time on task (TOT) for pre-test and post-test recordings (= within-subjects variable). Between-subjects variables indicate sport education (SPORT) and teaching style (CLASS)

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	***P***
Intercept	826751760.002	1	826751760.002	80.867	.000
SPORT	83106796.236	1	83106796.236	8.129	**.007**
CLASS	620745.367	1	620745.367	.061	.806
SPORT * CLASS	8075143.973	1	8075143.973	.790	.379
Error	460061793.700	45	10223595.416		
TOT	5323957.226	1	5323957.226	1.510	.225
TOT * SPORT	6526101.040	1	6526101.040	1.851	.180
TOT * CLASS	16192117.353	1	16192117.353	4.594	**.038**
TOT * SPORT * CLASS	1948668.402	1	1948668.402	.553	.461
Error(TOT)	158617797.338	45	3524839.941		

It can be observed in figure 3.9 that the RE group showed higher TP as compared to the PE group. LT students who performed traditional PE showed a higher rise in TP from pre-test to post-test than LT students who completed RE during the term. The graphs in the NLT class reveal an inverse tendency. There, students from the RE group showed a remarkable fall of 2000 ms^2 from pre-test to post-test, while students from the PE group only showed a slight decrease.

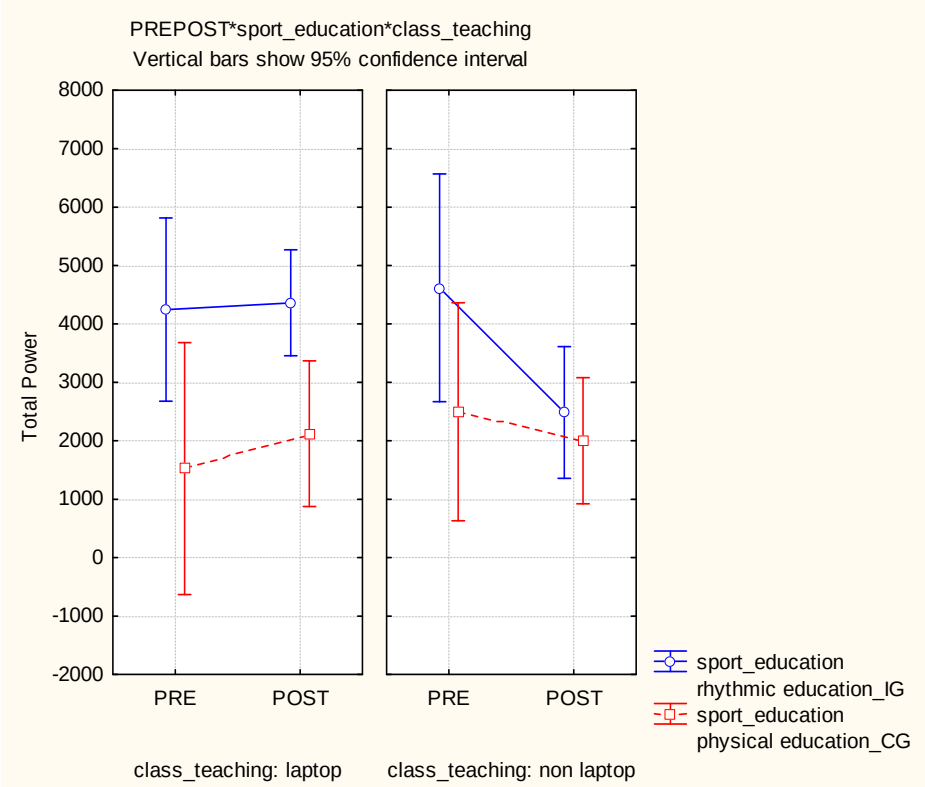


Figure 3.9: 3-way interaction between TOT * sport education * teaching style. Total power at pre- and post-test recordings for laptop and non laptop students demonstrated for rhythmic education group (RE) and physical education (PE).

3.1.2.4 Log LF/HF

Concerning the log LF/HF (table 3.10), there were no significant main effects at all. Likewise, no significant interaction effects are detected as well. All effects showed p-values above 0.05.

Table 3.10: Repeated measures ANOVA. Measure is average log LF/HF (ratio or sympathovagal balance, respectively) at time on task (TOT) for pre-test and post-test recordings (= within-subjects variable). Between-subjects variables indicate sport education (SPORT) and teaching style (CLASS)

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	***P***
Intercept	22.430	1	22.430	189.519	.000
SPORT	.202	1	.202	1.706	.198
CLASS	.026	1	.026	.221	.640
SPORT * CLASS	.217	1	.217	1.836	.182
Error	5.326	45	.118		
TOT	.001	1	.001	.027	.871
TOT * SPORT	.102	1	.102	2.009	.163
TOT * CLASS	.164	1	.164	3.210	.080
TOT * SPORT * CLASS	.082	1	.082	1.602	.212
Error(TOT)	2.294	45	.051		

Log LF/HF trends in the LT class reveal a similar trend (figure 3.10). Although higher log LF/HF values are observed in the PE group compared to the RE group, both sport groups showed a fall from pre-test to post-test. In contrast NLT class students had higher log LF/HF values in the RE group but they showed a fall from pre- to post-test recordings. NLT students who conducted PE demonstrated a remarkable rise in the log LF/HF according to pre- and post-test measurements.

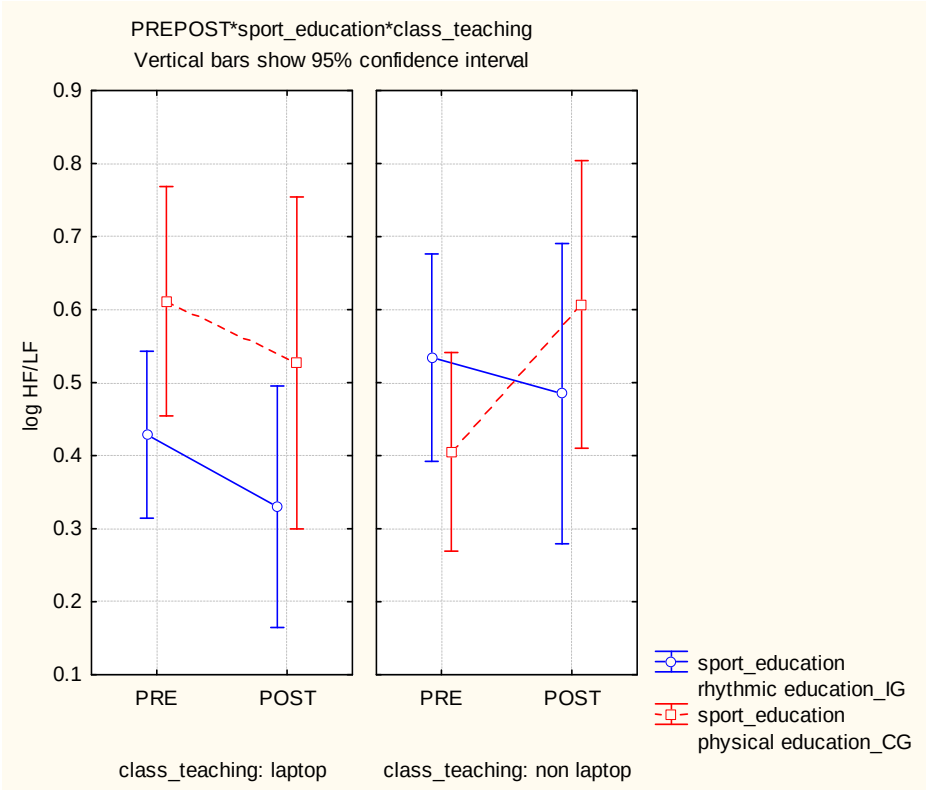


Figure 3.10: 3-way interaction between TOT * sport education * teaching style. Log LF/HF at pre- and post-test recordings for laptop and non laptop students demonstrated for rhythmic education group (RE) and physical education (PE).

3.1.2.5 normalized LF

HRV which was evaluated through the parameter LF in nu is demonstrated in table 3.11. There were no significant main effects of sport education, $F(1,45) = 0.039$, $p > 0.05$, of teaching style, $F(1,45) = 0.003$, $p > 0.05$, and of TOT, $F(1,45) = 0.883$, $p > 0.05$. Regarding the interaction, no significant effects are identified between sport education and teaching style, $F(1,45) = 0.566$, $p > 0.05$, and between TOT and sport education, $F(1,45) = 1.740$, $p > 0.05$. But there were significant effects between the interaction TOT and teaching style,

$F(1,45) = 4.248$, $p < 0.05$, and between the interaction TOT, sport education and teaching style, $F(1,45) = 6.632$, $p < 0.05$.

Table 3.11: Repeated measures ANOVA. Measure is average normalized LF at time on task (TOT) for pre-test and post-test recordings (= within-subjects variable). Between-subjects variables indicate sport education (SPORT) and teaching style (CLASS)

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	***P***
Intercept	4.874	1	4.874	187.732	.000
SPORT	.001	1	.001	.039	.844
CLASS	6.86E-005	1	6.86E-005	.003	.959
SPORT * CLASS	.015	1	.015	.566	.456
Error	1.168	45	.026		
TOT	.015	1	.015	.883	.353
TOT * SPORT	.030	1	.030	1.740	.194
TOT * CLASS	.073	1	.073	4.248	**.045**
TOT * SPORT * CLASS	.114	1	.114	6.632	**.013**
Error(TOT)	.771	45	.017		

The interaction graph (figure 3.11) depicts a fall in the normalized LF component from pre-to post-test recordings in LT students of both sport groups. The fall in normalized LF was steeper in the PE group than in the RE group. NLT students who performed RE demonstrated a fall in normalized LF as well, whereas NLT students conducting PE showed a remarkable increase in normalized LF from pre-test to post-test measurements.

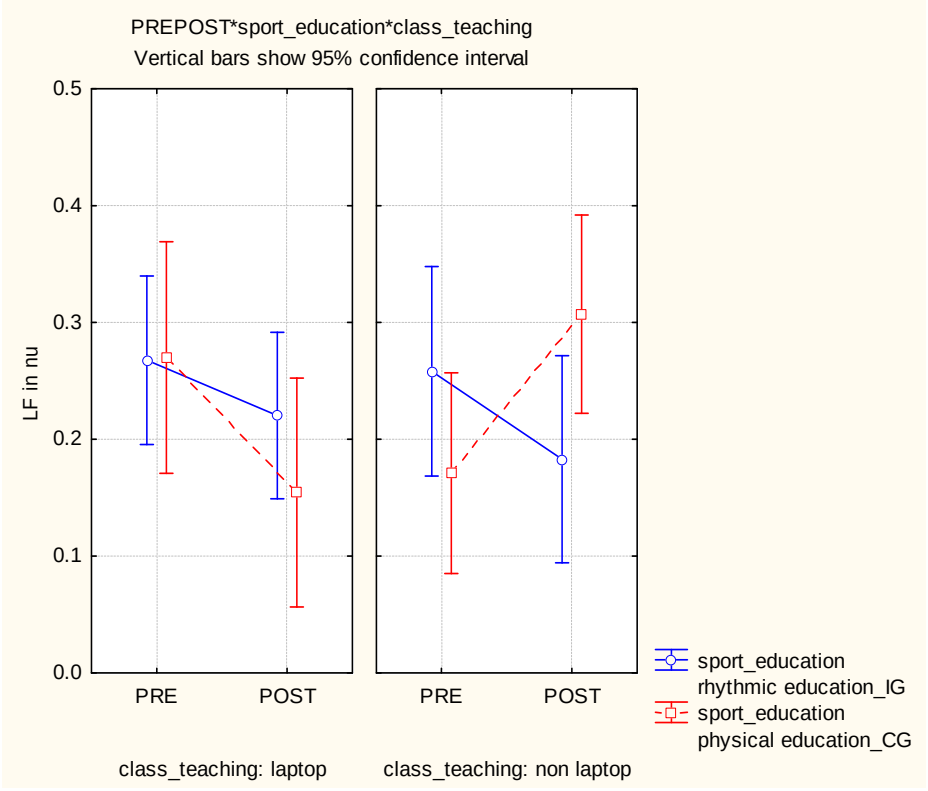


Figure 3.11: 3-way interaction between TOT * sport education * teaching style. Normalized low frequency at pre- and post-test recordings for laptop and non laptop students demonstrated for rhythmic education group (RE) and physical education (PE).

3.1.2.6 normalized HF

According to the HRV parameter HF in nu statistical analysis reveals a significant main effect of sport education, $F(1,45) = 4.987$, $p < 0.05$ (table 3.12). There were no significant main effects of teachings style and no significant main effect of TOT. Likewise, all interaction effects demonstrated non-significant results. All these non-significant effects showed p values above 0.05.

Table 3.12: Repeated measures ANOVA. Measure is average normalized HF at time on task (TOT) for pre-test and post-test recordings (= within-subjects variable). Between-subjects variables indicate sport education (SPORT) and teaching style (CLASS)

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	***P***
Intercept	.620	1	.620	92.893	.000
SPORT	.033	1	.033	4.987	**.031**
CLASS	.002	1	.002	.230	.634
SPORT * CLASS	.022	1	.022	3.330	.075
Error	.300	45	.007		
TOT	2.12E-005	1	2.12E-005	.005	.944
TOT * SPORT	.005	1	.005	1.122	.295
TOT * CLASS	.000	1	.000	.059	.809
TOT * SPORT * CLASS	.003	1	.003	.584	.449
Error(TOT)	.193	45	.004		

The graphs in figure 3.12 reveal that LT students who performed RE during the term showed an increase in normalized HF from pre- to post-test recordings. LT students who conducted PE however, demonstrated a decrease in normalized HF from pre-test to post-test. In contrast to the LT class, NLT students showed a similar tendency in both sport groups. Whereas the RE group demonstrated a faint rise in normalized HF, the PE group remained fairly constant from pre-test to post-test measurements.

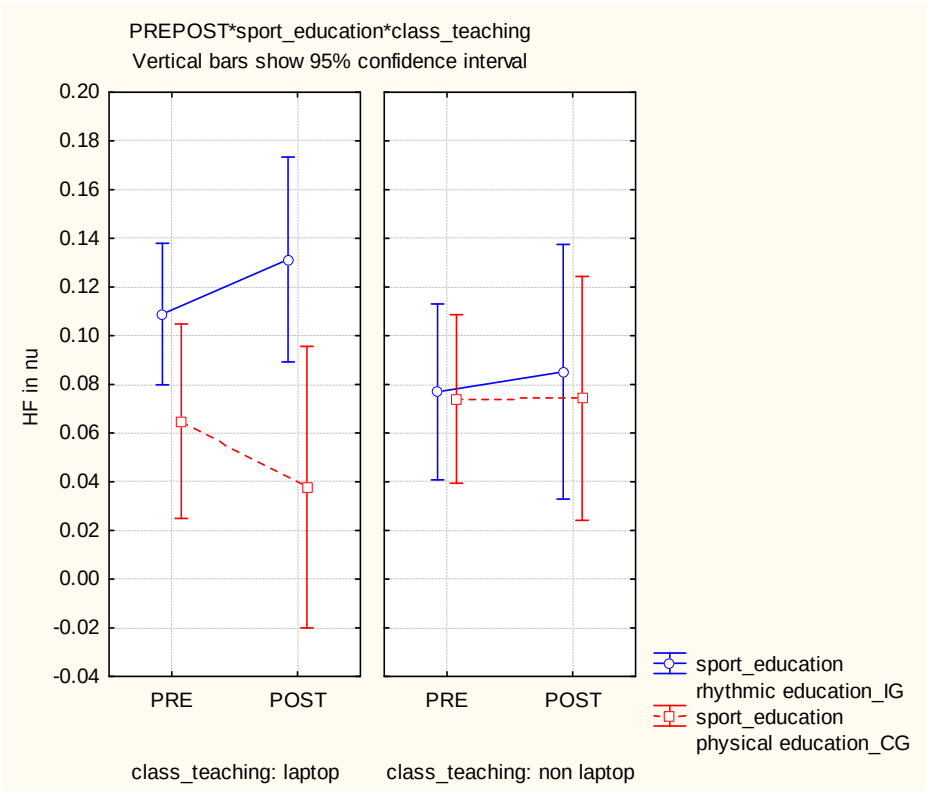


Figure 3.12: 3-way interaction between TOT * sport education * teaching style. Normalized high frequency at pre- and post-test recordings for laptop and non laptop students demonstrated for rhythmic education group (RE) and physical education (PE).

3.1.3 Atrial mean

Table 3.13 illustrates the statistical analysis of the atrial mean component. There were no significant main effects at all. Likewise, no significant interaction effects are detected as well. All effects showed p-values above 0.05.

Table 3.13: Repeated measures ANOVA. Measure is average atrial mean at time on task (TOT) for pre-test and post-test recordings (= within-subjects variable). Between-subjects variables indicate sport education (SPORT) and teaching style (CLASS)

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	***P***
Intercept	1.613	1	1.613	1821.274	.000
SPORT	.001	1	.001	.618	.436
CLASS	6.17E-005	1	6.17E-005	.070	.793
SPORT * CLASS	.001	1	.001	1.117	.296
Error	.040	45	.001		
TOT	.001	1	.001	2.677	.109
TOT * SPORT	.000	1	.000	1.532	.222
TOT * CLASS	9.71E-005	1	9.71E-005	.298	.588
TOT * SPORT * CLASS	.000	1	.000	1.377	.247
Error(TOT)	.015	45	.000		

The graphs in figure 3.13 reveal the trend of the atrial mean parameter. Whereas LT students performing RE showed an increase of atrial mean from pre-test to post-test, LT students from the PE group demonstrated a decrease of atrial mean from pre-test to post-test. Opposite to the LT class, NLT students showed a decrease in atrial mean from pre-test to post-test in both sport groups.

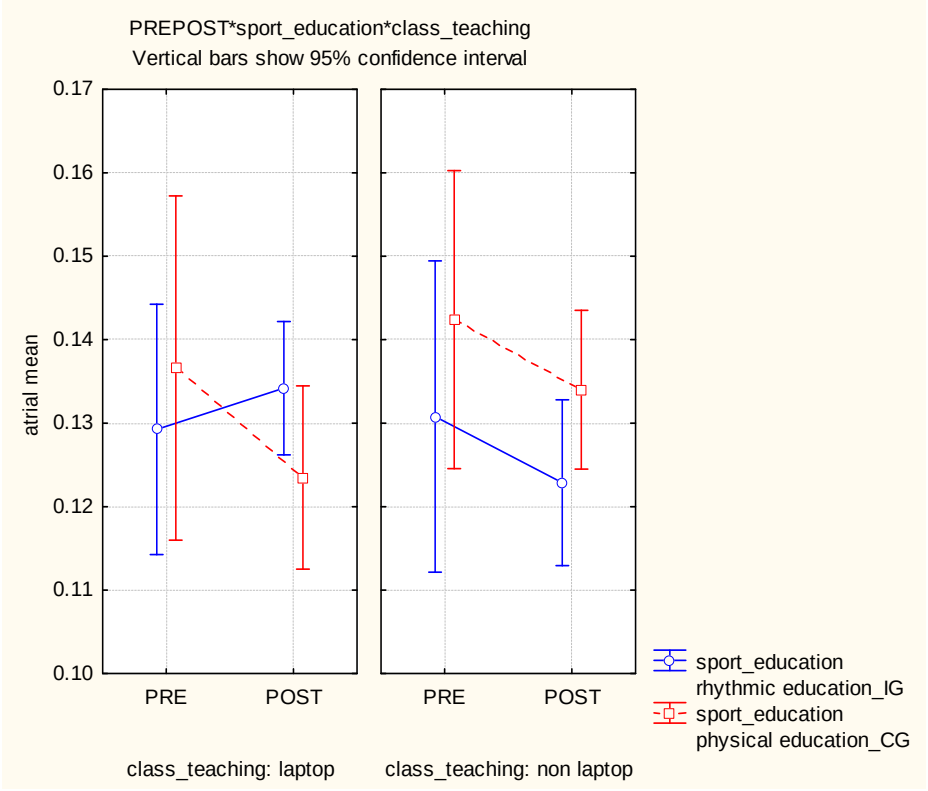


Figure 3.13: 3-way interaction between TOT * sport education * teaching style. Atrial mean at pre- and post-test recordings for laptop and non laptop students demonstrated for rhythmic education group (RE) and physical education (PE).

3.1.4 Atrial median

Concerning the atrial median (table 3.14), there was no significant main effects of sport education, $F(1,45) = 0.219$, $p > 0.05$, of teaching style, $F(1,45) = 0.221$, $p > 0.05$, and of TOT, when recordings were conducted, $F(1,45) = 0.431$, $p > 0.05$. Furthermore, no significant effects existed according to the interaction between sport education and teaching style, $F(1,45) = 1.253$, $p > 0.05$, between TOT and sport education, $F(1,45) = 3.779$, $p > 0.05$, as well as between TOT and teaching style, $F(1,45) = 0.091$, $p > 0.05$. Finally, there was a significant interaction effect between TOT, sport education and teaching style, $F(1,45) = 6.798$, $p < 0.05$.

Table 3.14: Repeated measures ANOVA. Measure is average atrial median at time on task (TOT) for pre-test and post-test recordings (= within-subjects variable). Between-subjects variables indicate sport education (SPORT) and teaching style (CLASS)

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	***P***
Intercept	1.477	1	1.477	2615.736	.000
SPORT	.000	1	.000	.219	.642
CLASS	.000	1	.000	.221	.641
SPORT * CLASS	.001	1	.001	1.253	.269
Error	.025	45	.001		
TOT	1.11E-005	1	1.11E-005	.431	.515
TOT * SPORT	9.75E-005	1	9.75E-005	3.779	.058
TOT * CLASS	2.35E-006	1	2.35E-006	.091	.764
TOT * SPORT * CLASS	.000	1	.000	6.798	**.012**
Error(TOT)	.001	45	2.58E-005		

The significant 3-way interaction is depicted in figure 3.14. LT students who performed RE showed a rise in atrial median, whereas LT students from the PE group demonstrated a fall in atrial median from pre-test to post-test. With respect to the NLT class students, both sport groups showed a faint rise in atrial median from pre-test to post-test. Considering the basis values at pre-test recordings, NLT students from the RE group had lower atrial median than NLT students from the PE group as well as both sport groups from the LT class.

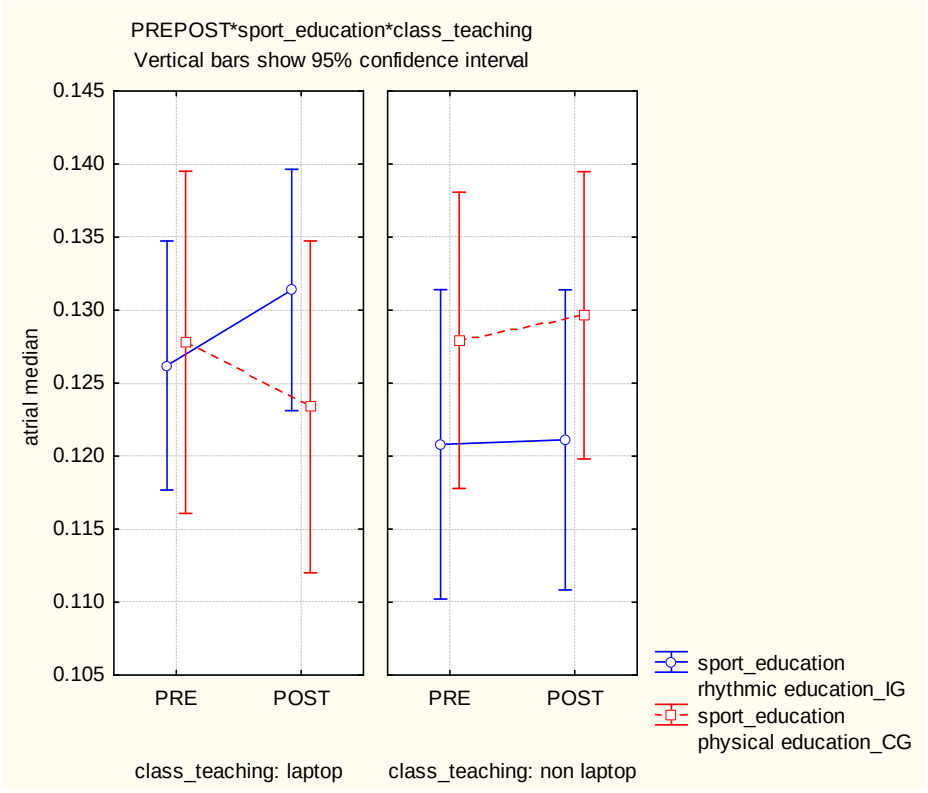


Figure 3.14: 3-way interaction between TOT * sport education * teaching style. Atrial median at pre- and post-test recordings for laptop and non laptop students demonstrated for rhythmic education group (RE) and physical education (PE).

3.2 HRV at fitness condition

This section illustrates the results of the selected HRV parameters during the fitness condition which were recorded and analysed in one-minute steps. Evaluation and graphical presentation are demonstrated via diagrams representing the interactions between the two sport groups (RE and PE), teaching styles (LT and NLT), TOT, for pre- and post-test recordings, and the fitness conditions. The fitness condition comprised eleven one-minute-segments, meaning five minutes baseline, one minute exercise, one minute knee bending, and five minutes recovery. Results are demonstrated via the statistical significance test repeated measures ANOVA. Afterwards the effects are described via graphs, which show the interactions between the two sport groups (PE and RE), class teaching style (LT versus NLT) TOT, for pre- and post-test recordings, and fitness condition, representing the eleven sessions.

The appropriate tables for mean values, standard errors and confidence intervals as well as relevant significant interaction effects are inserted in the appendix (see tables 7.21 – 7.38).

All effects are reported as significant at $p < 0.05$.

In terms of violation of the assumption of normality and variance homogeneity, respectively, the non parametric test Mann-Whitney U-test was conducted to recheck significant effects.

3.2.1 Time domain parameters

3.2.1.1 Minimum heart rate

Statistical analysis of the average minimum HR is illustrated in table 3.15. The results of the repeated measures ANOVA showed that the minimum HR was not significantly affected by the type of sport education performed or by the style of class teaching held during the term. But there were significant main effects concerning TOT recordings, $F(1,45) = 5.030$, $p < 0.05$, and concerning the fitness condition, $F(3.336,150.112) = 68.578$, $p < 0.05$. Moreover, significant interaction effects are identified between fitness condition and

sport education, $F(3.336,150.112) = 5.888$, $p < 0.05$, between fitness condition and teaching style, $F(3.336,150.112) = 5.226$, $p < 0.05$, and between TOT and fitness condition, $F(3.251, 146.305) = 8.135$, $p < 0.05$. The interaction effect between TOT, fitness condition, sport education and teaching style was significant as well, $F(3.251, 146.305) = 5.956$, $p < 0.05$.

Table 3.15: Repeated measures ANOVA. Measure is average minimum heart rate at time on task (TOT) for pre-test and post-test recordings and Fitness (= within-subjects variables). Between-subjects variables indicate sport education (SPORT) and teaching style (CLASS)

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	***P***
Intercept	8128052.901	1	8128052.901	2071.897	.000
SPORT	10205.913	1	10205.913	2.602	.114
CLASS	655.849	1	655.849	.167	.685
SPORT * CLASS	14992.228	1	14992.228	3.822	.057
Error	176534.997	45	3923.000		
TOT	3121.901	1	3121.901	5.030	**.030**
TOT * SPORT	2216.894	1	2216.894	3.572	.065
TOT * CLASS	49.311	1	49.311	.079	.779
TOT * SPORT * CLASS	2886.045	1	2886.045	4.650	.036
Error(TOT)	27932.081	45	620.713		
FITNESS	75059.404	3.336	22501.081	68.578	**.000**
FITNESS * SPORT	6444.999	3.336	1932.062	5.888	**.000**
FITNESS * CLASS	5719.709	3.336	1714.637	5.226	**.001**
FITNESS * SPORT * CLASS	2485.300	3.336	745.036	2.271	.076
Error(Fitness)	49253.056	150.112	328.110		
TOT * FITNESS	5948.214	3.251	1829.532	8.135	**.000**
TOT * FITNESS * SPORT	1235.403	3.251	379.981	1.690	.168
TOT * FITNESS * CLASS	1183.704	3.251	364.080	1.619	.184
TOT * FITNESS * SPORT * CLASS	4355.064	3.251	1339.516	5.956	**.001**
Error(TOT*FITNESS)	32904.634	146.305	224.904		

The interactions graphs reveal (figure 3.15) that LT students who performed RE show lower minimum HR than LT students from the PE group. Furthermore, the rise in HR at knee bending (KB) exercise was delayed in time for students who performed the RE. Differences between pre- and post-test recordings are demonstrated by a minor rise in HR during KB exercise and by a minor fall of HR during the first recovery minute at post-test measurements.

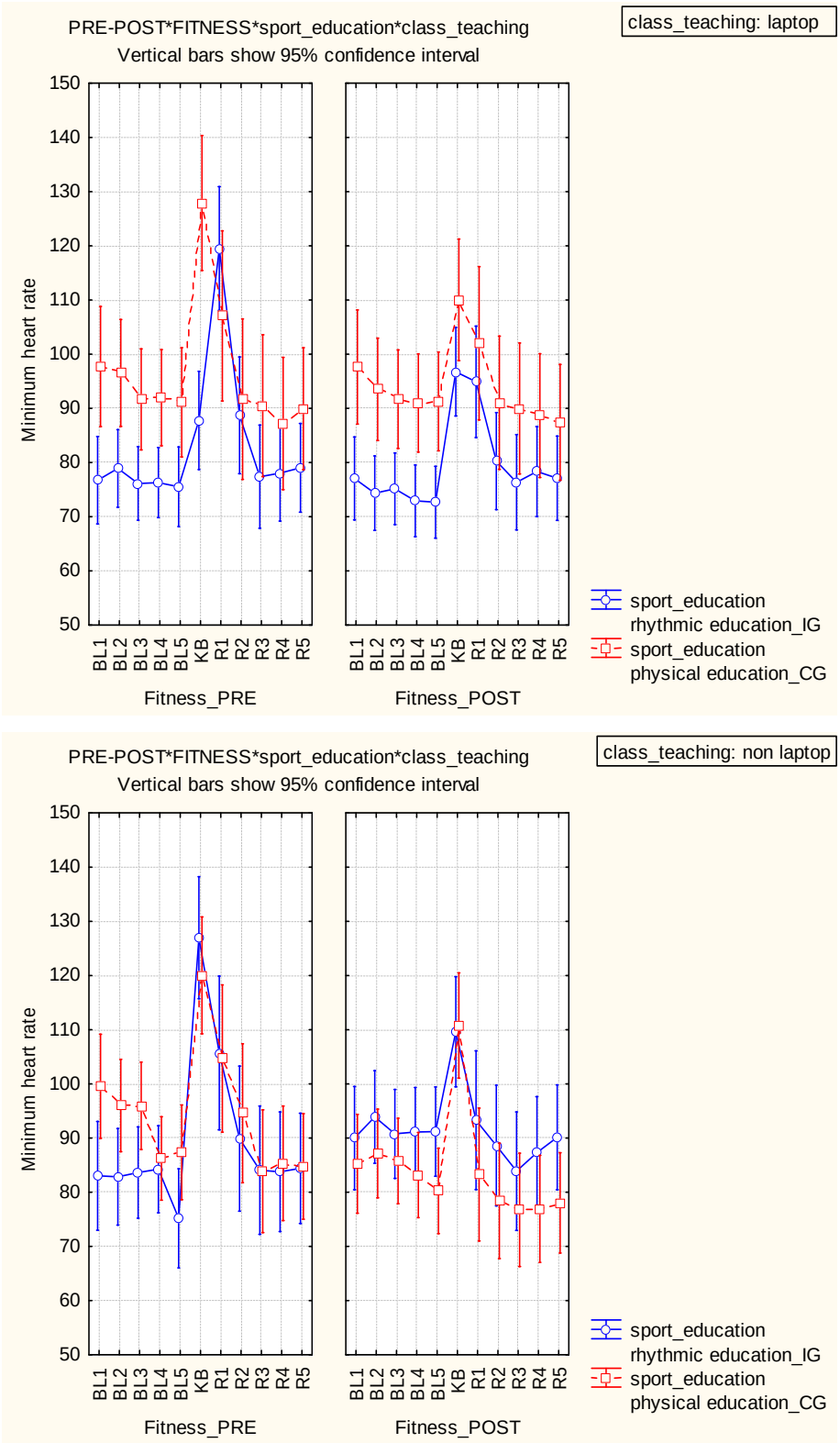


Figure 3.15: 4-way interaction between TOT * Fitness * sport education * teaching style. Average minimum heart rate across the fitness conditions at pre- and post-test recordings for laptop and non laptop students demonstrated for the rhythmic education group (RE) and the physical education group (PE)

Regarding NLT students, the RE group showed lower minimum heart rates at pre-test baseline measurements compared to the PE group. But both sport groups ended with similar minimum heart rates during recovery period. During post-test recordings the RE group however, started with higher minimum heart rates at baseline measurements than the PE group. At KB exercise the HR in both sport groups showed a minor rise compared to the pre-test. During the recovery period the RE group again exhibited higher minimum HR than the PE group.

3.2.1.2 Mean heart rate

Concerning the mean HR (table 3.16), there was a significant main effect of TOT, $F(1,45) = 6.712$, $p < 0.05$ and a significant main effect of fitness, $F(3.378,151.991) = 287.073$, $p < 0.05$. All other main effects revealed non-significant results with $p > 0.05$. Interaction effects showed significant results between fitness and sport education, $F(3.378,151.991) = 8.976$, $p < 0.05$, between fitness and teaching style, $F(3.378,151.991) = 6.977$, $p < 0.05$, and between fitness, sport education and teaching style, $F(3.378,151.991) = 4.254$, $p < 0.05$. Moreover, there were significant interaction effects between TOT and fitness, $F(2.897,130.355) = 10.568$, $p < 0.05$, between TOT, fitness and sport education, $F(2.897,130.355) = 3.994$, $p < 0.05$, between TOT, fitness and teaching style, $F(2.897,130.355) = 4.939$, $p < 0.05$ and between TOT, fitness, sport education and teaching style, $F(2.897,130.355) = 13.823$, $p < 0.05$.

Non parametric post-hoc tests via Mann-Whitney U-test revealed significant effects between RE and PE students during all five pre-test baseline minutes and at pre-test KB exercise. All significant results showed $p < 0.05$ (see appendix table 7.23). Regarding differences between LT and NLT students, significant effects are detected at pre-test KB exercise, $z = -3.055$, $p < 0.05$ and for post-test baseline minute 3, 4 and 5, $p < 0.05$ (see appendix table 7.24).

Table 3.16: Repeated measures ANOVA. Measure is average mean heart rate at time on task (TOT) for pre-test and post-test recordings and Fitness (= within-subjects variables). Between-subjects variables indicate sport education (SPORT) and teaching style (CLASS)

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	***P***
Intercept	11366218,772	1	11366218.772	3654,984	,000
SPORT	6629,640	1	6629,640	2,132	,151
CLASS	400,221	1	400,221	,129	,721
SPORT * CLASS	7141,483	1	7141,483	2,296	,137
Error	139940,390	45	3109,786		
TOT	4176.038	1.000	4176.038	6.712	**.013**
TOT * SPORT	2461.976	1.000	2461.976	3.957	.053
TOT * CLASS	40.864	1.000	40.864	.066	.799
TOT * SPORT * CLASS	1872.504	1.000	1872.504	3.010	.090
Error(TOT)	27996.989	45.000	622.155		
FITNESS	187662.076	3.378	55561.036	287.073	**.000**
FITNESS * SPORT	5867.802	3.378	1737.278	8.976	**.000**
FITNESS * CLASS	4561.097	3.378	1350.402	6.977	**.000**
FITNESS * SPORT * CLASS	2780.612	3.378	823.255	4.254	**.005**
Error(Fitness)	29416.933	151.991	193.544		
TOT * FITNESS	5487.080	2.897	1894.207	10.568	**.000**
TOT * FITNESS * SPORT	2073.757	2.897	715.886	3.994	**.010**
TOT * FITNESS * CLASS	2564.520	2.897	885.304	4.939	**.003**
TOT * FITNESS * SPORT * CLASS	7177.200	2.897	2477.657	13.823	**.000**
Error(TOT*FITNESS)	23364.910	130.355	179.241		

The significant 4-way interaction graph reveals an overall higher mean HR in students conducting the PE during the term (figure 3.16). In particular, this observation applies to the LT class. During KB exercise, the rise in mean HR was fairly similar in both sport groups with a small delay for the RE group while pre-test recording. Regarding the recovery period both sport groups showed a similar decrease in heart rates and ended above pre-exercise baseline values.

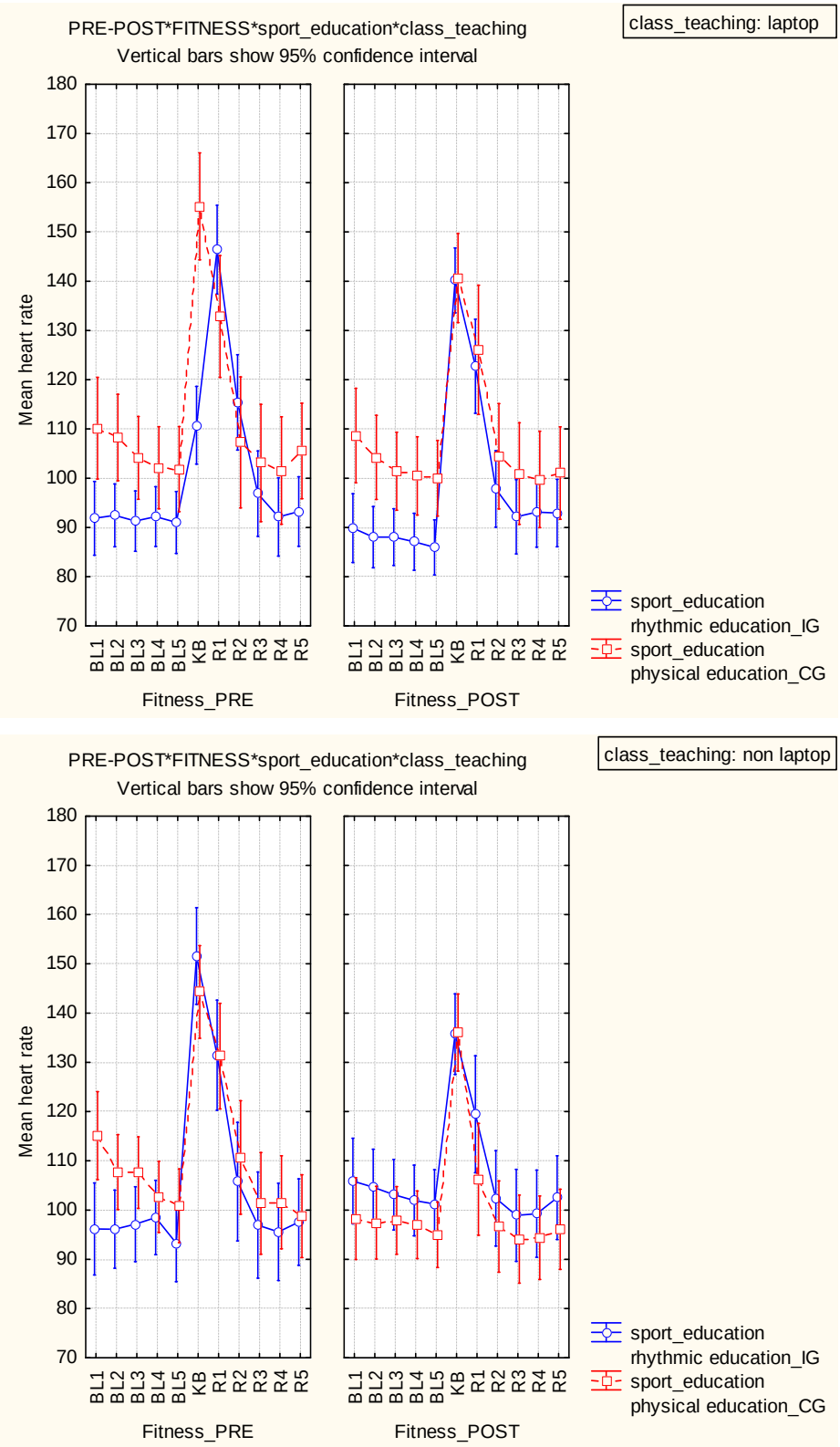


Figure 3.16: 4-way interaction between TOT * Fitness * sport education * teaching style. Average mean heart rate across the fitness conditions at pre- and post-test recordings for laptop and non laptop students demonstrated for the rhythmic education group (RE) and the physical education group (PE)

With respect to NLT students mean HR at pre-test recording revealed higher values in the PE group as compared to the RE group across baseline recording. During KB exercise both sport groups showed a rise in HR above 144 BpM and a similar fall during recovery period. During post-test recording however, the RE group revealed a slightly higher mean HR across baseline recording compared to the PE group. During KB exercise both sport groups showed lower mean heart rates (135 BpM) compared to pre-test recordings. Concerning the recovery phase, both sport groups demonstrated a fall in mean HR which was similar to the trend during pre-test recording.

3.2.1.3 Maximum heart rate

Maximum HR showed a significant main effect of TOT, $F(1,45) = 5.830$, $p < 0.05$ and a significant main effect of fitness, $F(3.899,175.438) = 308.472$, $p < 0.05$ (table 3.17). Concerning the interaction effects, there were significant results between fitness and sport education, $F(3.899,175.438) = 5.252$, $p < 0.05$ and between fitness and class teaching style, $F(3.899,175.438) = 5.071$, $p < 0.05$. Furthermore, significant interaction effects are detected between TOT and fitness, $F(5.206,234.272) = 5.666$, $p < 0.05$, between TOT, fitness and sport education, $F(5.206,234.272) = 5.699$, $p < 0.05$, between TOT, fitness and teaching style, $F(5.206,234.272) = 5.392$, $p < 0.05$ and between TOT, fitness, sport education and teaching style, $F(5.206,234.272) = 11.474$, $p < 0.05$.

Table 3.17: Repeated measures ANOVA. Measure is average maximum heart rate at time on task (TOT) for pre-test and post-test recordings and Fitness (= within-subjects variables). Between-subjects variables indicate sport education (SPORT) and teaching style (CLASS)

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	***P***
Intercept	15467199.634	1	15467199.634	5344.190	.000
SPORT	2727.723	1	2727.723	.942	.337
CLASS	177.723	1	177.723	.061	.805
SPORT * CLASS	4214.457	1	4214.457	1.456	.234
Error	130239.372	45	2894.208		
TOT	4150.245	1.000	4150.245	5.830	**.020**
TOT * SPORT	1387.985	1.000	1387.985	1.950	.169
TOT * CLASS	50.402	1.000	50.402	.071	.791
TOT * SPORT * CLASS	1067.832	1.000	1067.832	1.500	.227
Error(TOT)	32035.597	45.000	711.902		
FITNESS	375753.225	3.899	96380.812	308.472	**.000**
FITNESS * SPORT	6397.987	3.899	1641.085	5.252	**.001**
FITNESS * CLASS	6177.409	3.899	1584.507	5.071	**.001**
FITNESS * SPORT * CLASS	1949.470	3.899	500.040	1.600	.178
Error(Fitness)	54814.953	175.438	312.446		
TOT * FITNESS	5361.966	5.206	1029.950	5.666	**.000**
TOT * FITNESS * SPORT	5392.505	5.206	1035.816	5.699	**.000**
TOT * FITNESS * CLASS	5101.911	5.206	979.997	5.392	**.000**
TOT * FITNESS * SPORT * CLASS	10857.969	5.206	2085.645	11.474	**.000**
Error(TOT*FITNESS)	42582.631	234.272	181.766		

Interaction graphs in figure 3.17 depict the trend of the maximum HR. Again, an overall higher HR is observed in students conducting PE during the term especially in baseline and recovery measurements. During pre-test KB exercise maximum HR increased above 182 BpM for the PE group and above 175 BpM (time-delayed) for the RE group. Regarding post-test KB exercise measurements, maximum HR increased above 182 BpM in RE students and above 167 BpM in PE students.

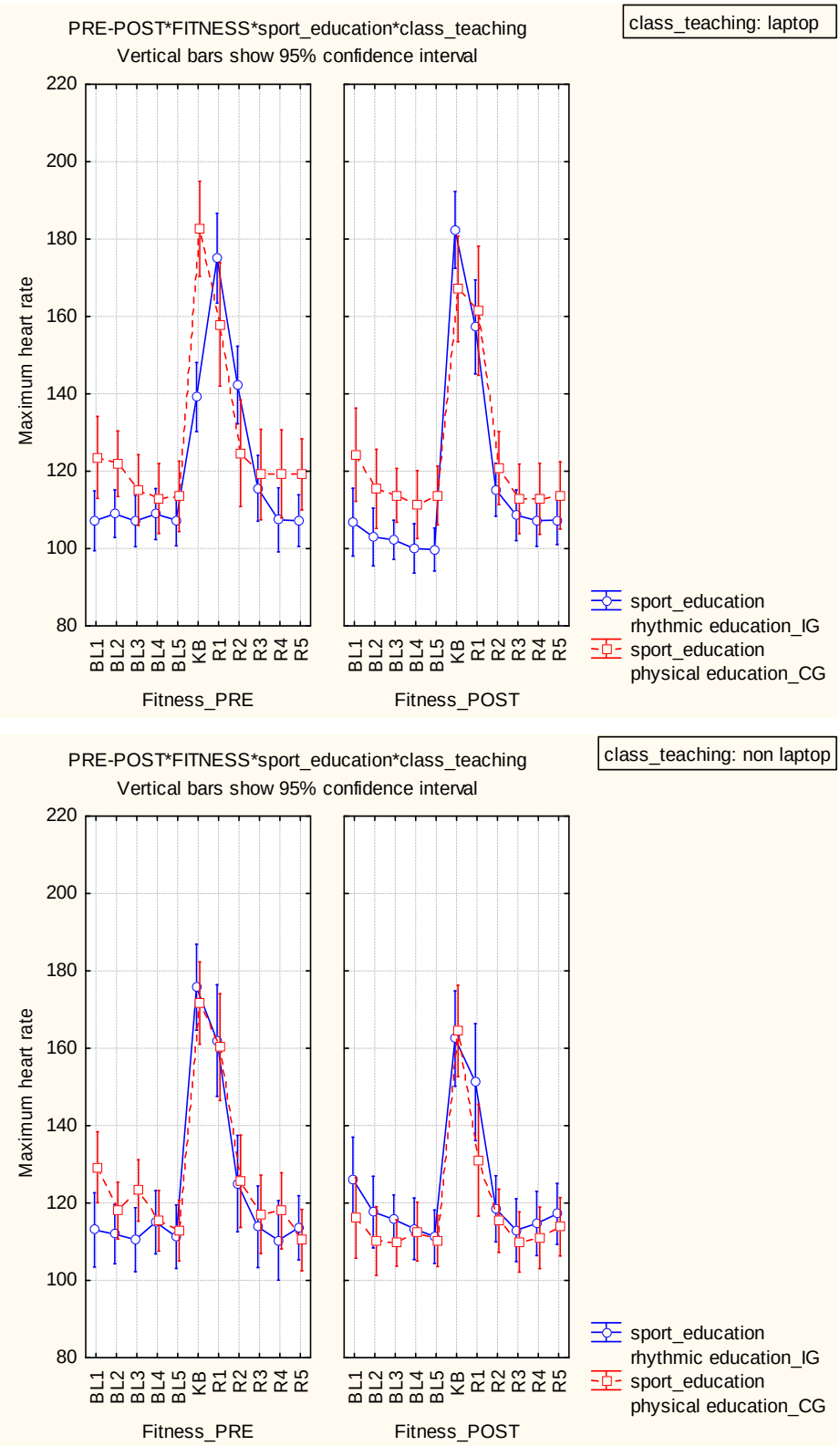


Figure 3.17: 4-way interaction between TOT * Fitness * sport education * teaching style. Average maximum heart rate across the fitness conditions at pre- and post-test recordings for laptop and non laptop students demonstrated for the rhythmic education group (RE) and the physical education group (PE)

Both NLT sport groups showed similar trends during pre-test recordings, with slightly higher maximum heart rates in the PE group. At KB exercise HR increased in both sport groups around 171 BpM. Except for baseline condition, in which higher maximum heart rates on students conducting the RE were measured, a similar maximum HR trend was observed during post-test measurements.

3.2.1.4 SDNN

HRV as measured by the parameter SDNN revealed a significant main effect of fitness, $F(4.711,211.992) = 9.528$, $p < 0.05$ (table 3.18). There were significant interaction effects between TOT and sport education, $F(1,45) = 5.914$, $p < 0.05$ and between TOT and teaching style, $F(1,45) = 4.869$, $p < 0.05$. The interactions between fitness and sport education, $F(4.711,211.992) = 2.956$, $p < 0.05$, between fitness and teaching style, $F(4.711,211.992) = 2.704$, $p < 0.05$ and between fitness, sport education and teaching style, $F(4.711,211.992) = 2.363$, $p < 0.05$ revealed significant results as well. Moreover, there were significant interaction effects between TOT and fitness, $F(4.179,188.063) = 4.517$, $p < 0.05$ and between TOT, fitness and teaching style, $F(4.179,188.063) = 2.888$, $p < 0.05$.

Table 3.18: Repeated measures ANOVA. Measure is average SDNN at time on task (TOT) for pre-test and post-test recordings and Fitness (= within-subjects variables). Between-subjects variables indicate sport education (SPORT) and teaching style (CLASS)

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	***P***
Intercept	2054745.306	1	2054745.306	321.078	.000
SPORT	16913.133	1	16913.133	2.643	.111
CLASS	124.483	1	124.483	.019	.890
SPORT * CLASS	10442.955	1	10442.955	1.632	.208
Error	287978.284	45	6399.517		
TOT	1.256	1.000	1.256	.001	.977
TOT * SPORT	8942.763	1.000	8942.763	5.914	**.019**
TOT * CLASS	225.060	1.000	225.060	.149	.701
TOT * SPORT * CLASS	7362.480	1.000	7362.480	4.869	**.032**
Error(TOT)	68050.094	45.000	1512.224		
FITNESS	28847.767	4.711	6123.572	9.528	**.000**
FITNESS * SPORT	8948.769	4.711	1899.573	2.956	**.015**
FITNESS * CLASS	8188.670	4.711	1738.225	2.704	**.024**
FITNESS * SPORT * CLASS	7155.752	4.711	1518.965	2.363	**.044**
Error(Fitness)	136251.432	211.992	642.719		
TOT * FITNESS	11103.530	4.179	2656.869	4.517	**.001**
TOT * FITNESS * SPORT	3657.136	4.179	875.085	1.488	.205
TOT * FITNESS * CLASS	7100.111	4.179	1698.925	2.888	**.022**
TOT * FITNESS * SPORT * CLASS	4501.881	4.179	1077.217	1.831	.121
Error(TOT*FITNESS)	110616.960	188.063	588.191		

Figure 3.18 depicts the course of the HRV parameter SDNN across the fitness condition. On average, the RE group presented higher SDNN values compared to the PE group during both TOT measurements. At pre-test KB exercise (time-delayed) RE students demonstrated a remarkable fall in SDNN. At the beginning of the recovery session a rise is observed which gradually decreased until the end of measurement.

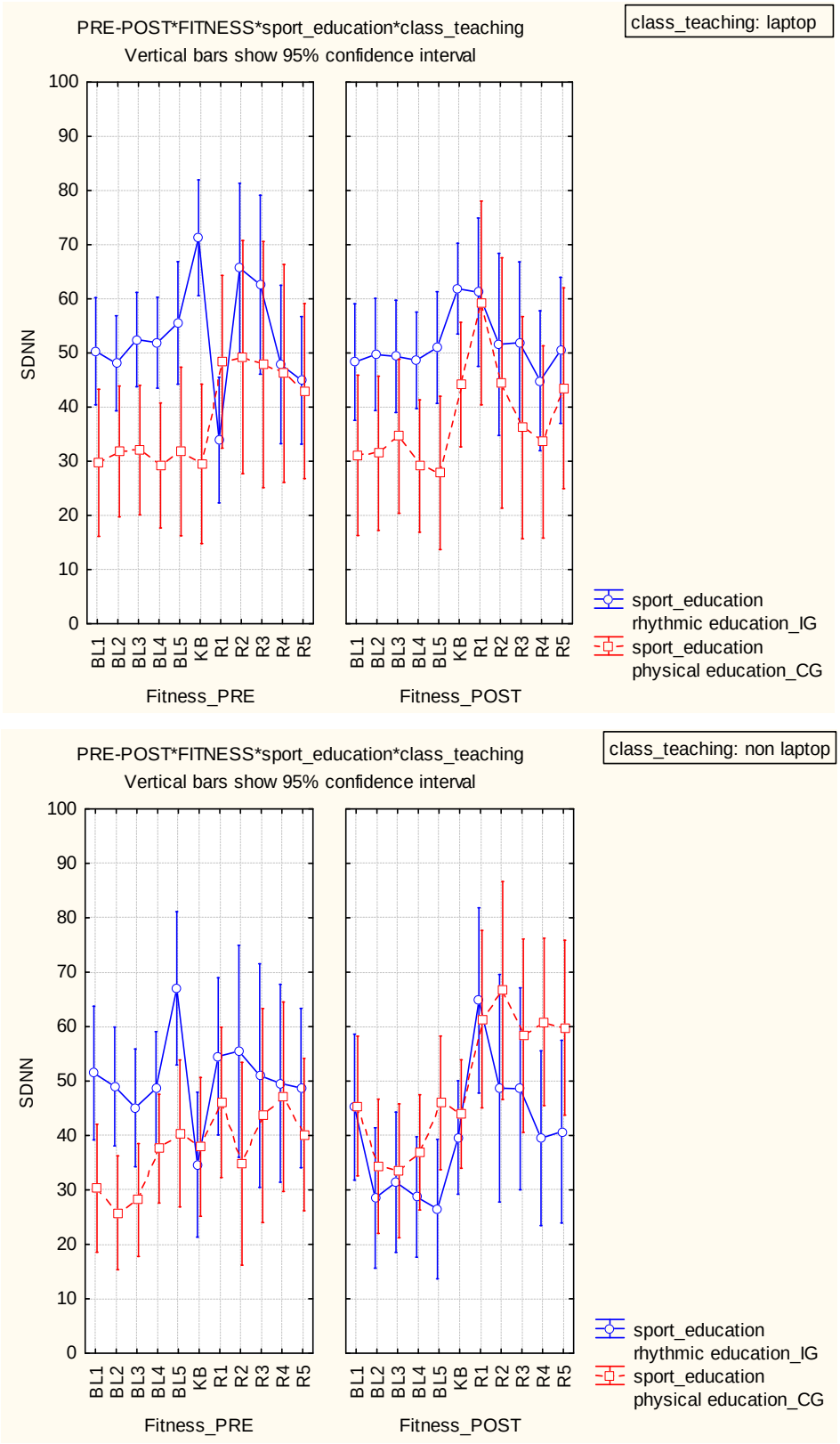


Figure 3.18: 4-way interaction between TOT * Fitness * sport education * teaching style. Average SDNN across the fitness conditions at pre- and post-test recordings for laptop and non laptop students demonstrated for the rhythmic education group (RE) and the physical education group (PE)

NLT students, who performed RE, showed higher SDNN values during pre-test baseline recordings. At KB exercise a noticeable fall in SDNN is observed (from 67 ms to 35 ms). During the recovery period SDNN levelled off at 50 ms. Compared to the RE group, students who conducted PE during the term showed a gradual increase in SDNN during baseline and KB recordings. At KB exercise both sport groups demonstrated similar SDNN. During the recovery period SDNN fluctuated between 35 ms und 47 ms in the PE group. Concerning post-test recordings both sport groups showed similar trends concerning the SDNN component across the fitness condition. During recovery period however, students from the PE group demonstrated higher SDNN values during the recovery session than RE students.

3.2.1.5 r-MSSD

HRV represented by the parameter r-MSSD is illustrated in table 3.19. There was a significant main effect of fitness, $F(2.642,118.871) = 15.867$, $p < 0.05$ and a significant interaction effect between TOT, sport education and teaching style, $F(1,45) = 4.403$, $p < 0.05$. All other main effect and interaction effects showed non-significant results with $p > 0.05$.

Table 3.19: Repeated measures ANOVA. Measure is average r-MSSD at time on task (TOT) for pre-test and post-test recordings and Fitness (= within-subjects variables). Between-subjects variables indicate sport education (SPORT) and teaching style (CLASS)

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	***P***
Intercept	844915.501	1	844915.501	227.983	.000
SPORT	1441.115	1	1441.115	.389	.536
CLASS	10823.327	1	10823.327	2.920	.094
SPORT * CLASS	3444.250	1	3444.250	.929	.340
Error	166772.212	45	3706.049		
TOT	132.392	1.000	132.392	.101	.753
TOT * SPORT	1262.529	1.000	1262.529	.959	.333
TOT * CLASS	16.566	1.000	16.566	.013	.911
TOT * SPORT * CLASS	5797.810	1.000	5797.810	4.403	**.042**
Error(TOT)	59258.423	45.000	1316.854		
FITNESS	30874.126	2.642	11687.712	15.867	**.000**
FITNESS * SPORT	4054.138	2.642	1534.735	2.084	.114
FITNESS * CLASS	2219.594	2.642	840.250	1.141	.332
FITNESS * SPORT * CLASS	2282.190	2.642	863.946	1.173	.321
Error(Fitness)	87558.630	118.871	736.582		
TOT * FITNESS	3316.828	2.986	1110.680	2.367	.074
TOT * FITNESS * SPORT	1070.326	2.986	358.412	.764	.516
TOT * FITNESS * CLASS	2132.720	2.986	714.167	1.522	.212
TOT * FITNESS * SPORT * CLASS	1834.856	2.986	614.424	1.310	.274
Error(TOT*FITNESS)	63049.138	134.384	469.173		

The interaction graphs (figure 3.19) reveal higher r-MSSD values in LT students performing RE during the school term. A fall in r-MSSD is observed at KB exercise in the RE group during both TOT measurements. At the beginning of the recovery period r-MSSD increased again and demonstrated a gradual fall until the end of recording. In the PE group r-MSSD levelled off at 20 ms during both TOT measurement. At the beginning of the recovery period r-MSSD increased and demonstrated a gradual fall until the end again.

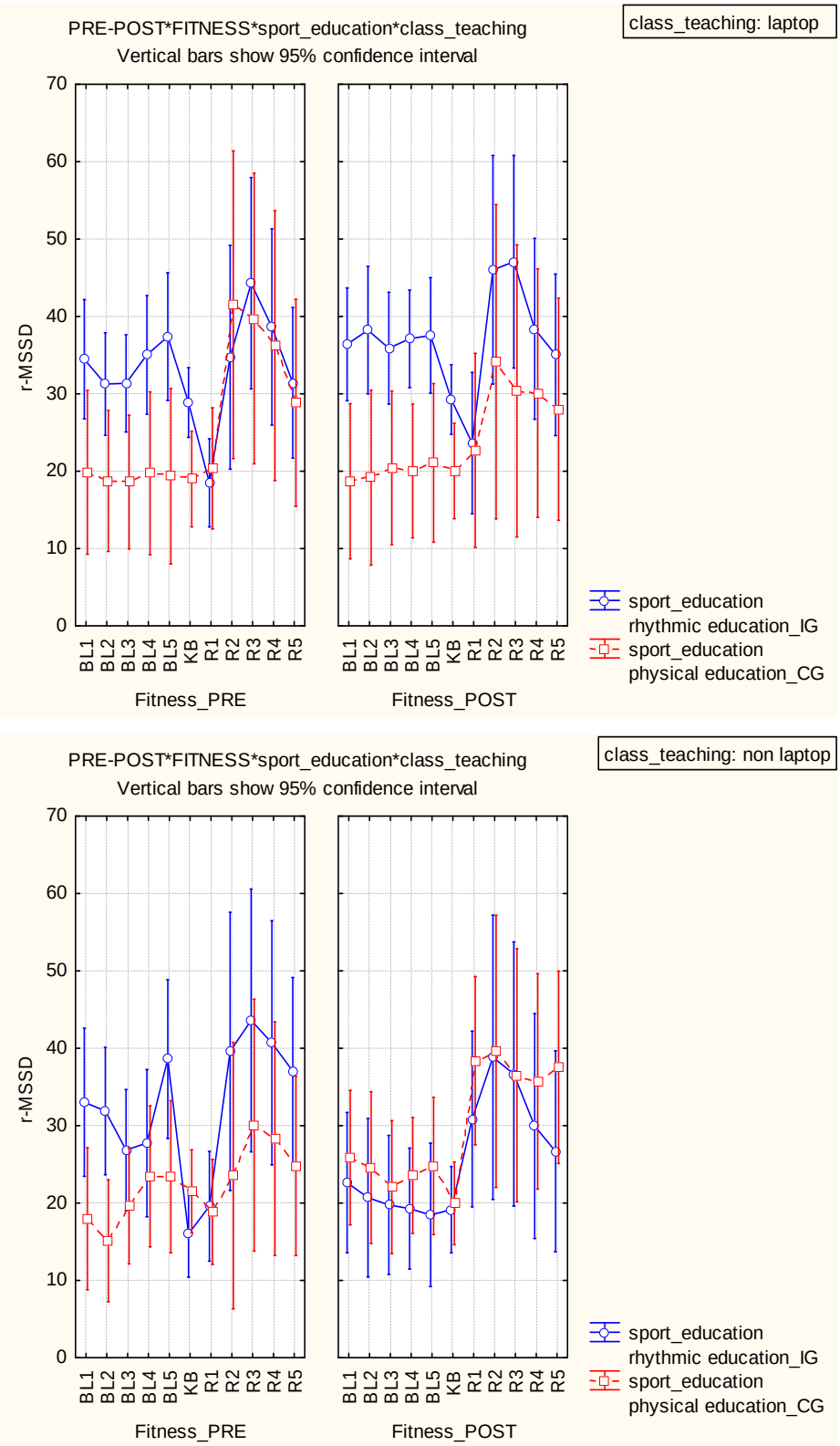


Figure 3.19: 4-way interaction between TOT * Fitness * sport education * teaching style. Average r-MSSD across the fitness conditions at pre- and post-test recordings for laptop and non laptop students demonstrated for the rhythmic education group (RE) and the physical education group (PE)

Concerning NLT students, the r-MSSD component demonstrated a similar trend during post-test recordings in both sport groups. There was a slight fall in r-MSSD during baseline measurements with a rise at the beginning of recovery session and a subsequently decrease during recovery session. In contrast to the preceding observation stronger fluctuations are found during pre-test recordings. NLT students performing RE during the term showed higher r-MSSD values during baseline recordings compared to the PE group. Furthermore, the RE group demonstrated a remarkable fall in r-MSSD at KB exercise. Afterwards a rise in r-MSSD at the beginning of the recovery period is identified which gradually decreased until recordings finished.

3.2.1.6 pNN50

Table 3.20 illustrates the results of the HRV as measured by pNN50. There was a significant main effect of fitness, $F(2.555,114.957) = 14.032$, $p < 0.05$ and a significant interaction effect between TOT, sport education and teaching style, $F(1,45) = 5.774$, $p < 0.05$. All remaining effects revealed non-significant results with $p > 0.05$.

Table 3.20: Repeated measures ANOVA. Measure is average pNN50 at time on task (TOT) for pre-test and post-test recordings and Fitness (= within-subjects variables). Between-subjects variables indicate sport education (SPORT) and teaching style (CLASS)

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	***P***
Intercept	129196.433	1	129196.433	77.720	.000
SPORT	3906.832	1	3906.832	2.350	.132
CLASS	996.362	1	996.362	.599	.443
SPORT * CLASS	233.132	1	233.132	.140	.710
Error	74805.263	45	1662.339		
TOT	87.820	1.000	87.820	.135	.715
TOT * SPORT	602.559	1.000	602.559	.927	.341
TOT * CLASS	126.497	1.000	126.497	.195	.661
TOT * SPORT * CLASS	3753.046	1.000	3753.046	5.774	**.020**
Error(TOT)	29247.381	45.000	649.942		
FITNESS	17258.298	2.555	6755.789	14.032	**.000**
FITNESS * SPORT	1700.163	2.555	665.532	1.382	.254
FITNESS * CLASS	1416.589	2.555	554.526	1.152	.328
FITNESS * SPORT * CLASS	1935.163	2.555	757.523	1.573	.205
Error(Fitness)	55345.109	114.957	481.443		
TOT * FITNESS	1055.300	3.509	300.702	1.349	.258
TOT * FITNESS * SPORT	703.456	3.509	200.446	.899	.456
TOT * FITNESS * CLASS	1122.604	3.509	319.880	1.435	.230
TOT * FITNESS * SPORT * CLASS	766.802	3.509	218.496	.980	.413
Error(TOT*FITNESS)	35206.491	157.925	222.931		

Figure 3.20 depicts the course of the HRV parameter pNN50 across the fitness condition. LT students from the RE group demonstrated a higher pNN50 compared to the PE group. At KB exercise the RE group showed a fall in pNN50 during both TOT measurements. At the beginning of the recovery period pNN50 increased and subsequently decreased again until the end of measurement. Students from the PE group showed pNN50 values around 6% for baseline recordings as well as at KB exercise recording. Likewise to the RE group, the PE group demonstrated a rise in early recovery session with a subsequently fall until the end of measurement.

NLT class students performing RE demonstrated a higher pNN50 across the baseline condition during pre-test recordings. At KB exercise a fall is observed with a subsequently rise in early recovery session and a fall again until the end of measurement. The PE however, revealed a gradual rise in pNN50 across the whole fitness condition. During post-test recordings the RE group showed slightly lower pNN50 values compared to the PE group. PNN50 slightly fluctuate in both sport groups across baseline and exercise condition. In early recovery pNN50 increased in both sport groups. Whereas in the RE group a fall in pNN50 is observed, in the PE group pNN50 values remained fairly constant until the end of measurement

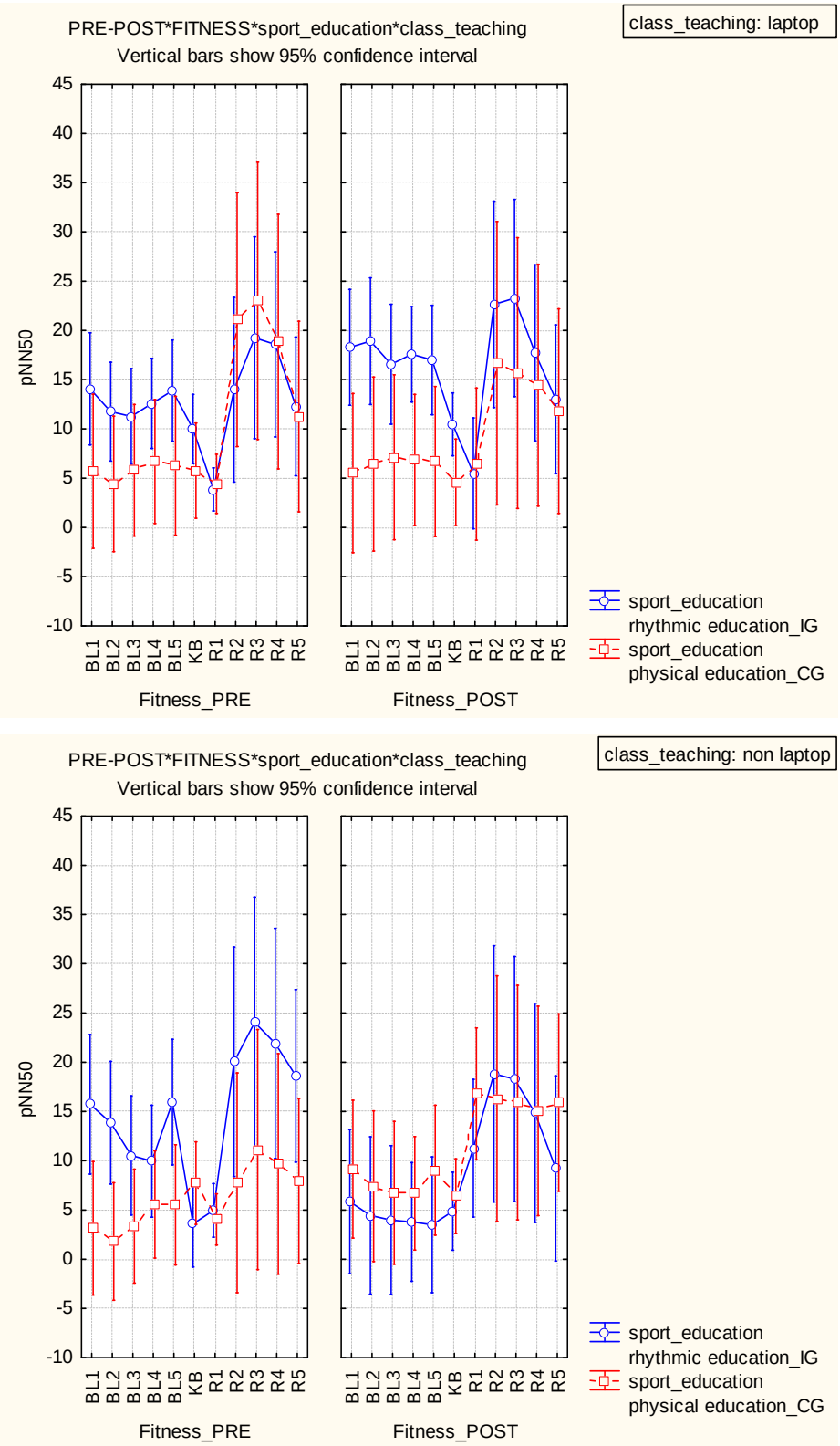


Figure 3.20: 4-way interaction between TOT * Fitness * sport education * teaching style. Average pNN50 across the fitness conditions at pre- and post-test recordings for laptop and non laptop students demonstrated for the rhythmic education group (RE) and the physical education group (PE)

3.2.2 Frequency domain parameters

3.2.2.1 LF Power

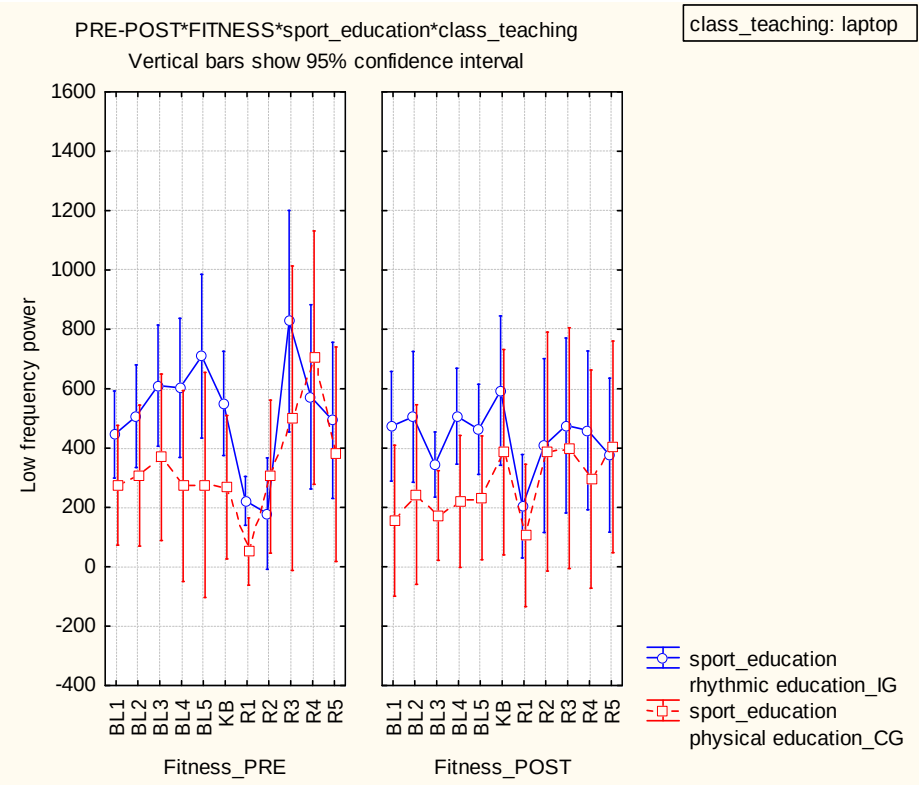
Regarding the LF power component, there was a significant main effect of fitness, $F(5.201,234.044) = 7.618$, $p < 0.05$ (table 3.21). Significant interaction effects are detected between TOT and sport education, $F(1,45) = 7.385$, $p < 0.05$ and between TOT, sport education and teaching style, $F(1,45) = 5.982$, $p < 0.05$. Moreover, there was also a significant interaction effect between TOT and fitness, $F(5.893,265.200) = 3.338$, $p < 0.05$.

Table 3.21: Repeated measures ANOVA. Measure is average low frequency power at time on task (TOT) for pre-test and post-test recordings and Fitness (= within-subjects variables). Between-subjects variables indicate sport education (SPORT) and teaching style (CLASS)

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	***P***
Intercept	160459685.218	1	160459685.218	93.923	.000
SPORT	3032040.163	1	3032040.163	1.775	.190
CLASS	18773.889	1	18773.889	.011	.917
SPORT * CLASS	1076319.250	1	1076319.250	.630	.432
Error	76878716.733	45	1708415.927		
TOT	63397.106	1.000	63397.106	.210	.649
TOT * SPORT	2231632.590	1.000	2231632.590	7.385	**.009**
TOT * CLASS	848912.181	1.000	848912.181	2.809	.101
TOT * SPORT * CLASS	1807638.245	1.000	1807638.245	5.982	**.018**
Error(TOT)	13598475.337	45.000	302188.341		
FITNESS	11692239.738	5.201	2248080.722	7.618	**.000**
FITNESS * SPORT	2924075.424	5.201	562215.430	1.905	.091
FITNESS * CLASS	1932492.111	5.201	371562.537	1.259	.281
FITNESS * SPORT * CLASS	835924.938	5.201	160724.274	.545	.749
Error(Fitness)	69069672.727	234.044	295113.498		
TOT * FITNESS	4260346.753	5.893	722909.687	3.338	**.004**
TOT * FITNESS * SPORT	1673199.809	5.893	283914.061	1.311	.253
TOT * FITNESS * CLASS	1550848.500	5.893	263153.088	1.215	.299
TOT * FITNESS * SPORT * CLASS	498607.776	5.893	84605.412	.391	.882
Error(TOT*FITNESS)	57426976.258	265.200	216542.194		

Figure 3.21 demonstrates the course of the HRV parameter LF power across the fitness condition. In general, LT students who performed RE presented higher LF power values than LT students who conducted PE during the school term. Both sport groups demonstrated a rise in LF power across baseline condition with a fall during KB exercise. At the beginning of the recovery session a rise in LF power is observed again with a

subsequently slight decrease until the end. This trend is observed for the pre-test recording as well as for the post-test recording. However, during post-tests LF power fluctuations decreased across the measurements.



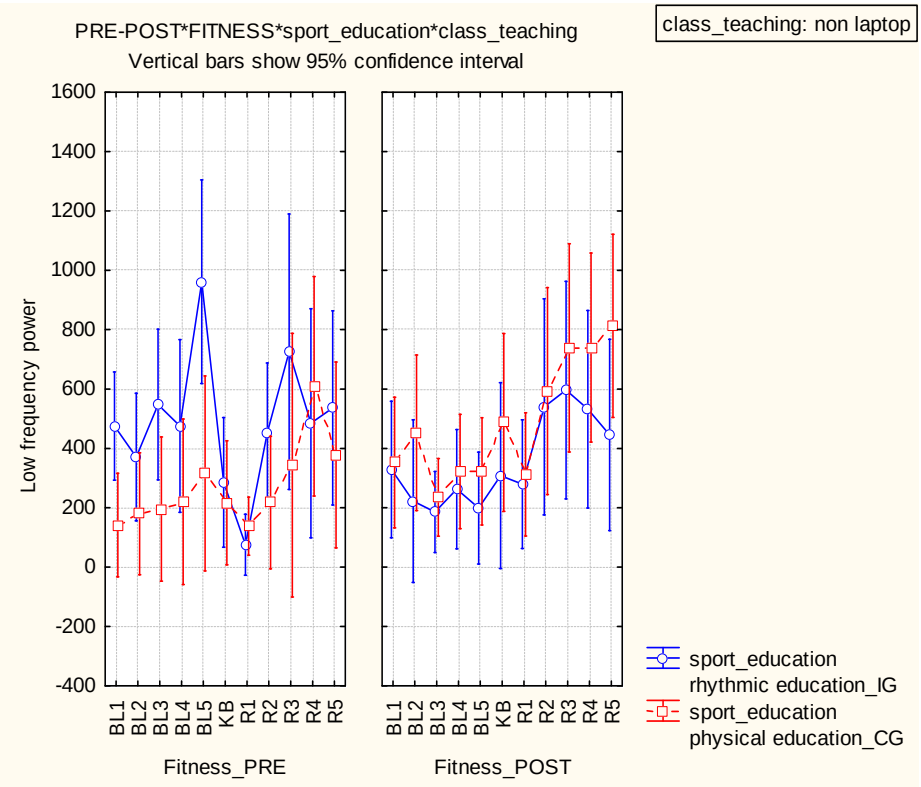


Figure 3.21: 4-way interaction between TOT * Fitness * sport education * teaching style. Average low frequency power across the fitness conditions at pre- and post-test recordings for laptop and non laptop students demonstrated for the rhythmic education group (RE) and the physical education group (PE)

NLT students demonstrate a similar trend of the HRV parameter LF power during pre-test recording. Likewise to LT students, NLT students who performed RE showed higher LF power than NLT students conducting PE during the term. Both sport groups demonstrated a rise during baseline condition, a fall at KB exercise and a rise again for early recovery session with a slight decrease towards the end of measurements. Concerning post-test recordings a general upward trend is observed across the fitness condition for both sport groups. Even though, higher fluctuations are identified over the whole recording. During recovery phase the RE group demonstrated a decrease in LF power whereas the PE group still showed a rise in LF power until the end of measurements.

3.2.2.2 HF Power

The results of the HRV parameter HF power is illustrated in table 3.22. There was a significant main effect of fitness, $F(2.594,116.715) = 14.374$, $p < 0.05$ and a significant interaction effect between TOT, sport education and teaching style, $F(1,45) = 4.603$, $p < 0.05$. All other main and interaction effects revealed non-significant results with $p > 0.05$.

Table 3.22: Repeated measures ANOVA. Measure is average high frequency power at time on task (TOT) for pre-test and post-test recordings and Fitness (= within-subjects variables). Between-subjects variables indicate sport education (SPORT) and teaching style (CLASS)

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	***P***
Intercept	35851278.030	1	35851278.030	62.214	.000
SPORT	1252181.028	1	1252181.028	2.173	.147
CLASS	134748.538	1	134748.538	.234	.631
SPORT * CLASS	74741.096	1	74741.096	.130	.720
Error	25931555.000	45	576256.778		
TOT	12826.095	1.000	12826.095	.077	.782
TOT * SPORT	3083.100	1.000	3083.100	.019	.892
TOT * CLASS	29611.751	1.000	29611.751	.178	.675
TOT * SPORT * CLASS	764293.624	1.000	764293.624	4.603	**.037**
Error(TOT)	7472713.409	45.000	166060.298		
FITNESS	7338759.719	2.594	2829487.156	14.374	**.000**
FITNESS * SPORT	285017.564	2.594	109889.622	.558	.618
FITNESS * CLASS	311375.359	2.594	120051.972	.610	.587
FITNESS * SPORT * CLASS	1062547.596	2.594	409669.330	2.081	.115
Error(Fitness)	22975135.463	116.715	196847.827		
TOT * FITNESS	377492.802	3.090	122158.404	1.270	.287
TOT * FITNESS * SPORT	467988.291	3.090	151443.160	1.574	.197
TOT * FITNESS * CLASS	583532.854	3.090	188833.910	1.963	.121
TOT * FITNESS * SPORT * CLASS	637556.099	3.090	206316.081	2.144	.096
Error(TOT*FITNESS)	13378885.572	139.059	96210.418		

Graphical representation of the HRV component HF power is illustrated in figure 3.22. LT students who performed RE demonstrated a higher HF power than students from the PE group. During pre-test recording HF power decreased from 319 ms² at baseline to 53 ms² at KB exercise. The recovery period illustrated a rise in HF power to 233 ms² until the end of measurement. In contrast to the RE group the PE group showed only minor fluctuation which range between 64 ms² and 110 ms² across baseline and KB condition. During recovery period however, a remarkable increase from 33 ms² to 550 ms² is observed. Concerning post-test measurements, differences are identified mainly during the recovery period. While the RE group showed a higher rise in HF power compared to pre-test measurements, the PE group demonstrated a minor rise compared to pre-test measurements.

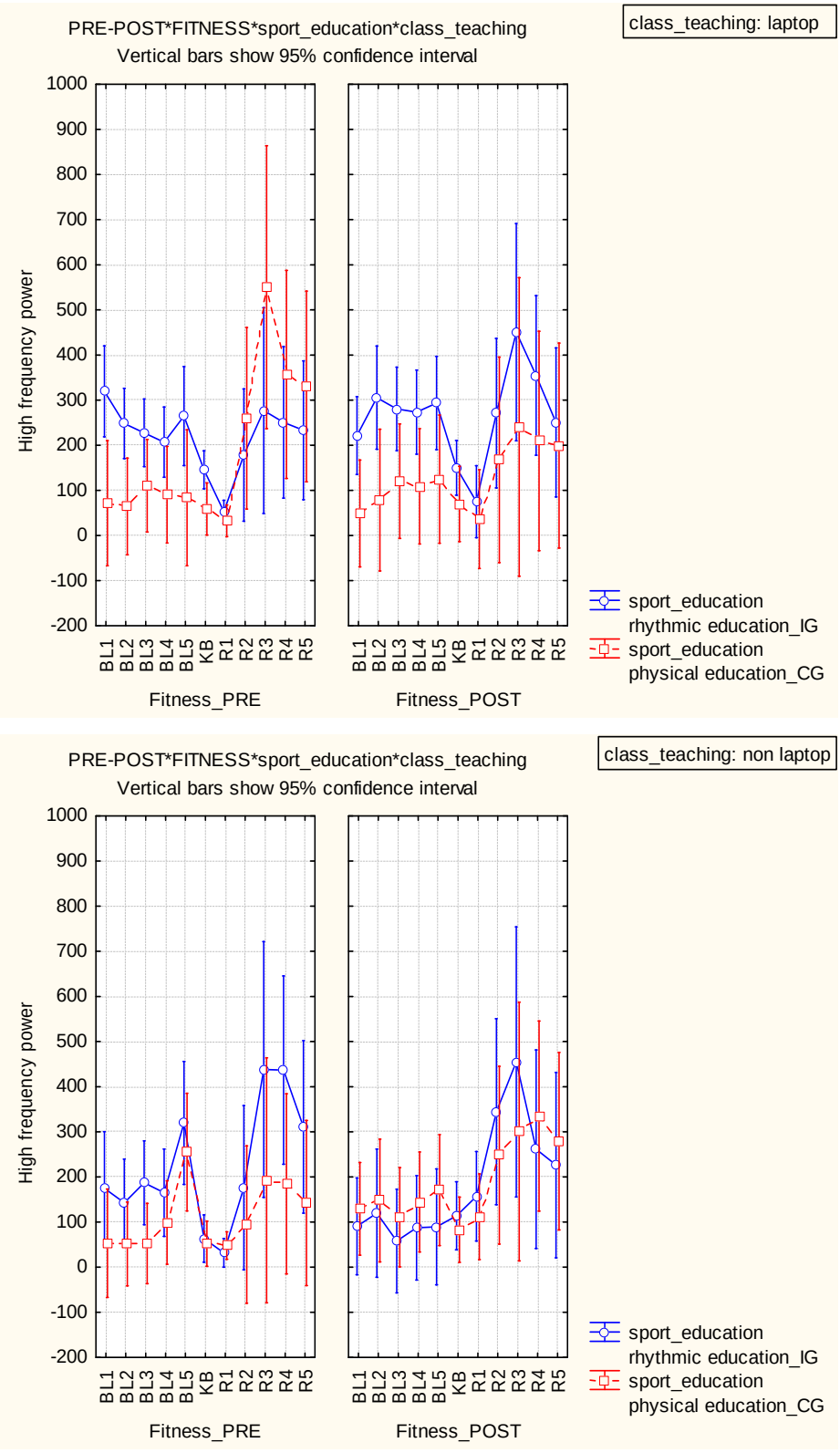


Figure 3.22: 4-way interaction between TOT * Fitness * sport education * teaching style. Average high frequency power across the fitness conditions at pre- and post-test recordings for laptop and non laptop students demonstrated for the rhythmic education group (RE) and the physical education group (PE)

Regarding NLT students HF power component across the fitness condition revealed higher fluctuations. During pre-test recording HF power increased across baseline condition and decreased at KB exercise in both sport groups. While HF power showed a remarkable rise at the beginning of the recovery period in RE students, HF power only showed a minor rise in PE students. During post-test measurements a general upward trend is observed in both sport groups with a slight decrease until the end of measurement.

3.2.2.3 Total Power

HRV evaluated through the parameter TP is demonstrated in table 3.23. There was a significant main effect of fitness, $F(4.436,199.624) = 7.616$, $p < 0.05$. Significant interaction effects are detected between TOT and sport education, $F(1,45) = 4.196$, $p < 0.05$ and between TOT, sport education and teaching style, $F(1,45) = 10.150$, $p < 0.05$. Moreover, there were significant interaction effects between TOT and fitness, $F(5.854, 263.409) = 4.036$, $p < 0.05$ as well as between TOT, fitness and teaching style, $F(5.854, 263.409) = 2.453$, $p < 0.05$.

Non parametric post-hoc tests via Mann-Whitney U-test only revealed a significant effect between LT and NLT students at baseline 3 while post-test recording, $z = -2.003$, $p < 0.05$. All other effects revealed non-significant results within the fitness condition and the teaching style (see appendix table 7.32).

Table 3.23: Repeated measures ANOVA. Measure is average total power at time on task (TOT) for pre-test and post-test recordings and Fitness (= within-subjects variables). Between-subjects variables indicate sport education (SPORT) and teaching style (CLASS)

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	***P***
Intercept	720098681.914	1	720098681.914	98.914	.000
SPORT	17863620.073	1	17863620.073	2.454	.124
CLASS	337021.383	1	337021.383	.046	.831
SPORT * CLASS	2440818.980	1	2440818.980	.335	.565
Error	327602437.427	45	7280054.165		
TOT	198923.539	1.000	198923.539	.146	.704
TOT * SPORT	5709462.342	1.000	5709462.342	4.196	**.046**
TOT * CLASS	1521913.196	1.000	1521913.196	1.119	.296
TOT * SPORT * CLASS	13810507.370	1.000	13810507.370	10.150	**.003**
Error(TOT)	61226985.584	45.000	1360599.680		
FITNESS	44121233.384	4.436	9945969.987	7.616	**.000**
FITNESS * SPORT	7642046.600	4.436	1722698.127	1.319	.261
FITNESS * CLASS	6418647.807	4.436	1446915.092	1.108	.356
FITNESS * SPORT * CLASS	1978039.025	4.436	445896.800	.341	.868
Error(Fitness)	260688009.254	199.624	1305894.347		
TOT * FITNESS	15712384.774	5.854	2684253.064	4.036	**.001**
TOT * FITNESS * SPORT	3486024.665	5.854	595541.194	.895	.497
TOT * FITNESS * CLASS	9548650.582	5.854	1631260.623	2.453	**.026**
TOT * FITNESS * SPORT * CLASS	3620225.670	5.854	618467.660	.930	.472
Error(TOT*FITNESS)	175194667.489	263.409	665104.247		

Figure 3.23 depicts the trend of TP across the fitness condition. LT students who performed RE during the term demonstrated higher TP values than LT students who conducted PE. During pre-test measurements, again a general upward trend in TP across baseline condition is observed. At KB exercise TP decreased followed by a subsequent increase in early recovery period and a minor fall until the end of measurement. This course is observed in both sport groups. During post-test measurements a similar trend in TP is identified according to the RE group. PE students demonstrated an overall upward trend across the fitness condition.

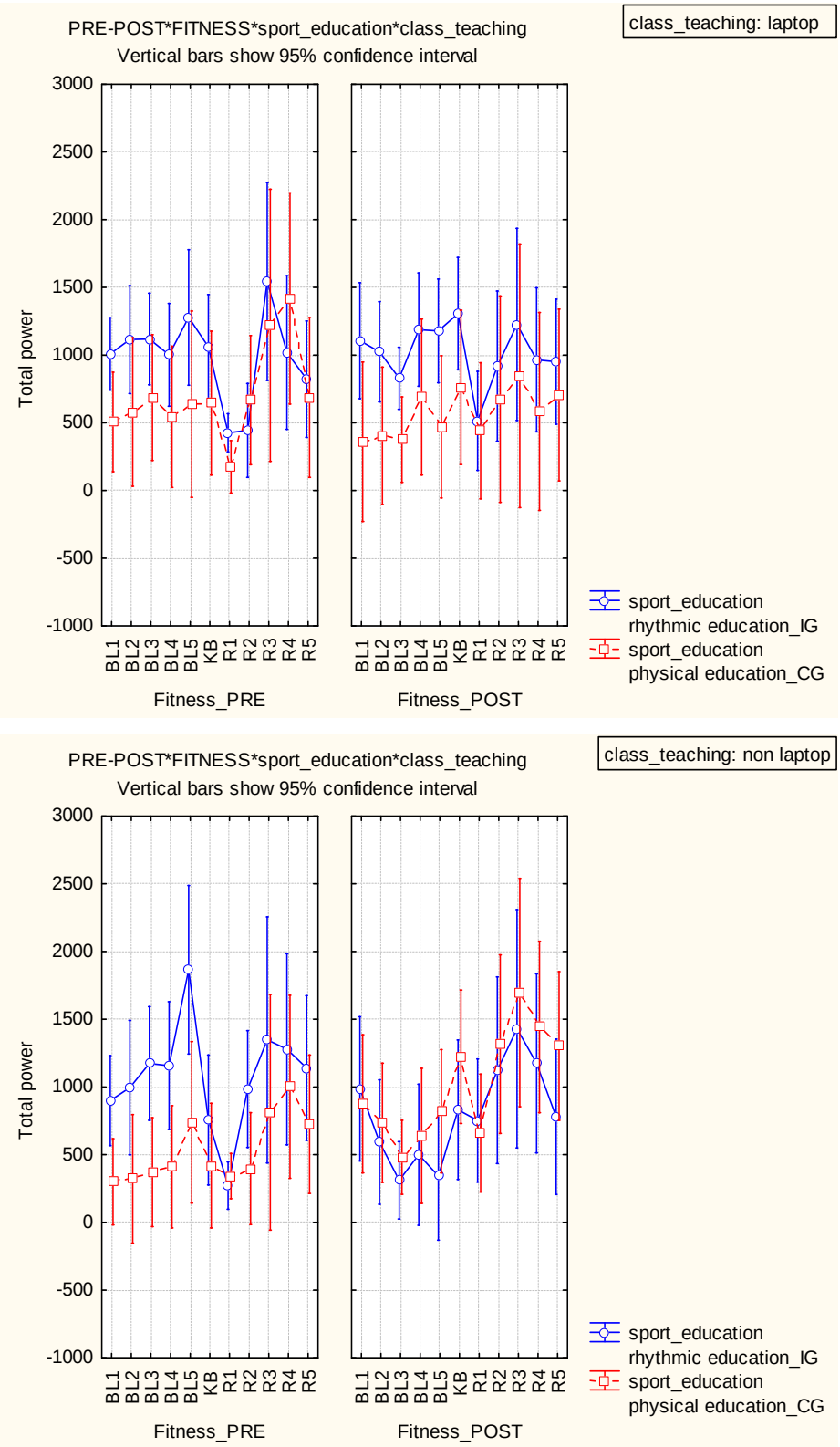


Figure 3.23: 4-way interaction between TOT * Fitness * sport education * teaching style. Average total power across the fitness conditions at pre- and post-test recordings for laptop and non laptop students demonstrated for the rhythmic education group (RE) and the physical education group (PE)

NLT students showed higher ranges regarding TP trends across the fitness condition than LT students. Particularly NLT students who performed RE exhibited a major rise in TP from 899 ms² to 1865 ms² during pre-test baseline measurements. Afterwards a remarkable decrease around KB exercise is observed. The recovery period started with a rise again and ended with a fall in TP. The PE group followed a similar trend in TP but represented minor fluctuations. Regarding post-test recordings TP decreased during early baseline conditions. Afterwards TP represented a general upward trend in both sport groups. In early recovery session a rise in TP is observed again with a decrease towards the end of measurement.

3.2.2.4 Log LF/HF

Statistical analysis of the HRV component log LF/HF revealed a significant main effect of sport education, $F(1,45) = 4.233$, $p < 0.05$ and a significant main effect of fitness, $F(6.815,306.663) = 6.724$, $p < 0.05$ (table 3.24). Significant interaction effects are detected between TOT and sport education, $F(1,45) = 5.050$, $p < 0.05$, between TOT, fitness and sport education, $F(7.333,329.964) = 2.565$, $p < 0.05$, between TOT, fitness and teaching style, $F(7.333,329.964) = 2.475$, $p < 0.05$ and between TOT, fitness, sport education and teaching style, $F(7.333,329.964) = 2.092$, $p < 0.05$.

Non parametric post-hoc tests via Mann-Whitney U-test revealed significant effects between RE and PE students during post-test recording at baseline 2, $z = -2.445$, $p < 0.05$, at baseline 5, $z = -2.586$, $p < 0.05$, at KB exercise, $z = -1.990$, $p < 0.05$, and at recovery 3, $z = -3.111$, $p < 0.05$ (see appendix table 7.34).

Table 3.24: Repeated measures ANOVA. Measure is average log LF/HF at time on task (TOT) for pre-test and post-test recordings and Fitness (= within-subjects variables). Between-subjects variables indicate sport education (SPORT) and teaching style (CLASS)

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	***P***
Intercept	187.872	1	187.872	353.028	.000
SPORT	2.252	1	2.252	4.233	**.045**
CLASS	.153	1	.153	.287	.595
SPORT * CLASS	1.555	1	1.555	2.922	.094
Error	23.948	45	.532		
TOT	.020	1.000	.020	.070	.793
TOT * SPORT	1.462	1.000	1.462	5.050	**.030**
TOT * CLASS	.556	1.000	.556	1.921	.173
TOT * SPORT * CLASS	.242	1.000	.242	.836	.365
Error(TOT)	13.025	45.000	.289		
FITNESS	6.522	6.815	.957	6.724	**.000**
FITNESS * SPORT	.944	6.815	.139	.973	.449
FITNESS * CLASS	1.251	6.815	.184	1.290	.256
FITNESS * SPORT * CLASS	1.752	6.815	.257	1.806	.088
Error(Fitness)	43.650	306.663	.142		
TOT * FITNESS	.995	7.333	.136	1.287	.253
TOT * FITNESS * SPORT	1.983	7.333	.270	2.565	**.012**
TOT * FITNESS * CLASS	1.913	7.333	.261	2.475	**.016**
TOT * FITNESS * SPORT * CLASS	1.617	7.333	.221	2.092	**.041**
Error(TOT*FITNESS)	34.785	329.964	.105		

The interaction graph reveals (figure 3.24) that LT students who conducted PE exhibited higher log LF/HF values than students performing RE during the term. During pre-test recordings the PE group demonstrated a general downward trend according to the log LF/HF component. With respect to the post-test recordings a rise at KB and a decrease during the recovery period is observed in both sport groups. PE students showed higher log LF/HF values at KB exercise compared to RE students who demonstrated a major rise from baseline to KB exercise but exhibited minor peak log LF/HF values.

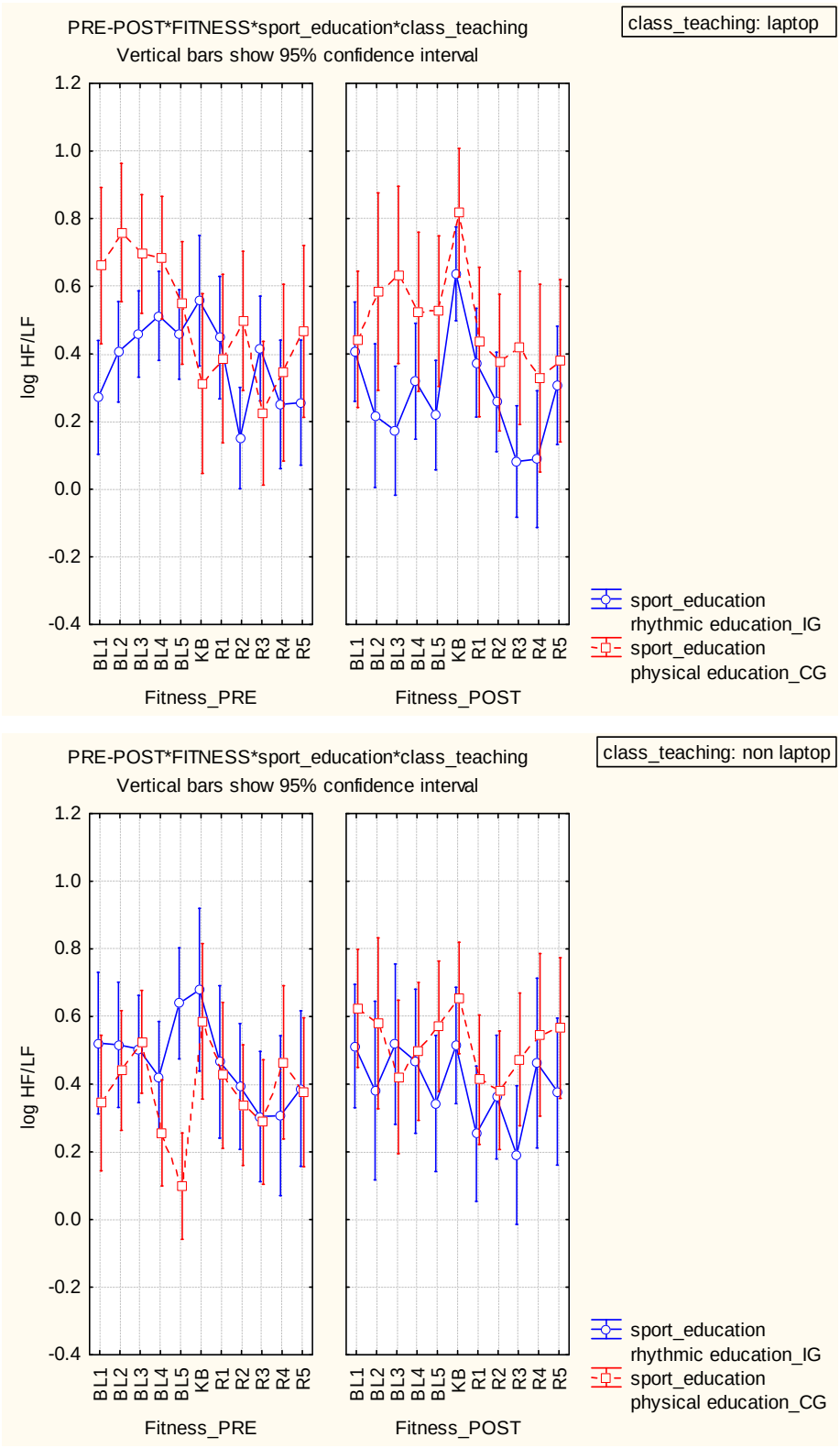


Figure 3.24: 4-way interaction between TOT * Fitness * sport education * teaching style. Average log LF/HF across the fitness conditions at pre- and post-test recordings for laptop and non laptop students demonstrated for the rhythmic education group (RE) and the physical education group (PE)

NLT students demonstrated higher fluctuations in the log LF/HF component than LT students. PE students presented a rise in log LF/HF during early baseline condition and a decrease towards the end of baseline condition during pre-test recordings. At KB exercise log LF/HF increased again and demonstrated a slight fall during recovery period. Log LF/HF in the RE group remained fairly steady during baseline condition and showed a rise at KB exercise ending with a minor decrease during the recovery period. Regarding post-test measurements increased log LF/HF fluctuations were observed across the whole fitness condition with a rise at KB exercise in both sport groups.

3.2.2.5 normalized LF

Regarding the normalized LF component, there were significant main effects of TOT, $F(1,45) = 4.417$, $p < 0.05$ and of fitness, $F(10,450) = 11.238$, $p < 0.05$ (table 3.25). Furthermore, a significant interaction effect is detected between TOT and teaching style, $F(1,45) = 5.135$, $p < 0.05$. All remaining effects showed non-significant results with $p > 0.05$.

Table 3.25: Repeated measures ANOVA. Measure is average low frequency in nu at time on task (TOT) for pre-test and post-test recordings and Fitness (= within-subjects variables). Between-subjects variables indicate sport education (SPORT) and teaching style (CLASS)

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	***P***
Intercept	214.313	1	214.313	2881.199	.000
SPORT	.005	1	.005	.071	.792
CLASS	.011	1	.011	.151	.699
SPORT * CLASS	.003	1	.003	.035	.852
Error	3.347	45	.074		
TOT	.171	1	.171	4.417	**.041**
TOT * SPORT	.118	1	.118	3.043	.088
TOT * CLASS	.199	1	.199	5.135	**.028**
TOT * SPORT * CLASS	.030	1	.030	.777	.383
Error(TOT)	1.744	45	.039		
FITNESS	3.209	10	.321	11.238	**.000**
FITNESS * SPORT	.248	10	.025	.867	.564
FITNESS * CLASS	.247	10	.025	.864	.567
FITNESS * SPORT * CLASS	.362	10	.036	1.269	.245
Error(Fitness)	12.849	450	.029		
TOT * FITNESS	.279	10	.028	1.129	.338
TOT * FITNESS * SPORT	.404	10	.040	1.635	.094
TOT * FITNESS * CLASS	.308	10	.031	1.247	.259
TOT * FITNESS * SPORT * CLASS	.422	10	.042	1.708	.076
Error(TOT*FITNESS)	11.109	450	.025		

The interaction graph in figure 3.25 depicts the trend of the normalized LF component across the fitness condition. LT students of both sport groups demonstrate a similar course in LF nu across the three fitness stages. During baseline a rise in LF nu is observed, followed with a fall around KB exercise and an increase again during recovery session.

NLT students demonstrate higher fluctuations across the fitness conditions during pre-test recordings, especially regarding the PE group. Likewise to the LT students, NLT students performing RE showed a fall in LF nu around KB exercise and a rise during recovery session. According to the post-tests both sport groups demonstrated a rise in LF nu at the beginning of the baseline condition and a gradual decrease until KB exercise. During recovery session a rise in normalized LF is identified again.

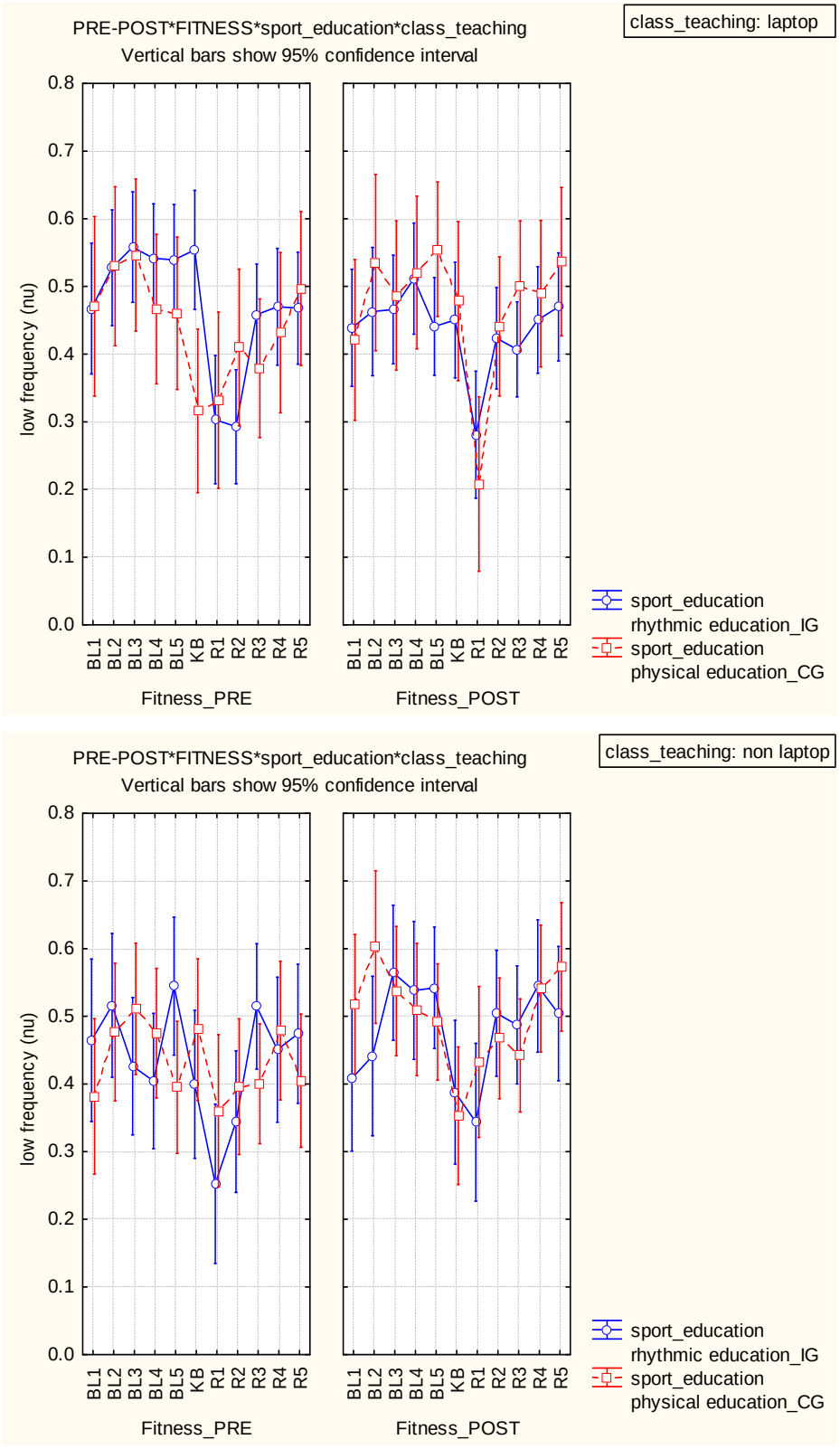


Figure 3.25: 4-way interaction between TOT * Fitness * sport education * teaching style. Average low frequency in nu across the fitness conditions at pre- and post-test recordings for laptop and non laptop students demonstrated for the rhythmic education group (RE) and the physical education group (PE)

3.2.2.6 normalized HF

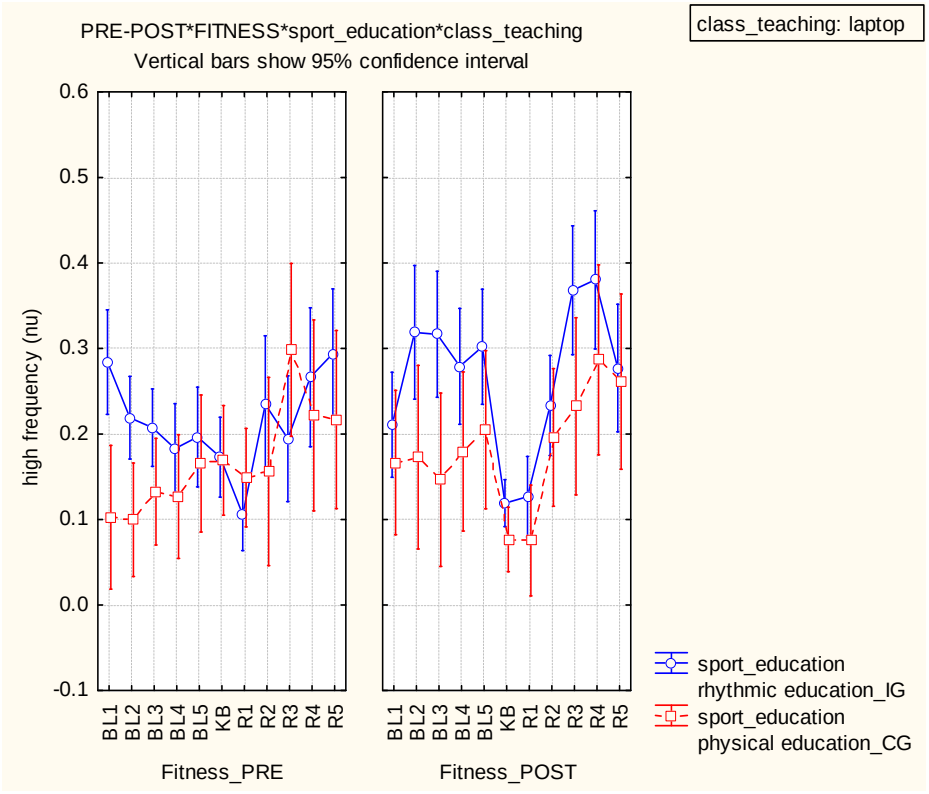
Table 3.26 illustrates the results of the HRV parameter as measured by normalized HF. There was a significant main effect of sport education, $F(1,45) = 4.591$, $p < 0.05$ and a significant main effect of fitness, $F(5.940,267.292) = 14.502$, $p < 0.05$. Concerning the interaction effects, significant results are detected between TOT and sport education, $F(1,45) = 5.145$, $p < 0.05$, between fitness, sport education and teaching style, $F(5.940,267.292) = 2.433$, $p < 0.05$, between TOT, fitness and sport education, $F(7.317,329.276) = 2.534$, $p < 0.05$ and between TOT, fitness and teaching style, $F(7.317,329.276) = 2.218$, $p < 0.05$.

Table 3.26: Repeated measures ANOVA. Measure is average high frequency in nu at time on task (TOT) for pre-test and post-test recordings and Fitness (= within-subjects variables). Between-subjects variables indicate sport education (SPORT) and teaching style (CLASS)

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	***P***
Intercept	41.006	1	41.006	493.513	.000
SPORT	.381	1	.381	4.591	**.038**
CLASS	.052	1	.052	.629	.432
SPORT * CLASS	.192	1	.192	2.310	.136
Error	3.739	45	.083		
TOT	.088	1.000	.088	1.915	.173
TOT * SPORT	.235	1.000	.235	5.145	**.028**
TOT * CLASS	.057	1.000	.057	1.238	.272
TOT * SPORT * CLASS	.034	1.000	.034	.746	.392
Error(TOT)	2.059	45.000	.046		
FITNESS	1.913	5.940	.322	14.502	**.000**
FITNESS * SPORT	.171	5.940	.029	1.299	.258
FITNESS * CLASS	.183	5.940	.031	1.385	.221
FITNESS * SPORT * CLASS	.321	5.940	.054	2.433	**.027**
Error(Fitness)	5.936	267.292	.022		
TOT * FITNESS	.215	7.317	.029	1.788	.085
TOT * FITNESS * SPORT	.305	7.317	.042	2.534	**.014**
TOT * FITNESS * CLASS	.267	7.317	.037	2.218	**.030**
TOT * FITNESS * SPORT * CLASS	.242	7.317	.033	2.005	.051
Error(TOT*FITNESS)	5.422	329.276	.016		

Figure 3.26 depicts the graphical representation of the normalized HF component across the fitness condition. During pre-test LT students who performed RE demonstrated a gradual fall in HF nu from baseline recording until KB exercise. During recovery period they showed an increase in HF nu until the end of measurement. In contrast to the RE group, the PE group demonstrated a gradual rise in HF until the end of measurement. During post-

test LT students from both sport group showed a fairly steady HF nu while baseline recordings. Around KB exercise a fall is observed with a subsequent increase during recovery session until the end of measurement.



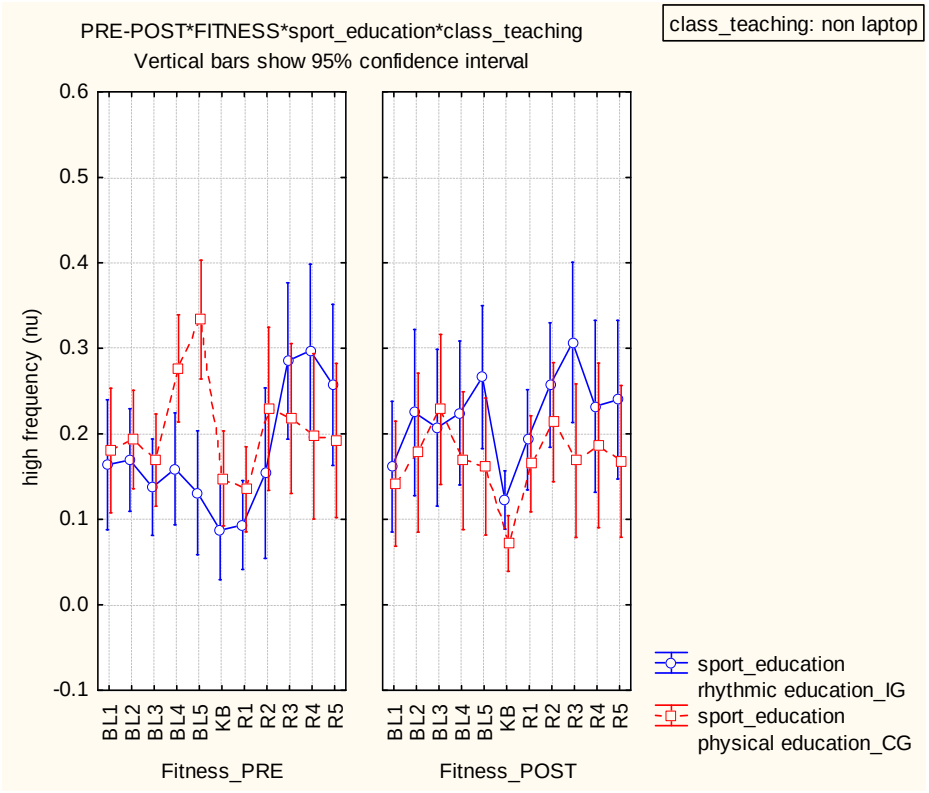


Figure 3.26: 4-way interaction between TOT * Fitness * sport education * teaching style. Average high frequency in nu across the fitness conditions at pre- and post-test recordings for laptop and non laptop students demonstrated for the rhythmic education group (RE) and the physical education group (PE)

NLT students who conducted the PE demonstrated a rise in normalized HF during pre-test baseline condition. At KB exercise a fall in HF nu was observed which increased again during recovery. In contrast to the PE group, the RE group demonstrated a gradual decrease in HF nu until KB exercise which increased during recovery session. During post-test NLT students from the PE group showed higher fluctuation in HF nu than NLT students from the RE group. But both sport groups demonstrated a fall in HF nu during KB exercise and a subsequent rise during recovery.

3.2.3 Atrial mean

Statistical analysis of the atrial mean is illustrated in table 3.27. There was a significant main effect of fitness, $F(3.883,170.830) = 11.708$, $p < 0.05$. Concerning interaction effects, significant results are detected between TOT, sport education and teaching style, $F(1,44) = 6.646$, $p < 0.05$ and between TOT and fitness, $F(3.662,161.147) = 12.041$, $p < 0.05$. All remaining effects revealed non-significant results with $p > 0.05$.

Table 3.27: Repeated measures ANOVA. Measure is average atrial mean at time on task (TOT) for pre-test and post-test recordings and Fitness (= within-subjects variables). Between-subjects variables indicate sport education (SPORT) and teaching style (CLASS)

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	***P***
Intercept	17.592	1	17.592	2871.469	.000
SPORT	.001	1	.001	.138	.712
CLASS	.001	1	.001	.096	.759
SPORT * CLASS	.009	1	.009	1.513	.225
Error	.270	44	.006		
TOT	.002	1.000	.002	1.608	.211
TOT * SPORT	.004	1.000	.004	2.667	.110
TOT * CLASS	.000	1.000	.000	.123	.727
TOT * SPORT * CLASS	.010	1.000	.010	6.646	**.013**
Error(TOT)	.066	44.000	.001		
FITNESS	.030	3.882	.008	11.708	**.000**
FITNESS * SPORT	.001	3.882	.000	.430	.781
FITNESS * CLASS	.002	3.882	.001	.958	.430
FITNESS * SPORT * CLASS	.005	3.882	.001	1.882	.118
Error(Fitness)	.112	170.830	.001		
TOT * FITNESS	.026	3.662	.007	12.041	**.000**
TOT * FITNESS * SPORT	.002	3.662	.001	1.159	.330
TOT * FITNESS * CLASS	.002	3.662	.001	1.003	.403
TOT * FITNESS * SPORT * CLASS	.005	3.662	.001	2.152	.083
Error(TOT*FITNESS)	.093	161.147	.001		

Graphical representation of the atrial mean parameter is illustrated in figure 3.27. During pre-test measurements LT students who conducted PE demonstrated a remarkable rise in atrial mean at KB exercise as compared to the RE group who only showed a minor rise in atrial mean. In contrast to the pre-tests, during post-test recordings only a gradual increase from the beginning until the end is observed in both sport groups.

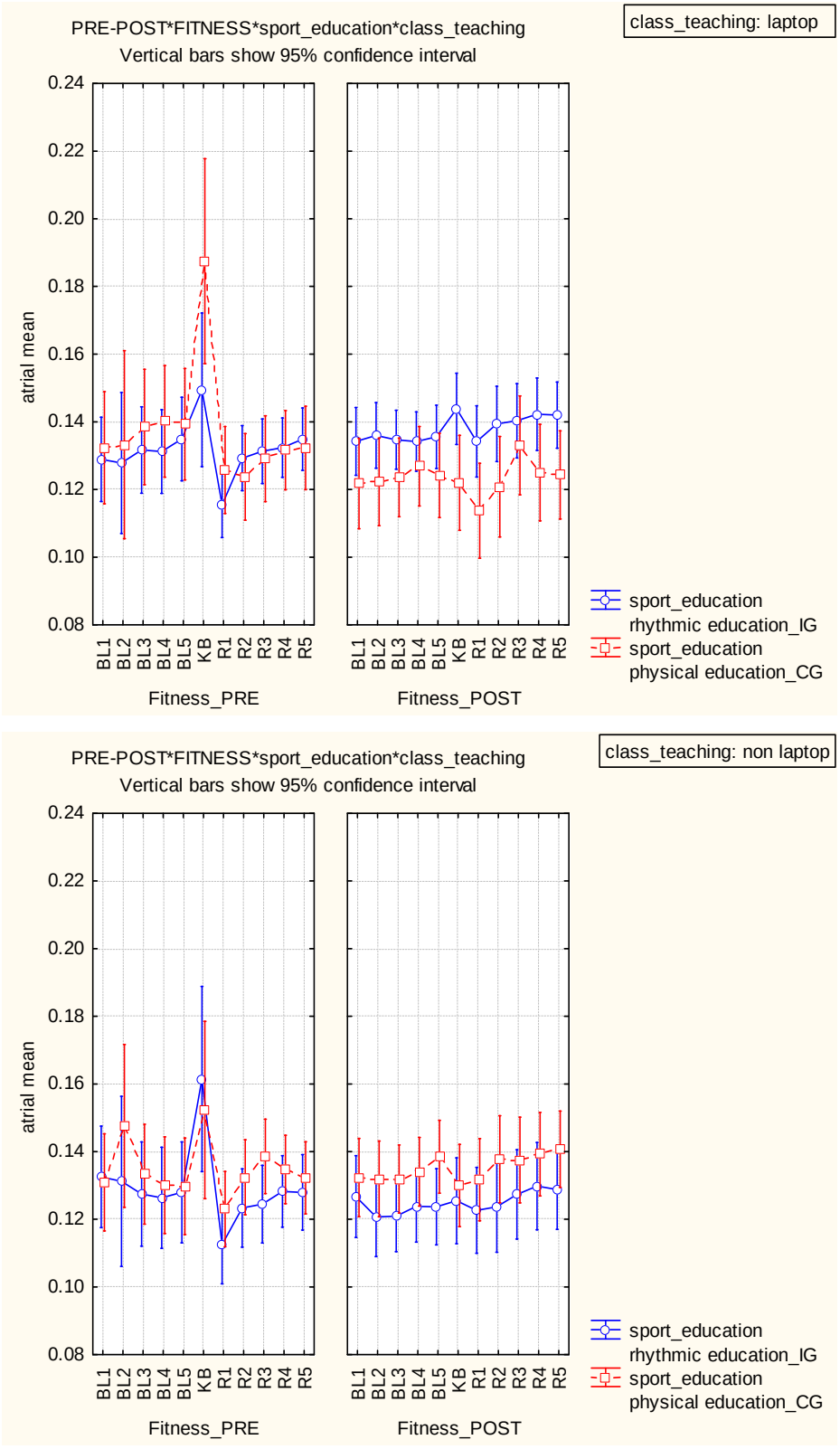


Figure 3.27: 4-way interaction between TOT * Fitness * sport education * teaching style. Average atrial mean across the fitness conditions at pre- and post-test recordings for laptop and non laptop students demonstrated for the rhythmic education group (RE) and the physical education group (PE)

A similar trend is observed for NLT students. At KB exercise a rise in atrial mean is identified in both sport groups during pre-test measurements. In contrast a general, gradual rise is detected according to the post-test measurements.

3.2.4 Atrial median

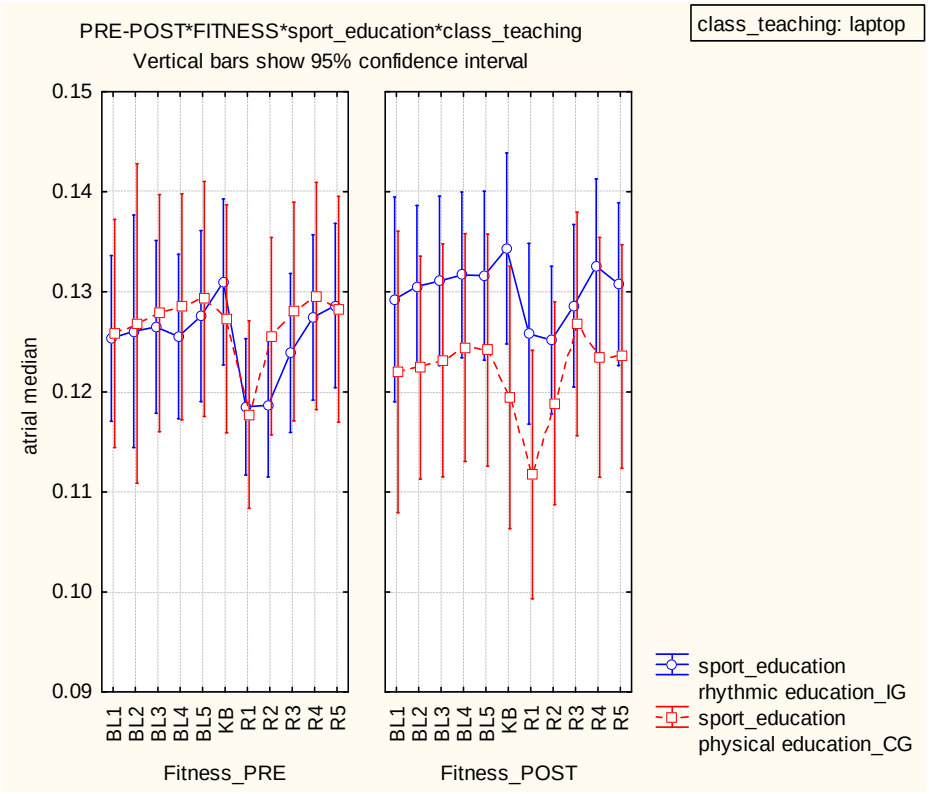
Concerning the atrial median (table 3.28) a significant main effect of fitness is detected, $F(2.995,134.764) = 11.056$, $p < 0.05$. There was also a significant interaction effect between TOT and sport education, $F(1,45) = 7.104$, $p < 0.05$. All other effects revealed non-significant results with $p > 0.05$.

Table 3.28: Repeated measures ANOVA. Measure is average atrial median at time on task (TOT) for pre-test and post-test recordings and Fitness (= within-subjects variables). Between-subjects variables indicate sport education (SPORT) and teaching style (CLASS)

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	***P***
Intercept	15.925	1	15.925	3004.470	.000
SPORT	.000	1	.000	.061	.806
CLASS	.002	1	.002	.300	.586
SPORT * CLASS	.005	1	.005	1.005	.321
Error	.239	45	.005		
TOT	.000	1.000	.000	.747	.392
TOT * SPORT	.002	1.000	.002	7.104	**.011**
TOT * CLASS	.000	1.000	.000	.944	.336
TOT * SPORT * CLASS	.001	1.000	.001	3.573	.065
Error(TOT)	.013	45.000	.000		
FITNESS	.007	2.995	.002	11.056	**.000**
FITNESS * SPORT	.001	2.995	.000	2.081	.106
FITNESS * CLASS	.000	2.995	.000	.744	.528
FITNESS * SPORT * CLASS	.000	2.995	7.95E-005	.371	.774
Error(Fitness)	.029	134.764	.000		
TOT * FITNESS	.001	2.384	.000	1.675	.187
TOT * FITNESS * SPORT	.001	2.384	.000	1.420	.245
TOT * FITNESS * CLASS	.000	2.384	.000	.988	.387
TOT * FITNESS * SPORT * CLASS	.000	2.384	.000	.805	.469
Error(TOT*FITNESS)	.021	107.270	.000		

Graphical representation of the atrial median parameter is depicted in figure 3.28. During pre-test both sport groups from the LT class demonstrated a gradual rise in atrial median with a subsequent decrease early recovery and a rise again until the end of measurement. Regarding post-test recordings, the RE group exhibited higher atrial median

values than the PE group but both sport groups showed a fall in atrial median during early recovery.



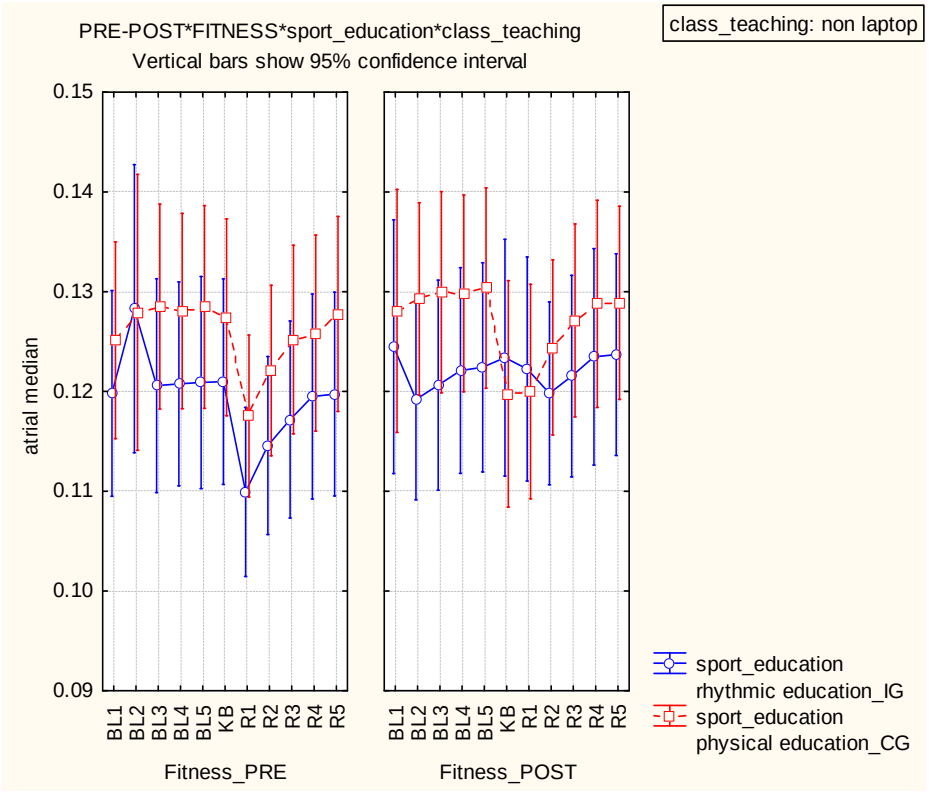


Figure 3.28: 4-way interaction between TOT * Fitness * sport education * teaching style. Average atrial median across the fitness conditions at pre- and post-test recordings for laptop and non laptop students demonstrated for the rhythmic education group (RE) and the physical education group (PE)

NLT students who conducted PE showed higher atrial median values than RE students. Both sport groups demonstrated a fall in atrial median around KB exercise and early recovery regarding both TOT measurements. Afterwards atrial median increased again until the end of recording.

3.3 HRV and Mental Stress

This section describes the results of the HRV components during the mental stress task which were analysed in 5-minute-segments. Due to time restrictions, ECG records are only available for the RE group. Therefore, sample size for the statistical analyses decreased to 17 LT students and 11 NLT students. Results are demonstrated via the statistical significance test repeated measures ANOVA. Afterwards the effects are described using graphs, which show the interactions between the two classes (LT versus NLT) and TOT, for pre- and post-test recordings.

The appropriate tables for mean values, standard errors and confidence intervals are inserted in the appendix (see tables 7.39 – 7.52).

All effects are reported as significant at $p < 0.05$.

3.3.1 Time domain parameters

3.3.1.1 Minimum heart rate

Concerning the minimum HR (table 3.29), there was a non-significant main effect between the two teaching classes. There was a non-significant main effect for TOT measurements as well. Likewise, no significant interaction effect was detected between TOT and teaching style. All effects showed p-values above 0.05.

Table 3.29: Repeated measures ANOVA. Measure is average minimum heart rate at time on task (TOT) for pre-test and post-test recordings (= within-subjects variable). Between-subjects variables indicate teaching style (CLASS) for the rhythmic intervention group.

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	***P***
Intercept	374895.403	1	374895.403	1006.243	.000
CLASS	38.461	1	38.461	.103	.751
Error	9686.810	26	372.570		
TOT	25.698	1	25.698	.294	.592
TOT * CLASS	21.644	1	21.644	.248	.623
Error(TOT)	2268.952	26	87.267		

The interaction graph (figure 3.29) depicts the trend between LT and NLT students during pre- and post-test measurements. NLT students showed a higher minimum HR of 3 BpM compared to LT students during pre-test recordings. While LT students remained fairly steady in minimum HR during post-test recordings, NLT students showed a fall of 2.6 BpM from pre- to post-tests.

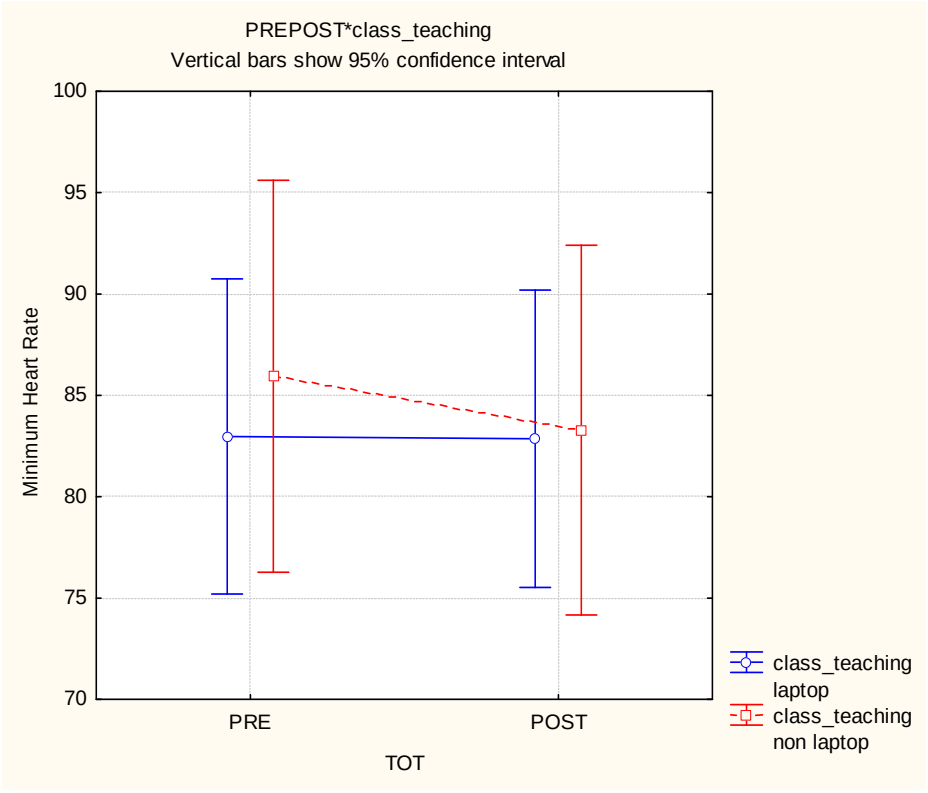


Figure 3.29: Interaction graph with 95% confidence interval. Average minimum heart rate for pre-test and post-test for laptop and non laptop classes in rhythmic intervention group.

3.3.1.2 Mean heart rate

With respect to the mean HR (table 3.30), there were no significant main effects at all. Likewise, no significant interaction effect was detected as well. All effects showed p-values above 0.05.

Table 3.30: Repeated measures ANOVA. Measure is average mean heart rate at time on task (TOT) for pre-test and post-test recordings (= within-subjects variable). Between-subjects variables indicate teaching style (CLASS) for the rhythmic intervention group.

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	***P***
Intercept	546711.273	1	546711.273	2046.722	.000
CLASS	.218	1	.218	.001	.977
Error	6945.004	26	267.116		
TOT	43.232	1	43.232	.853	.364
TOT * CLASS	4.080	1	4.080	.080	.779
Error(TOT)	1318.496	26	50.711		

In figure 3.30 LT class students and NLT class students revealed a similar trend. Both classes showed a fall in mean HR from pre- to post-test recordings.

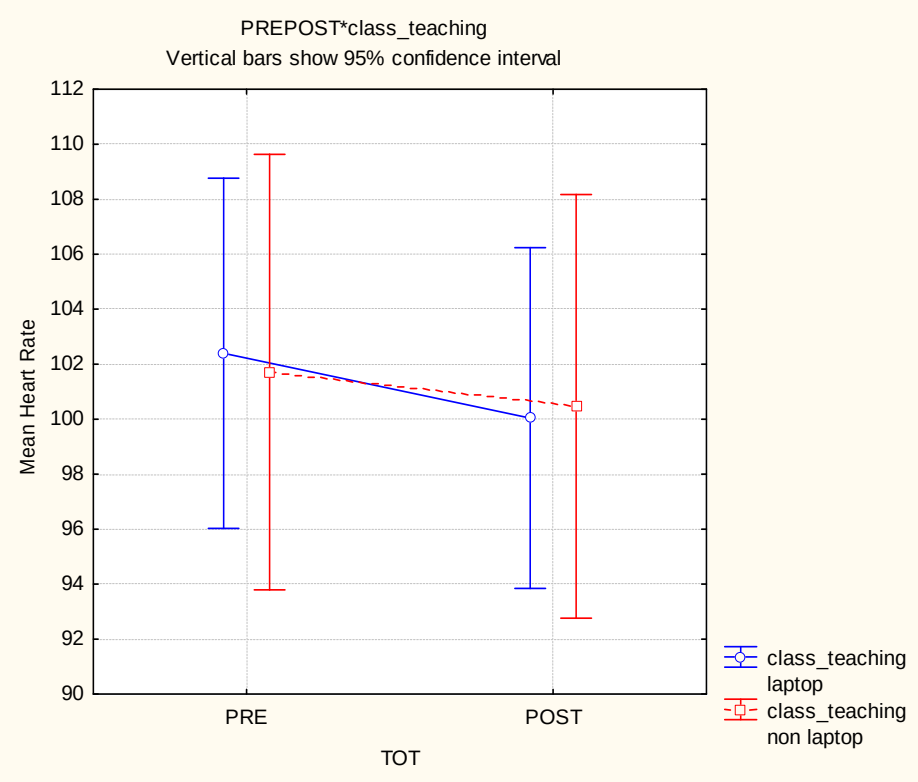


Figure 3.30: Interaction graph with 95% confidence interval. Average mean heart rate for pre-test and post-test for laptop and non laptop classes in rhythmic intervention group.

3.3.1.3 Maximum heart rate

Similar to the previous results, the maximum HR (table 3.31) revealed no significant main effects at all. Furthermore, there was no significant interaction effect. All effects showed p-values above 0.05.

Table 3.31: Repeated measures ANOVA. Measure is average maximum heart rate at time on task (TOT) for pre-test and post-test recordings (= within-subjects variable). Between-subjects variables indicate teaching style (CLASS) for the rhythmic intervention group.

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	***P***
Intercept	770361,232	1	770361,232	3366,612	,000
CLASS	17,671	1	17,671	,077	,783
Error	5949,422	26	228,824		
TOT	104,113	1	104,113	1,009	,324
TOT * CLASS	37,047	1	37,047	,359	,554
Error(TOT)	2683,331	26	103,205		

Concerning the maximum HR the interaction graph revealed an inverse trend (figure 3.31). Whereas LT students showed a fairly steady maximum HR across pre- and post-test measurements, a rise in maximum HR above 4 BpM is observed from pre-to post-test recordings for LT students.

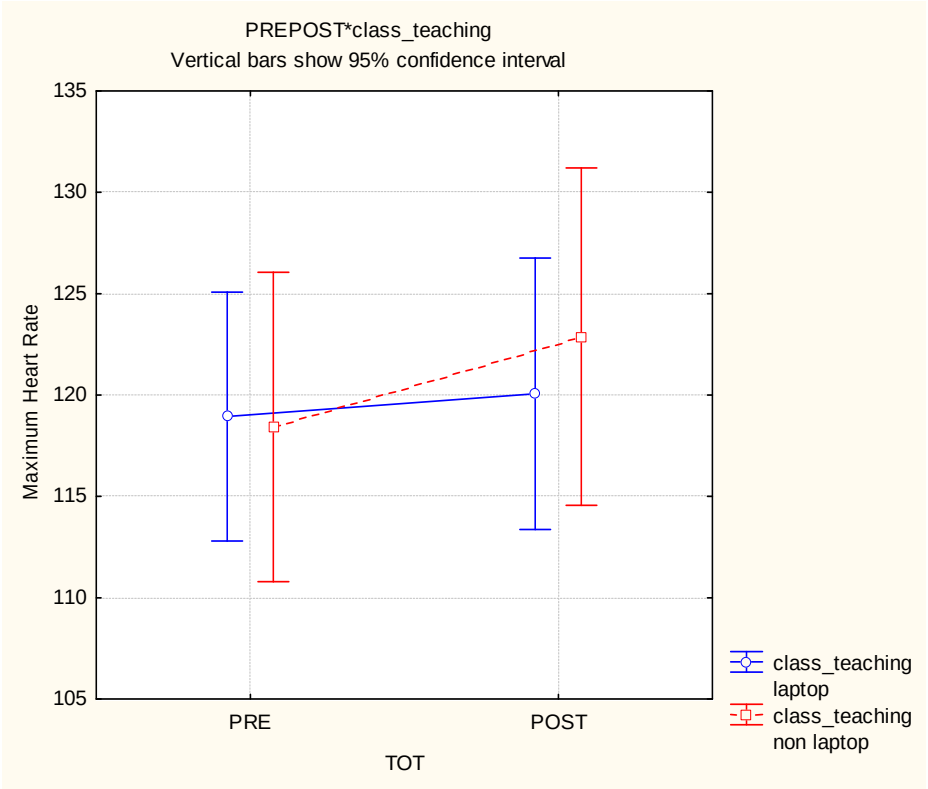


Figure 3.31: Interaction graph with 95% confidence interval. Average maximum heart rate for pre-test and post-test for laptop and non laptop classes in rhythmic intervention group.

3.3.1.4 SDNN

HRV which is represented by the SDNN parameter is demonstrated in table 3.32. There were no significant main effects at all. Likewise, there was a non-significant interaction effect between TOT and teachings style as well. All effects showed p-values above 0.05.

Table 3.32: Repeated measures ANOVA. Measure is average SDNN at time on task (TOT) for pre-test and post-test recordings (= within-subjects variable). Between-subjects variables indicate teaching style (CLASS) for the rhythmic intervention group.

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	***P***
Intercept	80869.211	1	80869.211	127.175	.000
CLASS	133.618	1	133.618	.210	.650
Error	16533.182	26	635.892		
TOT	496.714	1	496.714	3.668	.067
TOT * CLASS	1.007	1	1.007	.007	.932
Error(TOT)	3521.136	26	135.428		

The graph in figure 3.32 reveals a rise in SDNN from pre-to post-test recordings in both teaching classes. On average NLT students showed higher SDNN values of 3 ms compared to SDNN values in LT students.

Figure 3.32: Interaction graph with 95% confidence interval. Average SDNN for pre-test and post-test for laptop and non laptop classes in rhythmic intervention group.

3.3.1.5 r-MSSD

HRV evaluated through the parameter r-MSSD reveals no significant main effects at all (table 3.33). There was also no significant interaction effect between TOT and class teaching style. All effects showed p-values above 0.05.

Table 3.33: Repeated measures ANOVA. Measure is average r-MSSD at time on task (TOT) for pre-test and post-test recordings (= within-subjects variable). Between-subjects variables indicate teaching style (CLASS) for the rhythmic intervention group.

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	***P***
Intercept	29107.114	1	29107.114	107.561	.000
CLASS	682.085	1	682.085	2.521	.124
Error	7035.890	26	270.611		
TOT	75.300	1	75.300	1.063	.312
TOT * CLASS	26.925	1	26.925	.380	.543
Error(TOT)	1841.238	26	70.817		

Figure 3.33 illustrates the interaction graph for the HRV parameter r-MSSD between LT and NLT students during pre-and post-test measurements. NLT class students showed higher r-MSSD values of 8.5 ms than LT class students during pre-test recordings. In NLT class students the r-MSSD component remained fairly steady across TOT measurements. In contrast, LT students showed a rise of almost 4 ms from pre-to post-test measurements.

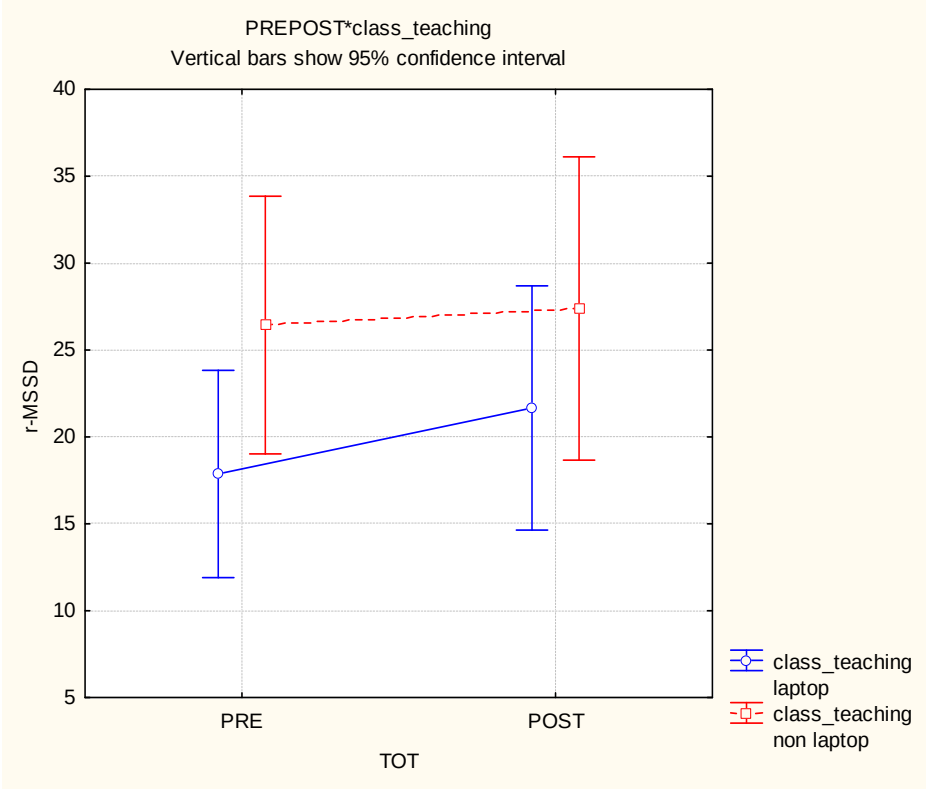


Figure 3.33: Interaction graph with 95% confidence interval. Average r-MSSD for pre-test and post-test for laptop and non laptop classes in rhythmic intervention group.

3.3.1.9 pNN50

HRV as measured by pNN50 showed non-significant main effects of class teaching style as well as of TOT (table 3.34). Furthermore, there was no significant interaction effect between TOT and class teaching style. All effects showed p-values above 0.05.

Table 3.34: Repeated measures ANOVA. Measure is average pNN50 at time on task (TOT) for pre-test and post-test recordings (= within-subjects variable). Between-subjects variables indicate teaching style (CLASS) for the rhythmic intervention group.

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	***P***
Intercept	2562.141	1	2562.141	22.531	.000
CLASS	466.421	1	466.421	4.102	.053
Error	2956.688	26	113.719		
TOT	29.346	1	29.346	.668	.421
TOT * CLASS	7.305	1	7.305	.166	.687
Error(TOT)	1142.842	26	43.955		

Regarding the pNN50 component of HRV the interaction graph (figure 3.34) revealed a rise in pNN50 from pre-test to post-test in both teaching styles. NLT students showed on average higher values in pNN50 and the rise from pre-to post-test recording was minimal (around 1%). LT students' pNN50 increased from 2.859% up to 5.081%.

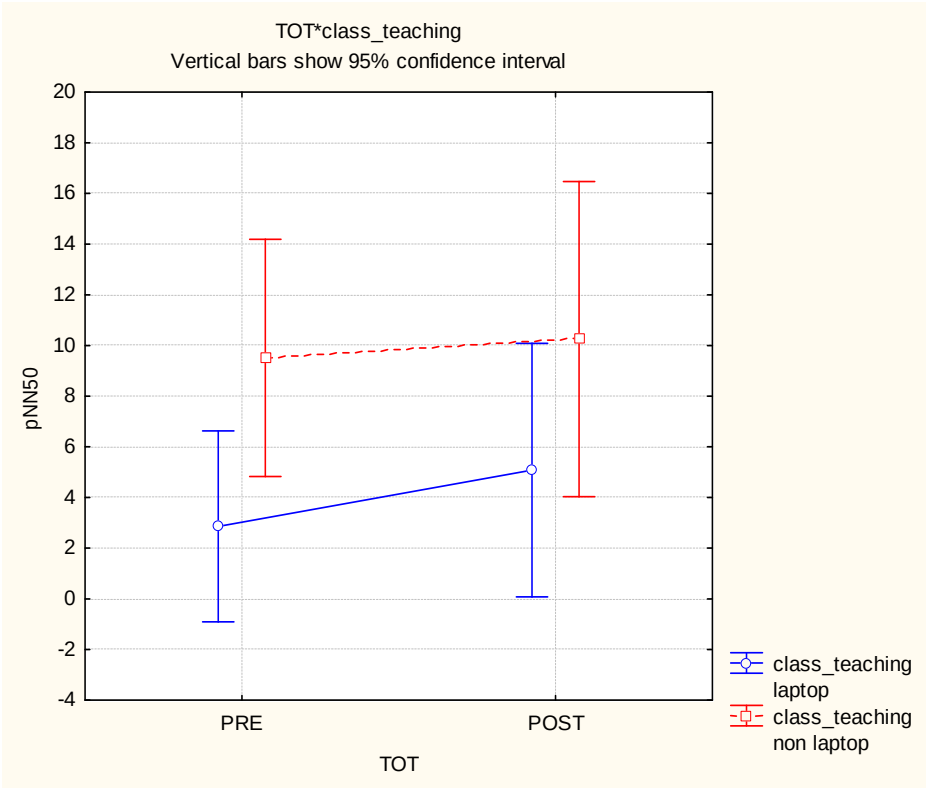


Figure 3.34: Interaction graph with 95% confidence interval. Average pNN50 for pre-test and post-test for laptop and non laptop classes in rhythmic intervention group.

3.3.2 Frequency domain parameters

3.3.2.1 LF power

Concerning LF power (table 3.35), statistical analysis revealed no significant main effects at all. There was no significant interaction effect between TOT and teaching style as well. All effects showed p-values above 0.05.

Table 3.35: Repeated measures ANOVA. Measure is average low frequency power at time on task (TOT) for pre-test and post-test recordings (= within-subjects variable). Between-subjects variables indicate teaching style (CLASS) for the rhythmic intervention group.

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	***P***
Intercept	36327081.583	1	36327081.583	26.799	.000
CLASS	1786533.318	1	1786533.318	1.318	.261
Error	35243361.318	26	1355513.897		
TOT	319.831	1	319.831	.001	.973
TOT * CLASS	73238.359	1	73238.359	.265	.611
Error(TOT)	7193558.884	26	276675.342		

The interaction graph in figure 3.35 depicts the trend of the LF power component of HRV. On average NLT students had higher LF power values than LT students. NLT students presented a mean LF power of 972.855 ms² compared to LT students' mean LF power, who had 681.182 ms² during pre-test measurements. While observing a slight rise in LF power in NLT students, LT students showed a fall of almost 100 ms² from pre-test to post-test.

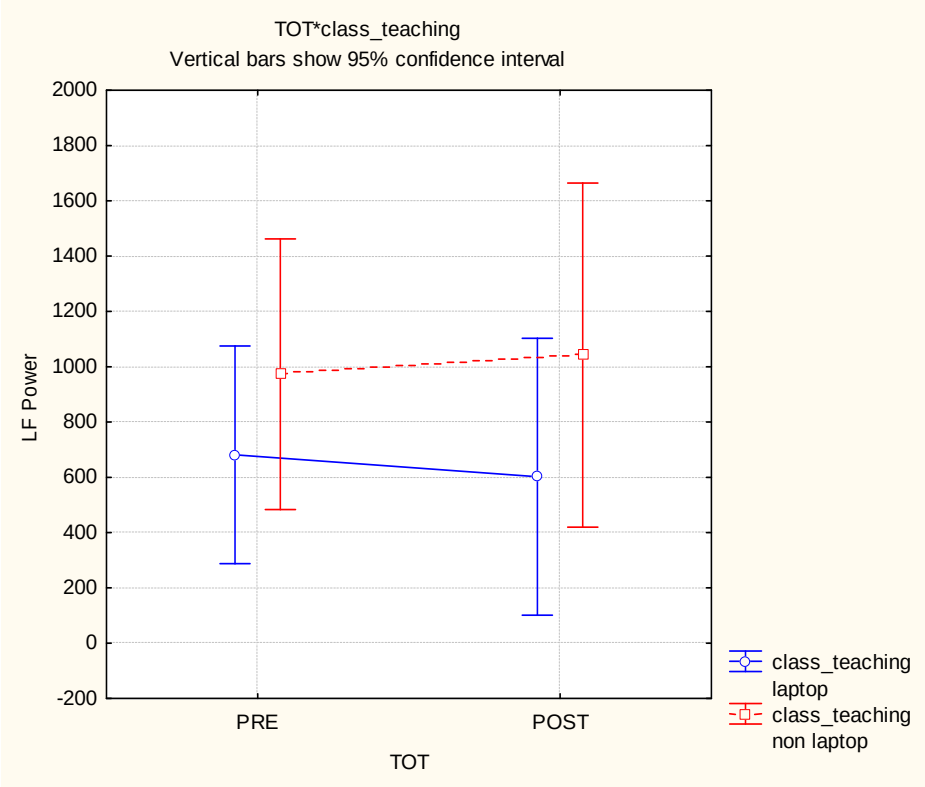


Figure 3.35: Interaction graph with 95% confidence interval. Average low frequency power for pre-test and post-test for laptop and non laptop classes in rhythmic intervention group.

3.3.2.2 HF power

With respect to HF power (table 3.36), there were no significant main effects at all. Likewise, no significant interaction effect was detected as well. All effects showed p-values above 0.05.

Table 3.36: Repeated measures ANOVA. Measure is average high frequency power at time on task (TOT) for pre-test and post-test recordings (= within-subjects variable). Between-subjects variables indicate teaching style (CLASS) for the rhythmic intervention group.

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	***P***
Intercept	8872840.978	1	8872840.978	25.321	.000
CLASS	3920.311	1	3920.311	.011	.917
Error	9110616.093	26	350408.311		
TOT	115409.708	1	115409.708	.461	.503
TOT * CLASS	3709.564	1	3709.564	.015	.904
Error(TOT)	6504187.877	26	250161.072		

The interaction graph in figure 3.36 revealed a fall from pre-to post-test recordings in both teaching style classrooms. LT students as well as NLT students showed fairly similar HF power values during pre-test and post-test (see appendix table 7.46).

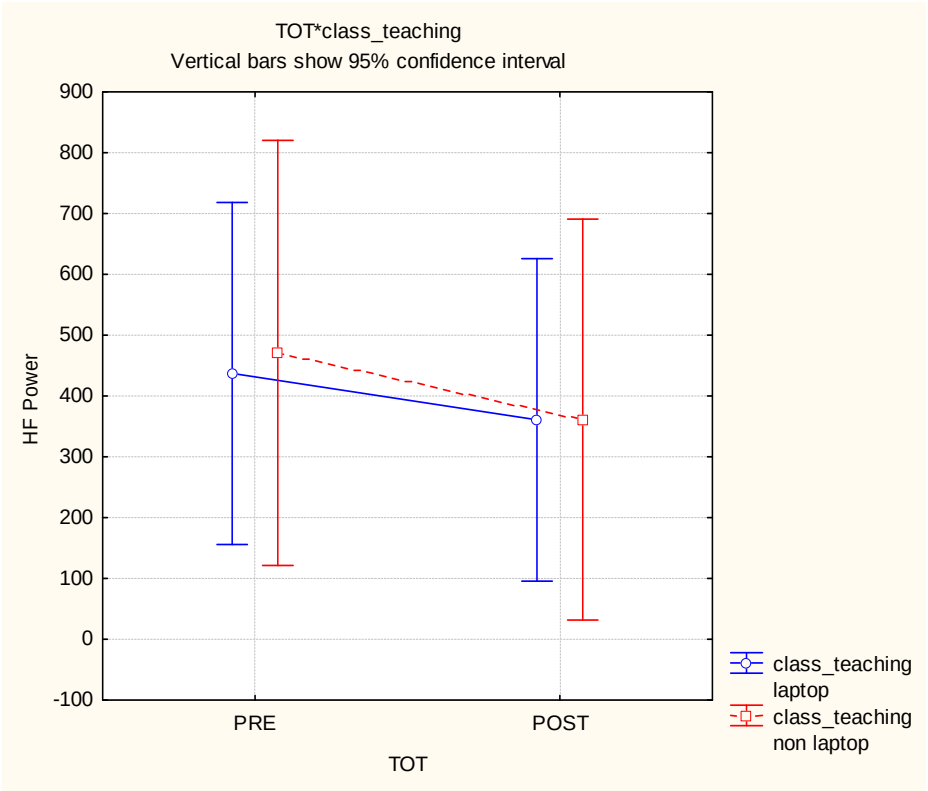


Figure 3.36: Interaction graph with 95% confidence interval. Average high frequency power for pre-test and post-test for laptop and non laptop classes in rhythmic intervention group.

3.3.2.3 Total power

Similar to previous results, TP (table 3.37) revealed no significant main effects at all. Furthermore, there was no significant interaction effect as well. All effects showed p-values above 0.05.

Table 3.37: Repeated measures ANOVA. Measure is average total power at time on task (TOT) for pre-test and post-test recordings (= within-subjects variable). Between-subjects variables indicate teaching style (CLASS) for the rhythmic intervention group.

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	***P***
Intercept	488243952.766	1	488243952.766	30.355	.000
CLASS	11301674.607	1	11301674.607	.703	.410
Error	418199830.683	26	16084608.872		
TOT	7194951.172	1	7194951.172	.787	.383
TOT * CLASS	2359489.147	1	2359489.147	.258	.616
Error(TOT)	237549317.772	26	9136512.222		

Figure 3.37 demonstrates the trend for the TP component of HRV. LT students showed TP values of 2406.212 ms² during pre-test which increased to 2719.853 ms² at post-test measurements. NLT students had slightly higher TP values at pre-test recording (2905.764 ms²) and showed a rise in TP up to 4059.991 ms² at post-test recording.

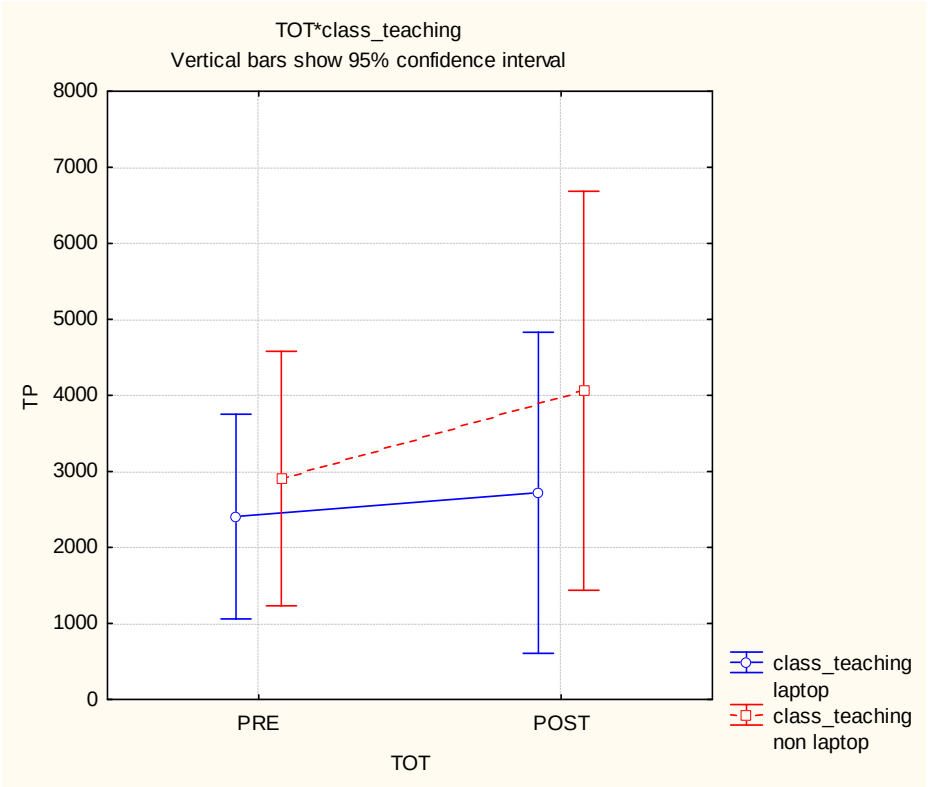


Figure 3.37: Interaction graph with 95% confidence interval. Average total power for pre-test and post-test for laptop and non laptop classes in rhythmic intervention group.

3.3.2.4 Log LF/HF

HRV represented by the parameter log LF/HF is demonstrated in table 3.38. There were no significant main effects at all. Likewise, there was a non-significant interaction effect between TOT and teachings style as well. All effects showed p-values above 0.05.

Table 3.38: Repeated measures ANOVA. Measure is average log LF/HF (ratio or sympathovagal balance) at time on task (TOT) for pre-test and post-test recordings (= within-subjects variable). Between-subjects variables indicate teaching style (CLASS) for the rhythmic intervention group.

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	***P***
Intercept	7.479	1	7.479	62.182	.000
CLASS	.027	1	.027	.226	.639
Error	3.127	26	.120		
TOT	.031	1	.031	.821	.373
TOT * CLASS	.031	1	.031	.811	.376
Error(TOT)	.990	26	.038		

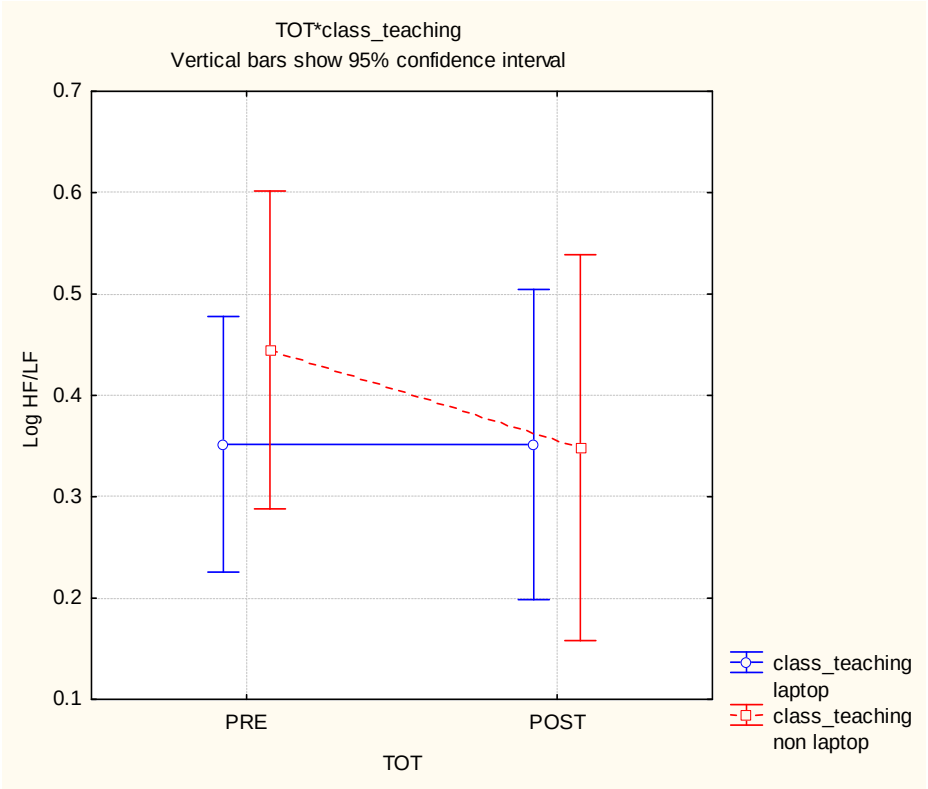


Figure 3.38: Interaction graph with 95% confidence interval. Average log LF/HF for pre-test and post-test for laptop and non laptop classes in rhythmic intervention group.

The interaction graph (figure 3.38) revealed the trend for the log LF/HF component. At pre-test recordings, NLT students showed higher log LF/HF values than LT students. While log LF/HF values remained fairly steady for LT students during post-test measurements, NLT students demonstrated a fall in log LF/HF from pre- to post-test recording.

3.3.2.5 normalized LF

HRV evaluated through the parameter LF in nu revealed no significant main effects at all (table 3.39). There was also no significant interaction effect between TOT and class teaching style. All effects showed p-values above 0.05.

Table 3.39: Repeated measures ANOVA. Measure is average normalized low frequency at time on task (TOT) for pre-test and post-test recordings (= within-subjects variable). Between-subjects variables indicate teaching style (CLASS) for the rhythmic intervention group.

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	***P***
Intercept	5.073	1	5.073	249.470	.000
CLASS	.002	1	.002	.092	.764
Error	.529	26	.020		
TOT	.032	1	.032	4.052	.055
TOT * CLASS	.006	1	.006	.767	.389
Error(TOT)	.206	26	.008		

Figure 3.39 depicts the trend of the normalized LF component. Students from both classes demonstrated a similar trend. At pre-test normalized LF values range between .328 % for NLT students and .337 % for LT students. During post-test the normalized LF component decreased to .300 % for NLT students and to .267 % for LT students.

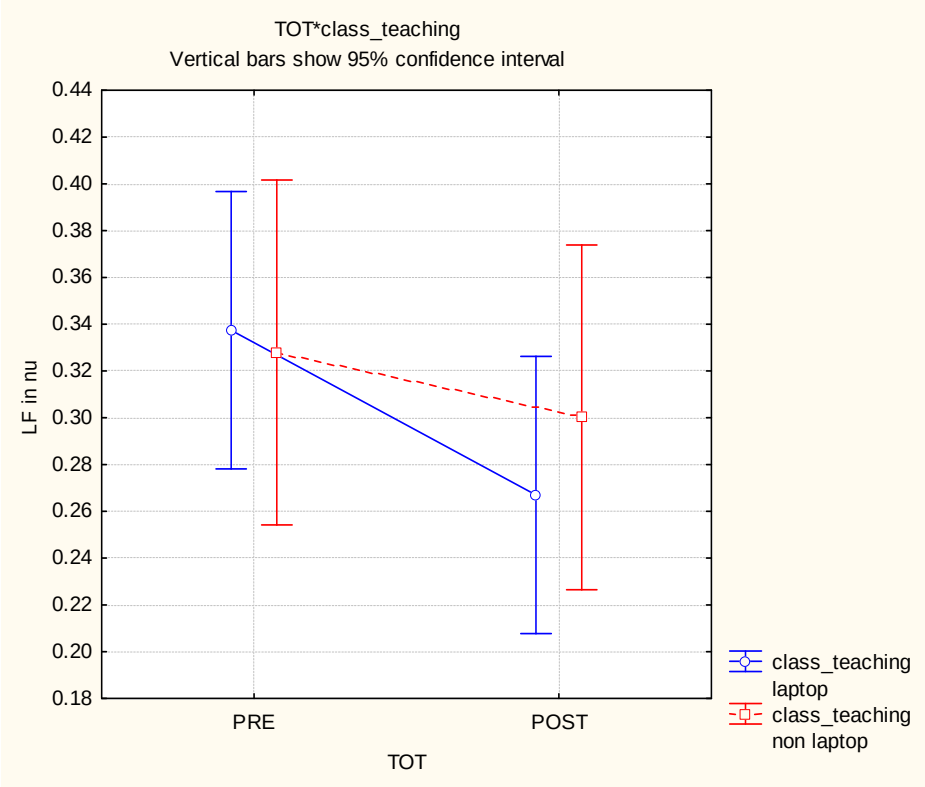


Figure 3.39: Interaction graph with 95% confidence interval. Average LF in normalized units for pre-test and post-test for laptop and non laptop classes in rhythmic intervention group.

3.3.2.6 normalized HF

HRV as measured by HF in nu showed non-significant main effects of class teaching style as well as of TOT (table 3.40). Furthermore, there was no significant interaction effect between TOT and class teaching style. All effects showed p-values above 0.05.

Table 3.40: Repeated measures ANOVA. Measure is average normalized high frequency at time on task (TOT) for pre-test and post-test recordings (= within-subjects variable). Between-subjects variables indicate teaching style (CLASS) for the rhythmic intervention group.

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	***P***
Intercept	1.086	1	1.086	116.760	.000
CLASS	1.37E-005	1	1.37E-005	.001	.970
Error	.242	26	.009		
TOT	.001	1	.001	.269	.608
TOT * CLASS	.006	1	.006	1.373	.252
Error(TOT)	.109	26	.004		

The interaction graph (figure 3.40) demonstrates the trend for the normalized HF component. LT students exhibit higher normalized HF components (.158 %) than NLT students (.136 %) during pre-test recordings. Whereas NLT students show a rise in normalized HF at post-test recordings, LT students' normalized HF component decreased to .128 % during post-test measurements.

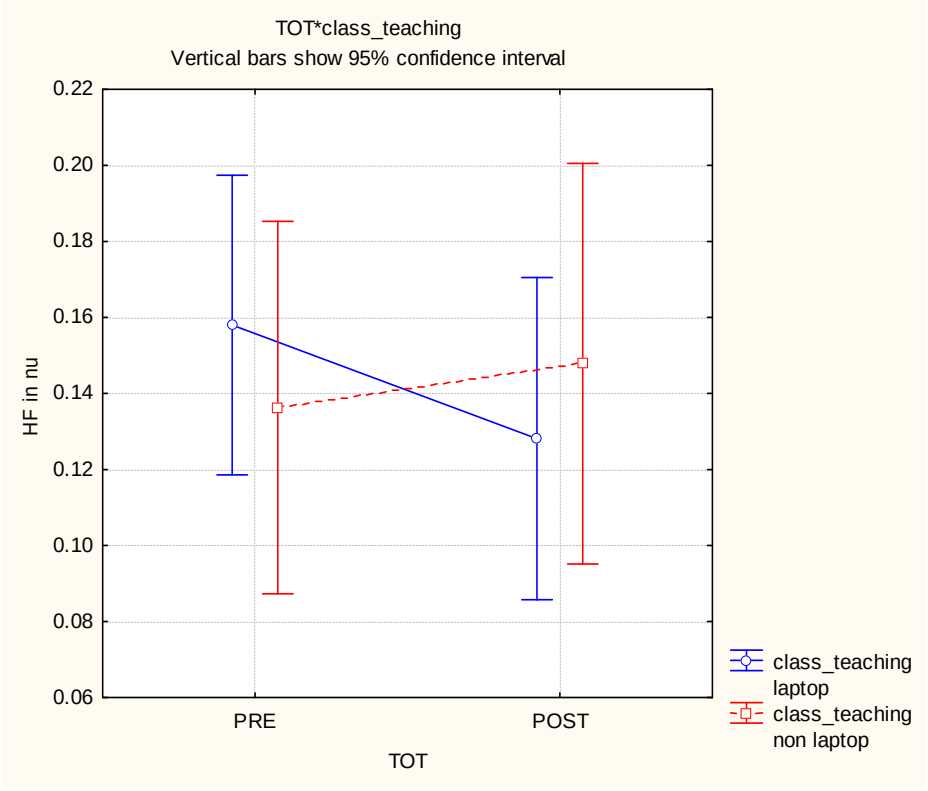


Figure 3.40: Interaction graph with 95% confidence interval. Average HF in normalized units for pre-test and post-test for laptop and non laptop classes in rhythmic intervention group.

3.3.3 Atrial mean

According to the atrial mean parameter statistical analysis revealed a significant main effect of class teaching style, $F(1,26) = 5.868$, $p < 0.05$ (table 3.41). There was a non-significant main effect of TOT and a non-significant interaction effect between TOT and class teaching style. All effects showed p values over 0.05.

Table 3.41: Repeated measures ANOVA. Measure is average atrial mean at time on task (TOT) for pre-test and post-test recordings (= within-subjects variable). Between-subjects variables indicate teaching style (CLASS) for the rhythmic intervention group.

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	***P***
Intercept	.959	1	.959	1801.921	.000
CLASS	.003	1	.003	5.868	**.023**
Error	.014	26	.001		
TOT	.000	1	.000	3.256	.083
TOT * CLASS	9.19E-005	1	9.19E-005	.676	.419
Error(TOT)	.004	26	.000		

The graph in figure 3.41 reveals the trend for the atrial mean parameter. On average LT students presented higher mean atrial values than NLT students. Both classes demonstrated a rise from pre-test to post-test. Whereas atrial mean demonstrated an increase in LT students, NLT students only showed a minimal rise during post-test recordings.

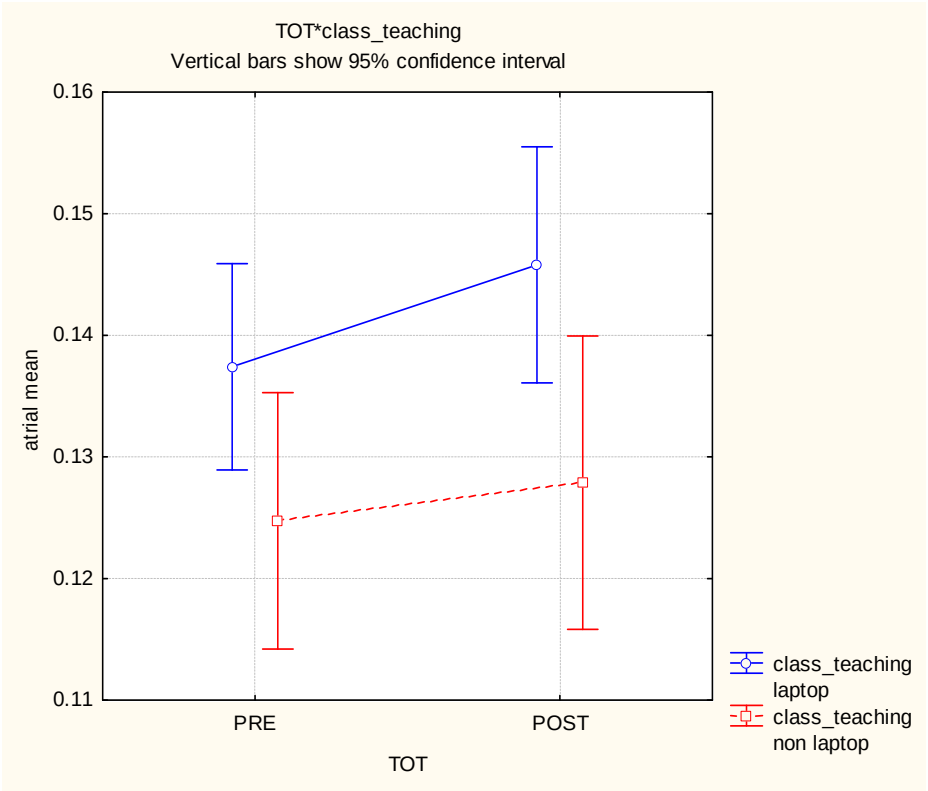


Figure 3.41: Interaction graph with 95% confidence interval. Average atrial mean for pre-test and post-test for laptop and non laptop classes in rhythmic intervention group.

3.3.4 Atrial median

Concerning the atrial median (table 3.42), there were no significant main effects at all. Likewise, no significant interaction effects are detected as well. All effects showed p-values above 0.05.

Table 3.42: Repeated measures ANOVA. Measure is average atrial median at time on task (TOT) for pre-test and post-test recordings (= within-subjects variable). Between-subjects variables indicate teaching style (CLASS) for the rhythmic intervention group.

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	***P***
Intercept	.860	1	.860	1553.220	.000
CLASS	.001	1	.001	2.697	.113
Error	.014	26	.001		
TOT	5.88E-005	1	5.88E-005	2.959	.097
TOT * CLASS	1.03E-005	1	1.03E-005	.517	.479
Error(TOT)	.001	26	1.99E-005		

Regarding the atrial median parameter, the graph depicts a similar trend (figure 3.42). Both classes show a slight rise from pre-test to post-test. In general LT students exhibited higher atrial median values than NLT students.

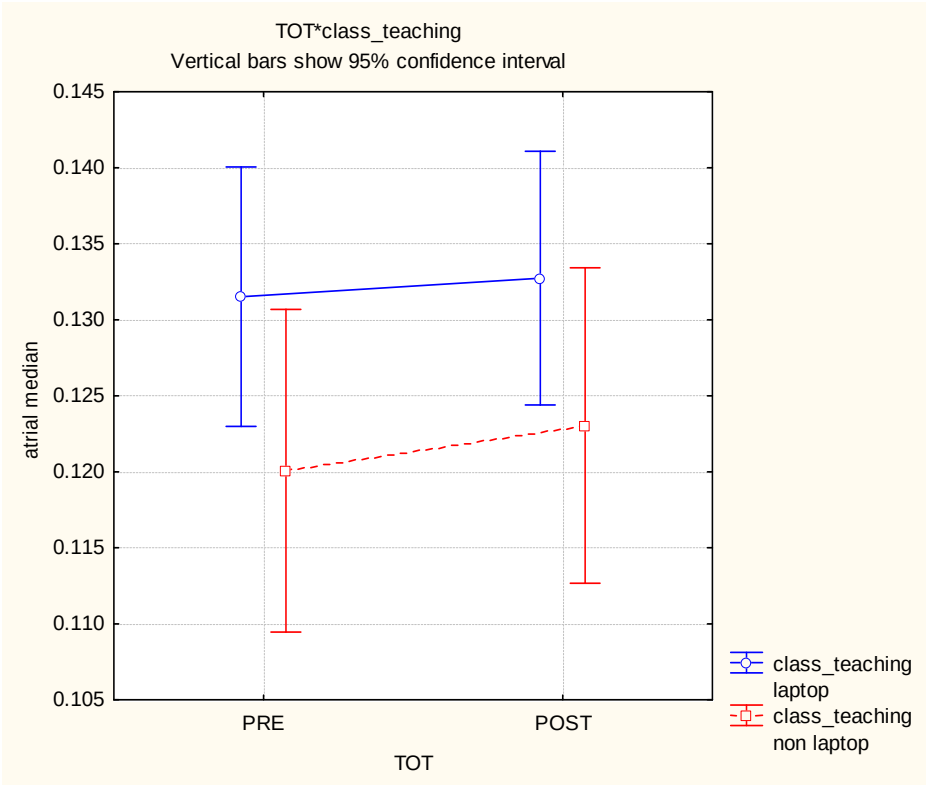


Figure 3.42: Interaction graph with 95% confidence interval. Average atrial median for pre-test and post-test for laptop and non laptop classes in rhythmic intervention group

3.4 Psychological data

The following section describes the evaluation of differences between teaching style and investigated locations of body discomfort. Moreover, correlations between evaluated variables and scores about psychological indicators and selected parameters of HRV are illustrated. Sample size comprised all 49 female students. All correlations are significant at the 0.05 level (two-tailed).

3.4.1 Body discomfort

3.4.1.1 Differences between teaching style and body discomfort

Statistical analysis with MANOVA revealed a non-significant effect of teaching style, $F(6,42) = 0.604$, $p > 0.05$ during pre-test evaluation (table 3.43).

Table 3.43: MANOVA test statistics. Measure is average body discomfort of all six body parts during pre-test evaluation. Between-subjects factors indicate teaching style (CLASS) representing LT and NLT students.

Source	*F*	*Hypothesis df*	*Error df*	*P*
Intercept	23.653	6.000	42.000	.000
CLASS	.604	6.000	42.000	.726

There were no significant differences between the investigated body parts and the two teaching style during pre-test recording. Average frequencies of rated areas of body discomfort however, presumed higher mean values for laptop students (table 3.44). Particularly, locations such as head and arms may indicate higher feelings of discomfort in LT students.

Table 3.44: Sample size (N), mean value, standard error and confidence interval of rated frequencies of body discomfort for head, neck, back, arms, eyes and hands for LT students and NLT students at pre-test recordings.

Body discomfort Pre-test	Teaching style	N	Mean value	Standard error	95% confidence interval	
					lower limit	upper limit
Head	LT	26	1.115	.158	.798	1.433
	NLT	23	.913	.168	.575	1.251
Neck	LT	26	.962	.169	.622	1.301
	NLT	23	.913	.179	.552	1.274
Back	LT	26	.962	.142	.675	1.248
	NLT	23	1.087	.151	.782	1.392
Arms	LT	26	.346	.096	.154	.539
	NLT	23	.174	.102	-.031	.379
Eyes	LT	26	.808	.153	.500	1.116
	NLT	23	.870	.163	.542	1.197
Hands	LT	26	.192	.078	.036	.348
	NLT	23	.174	.082	.008	.340

Regarding post-test evaluation MANOVA revealed a non-significant effect of teaching style as well, $F(6,42) = 1.812$, $p > 0.05$ (table 3.45).

Table 3.45: MANOVA test statistics. Measure is average body discomfort of all six body parts during post-test evaluation. Between-subjects factors indicate teaching style (CLASS) representing LT and NLT students.

Source	*F*	*Hypothesis df*	*Error df*	*P*
Intercept	17.695	6.000	42.000	.000
CLASS	1.812	6.000	42.000	.120

There were no significant differences between the investigated body parts and the two teaching style during post-test recording. Average frequencies of rated areas of body discomfort however, again presumed higher mean values for laptop students (table 3.46). Regarding post-test measurements feelings of body discomfort seem to appear more frequent. LT students reported higher discomfort in head, neck, eyes and hands.

Table 3.46: Sample size (N), mean value, standard error and confidence interval of rated frequencies of body discomfort for head, neck, back, arms, eyes and hands for LT students and NLT students at post-test recordings.

Body discomfort Post-test	Teaching style	N	Mean value	Standard error	95% confidence interval	
					lower limit	upper limit
Head	LT	26	1.192	.157	.877	1.507
	NLT	23	.783	.166	.448	1.117
Neck	LT	26	1.154	.163	.827	1.481
	NLT	23	.957	.173	.609	1.304
Back	LT	26	.923	.179	.563	1.283
	NLT	23	1.174	.190	.791	1.557
Arms	LT	26	.346	.118	.108	.584
	NLT	23	.348	.126	.095	.601
Eyes	LT	26	.769	.141	.485	1.053
	NLT	23	.522	.150	.220	.824
Hands	LT	26	.308	.096	.114	.502
	NLT	23	.087	.103	-.119	.293

3.4.1.2 Correlation between body discomfort and HRV variables

Table 3.47 illustrates the statistical analyses of Pearson's correlation matrix. There were no significant correlations between the selected HRV variables and BD during pre-test evaluation. Concerning post-test evaluation there were no significant correlations between the parameters of HRV and BD.

Table 3.47: Pearson's correlation matrix. Selected HRV parameters during 5-min BL recordings and body discomfort index for pre- and post-test evaluation.

HRV parameter	Coefficients	Body discomfort Pre-test	Body discomfort Post-test
Mean HR	*r*	-.004	-.006
	p	.979	.970
SDNN	*r*	-.071	-.116
	p	.628	.427
r-MSSD	*r*	-.104	-.056
	p	.476	.705
pNN50	*r*	-.153	-.037
	p	.293	.803
LF power	*r*	.008	-.135
	p	.957	.356
HF power	*r*	-.167	-.041
	p	.253	.782
Total power	*r*	-.059	-.070
	p	.687	.635
Log LF/HF	*r*	.204	.001
	p	.160	.994
Atrial mean	*r*	-.073	-.118
	p	.619	.420
Atrial median	*r*	-.103	-.132
	p	.481	.367

*****correlation is significant at the .05 level (two-tailed).

3.4.2 Self-reported physical activity ("Lüdenscheider Aktivitätsfragebogen")

There were no significant correlations between the score of the Lüdenscheider Aktivitätsfragebogen (extent of physical activity) and HRV parameters (table 3.48), but the atrial mean component showed a positive relationship with the self-reported extent of physical activity at post-test evaluation. Moreover a positive relationship is detected between the atrial median component and the score of the Lüdenscheider Aktivitätsfragebogen for both TOT measurements. Additional observation of psychological data indicated a positive relationship between the score of the "Lüdenscheider Aktivitätsfragebogen" and the frequency of LT use at school during pre-test measurements. Concerning the BMI and the extent of physical activity a positive relationship is identified only during post-test evaluation.

Table 3.48: Pearson's correlation matrix. Selected HRV parameters during 5-min BL recordings and psychological indicators computer application at school, body mass index and extent of physical activity (Lüdenscheider Aktivitätsfragebogen) for pre- and post-test evaluation.

HRV parameter	**Coefficients**	**Lüdenscheider Aktivitätsfragebogen Pre-test**	**Lüdenscheider Aktivitätsfragebogen Post-test**
Mean HR	*r* *p*	-.152 .297	-.048 .745
SDNN	*r* *p*	.083 .573	-.011 .942
r-MSSD	*r* *p*	.198 .172	.213 .142
pNN50	*r* *p*	.229 .114	.219 .130
LF power	*r* *p*	.031 .831	.163 .264
HF power	*r* *p*	.134 .359	.121 .406
Total power	*r* *p*	.118 .417	.204 .159
Log LF/HF	*r* *p*	-.130 .372	-.091 .535
Atrial mean	*r* *p*	.265 .066	**.366*** **.010**
Atrial median	*r* *p*	**.346*** **.015**	**.336*** **.018**
Psychological data			
PC use (school)	*r* *p*	**-.292*** **.042**	-.152 .298
BMI	*r* *p*	-.132 .367	**-.291*** **.042**

*****correlation is significant at the .05 level (two-tailed)

3.4.3 Body mass index (BMI)

There was a significant positive relationship between BMI and mean HR during pre-test evaluation (table 3.49). All other correlations showed a non-significant relationship. Additional analyses of psychological data revealed a positive relationship between BMI and frequency of computer use at home, but only for pre-test evaluation. At post-test evaluation a negative relationship between BMI and extent of physical activity is observed.

Table 3.49: Pearson's correlation matrix. Selected HRV parameters during 5-min BL recordings and psychological indicators computer application at home, extent of physical activity (Lüdenscheider Aktivitätsfragebogen) and body mass index (BMI) for pre- and post-test evaluation.

HRV parameter	**Coefficients**	**BMI Pre-test**	**BMI Post-test**
Mean HR	*r* *p*	**.302*** **.035**	.051 .728
SDNN	*r* *p*	-.136 .352	-.182 .212
r-MSSD	*r* *p*	-.262 .069	-.219 .131
pNN50	*r* *p*	-.172 .238	-.145 .321
LF power	*r* *p*	-.179 .217	-.215 .139
HF power	*r* *p*	-.105 .475	-.176 .226
Total power	*r* *p*	-.075 .609	-.055 .707
Log LF/HF	*r* *p*	.175 .228	.206 .156
Atrial mean	*r* *p*	-.058 .692	-.205 .158
Atrial median	*r* *p*	-.041 .777	-.160 .271
Psychological data			
PC use (house)	*r* *p*	**.289*** **.044**	.167 .252
Extent of physical activity (Lüdenscheider Aktivitätsfragebogen)	*r* *p*	-.132 .367	**-.291*** **.042**

*****correlation is significant at the .05 level (two-tailed)

3.4.4 Computer use

There were no significant correlations between the selected HRV variables and frequency of laptop use at home and at school, respectively (table 3.50). This didn't apply to the indicator PC use at home during post-test evaluation. A positive relationship is detected between the log LF/HF component and computer use at home. Furthermore, atrial mean and atrial median showed a positive relationship with computer use at home during post-test evaluation.

Further correlation analyses with psychological indicators revealed a significant positive relationship between the BMI and the frequency of computer use at home during pre-test evaluation. There was also a negative relationship between laptop use at school and the extent of physical activity during pre-test evaluation.

Table 3.50: Pearson's correlation matrix. Selected HRV parameters during 5-min BL recordings and psychological indicators computer use at home and at school, the extent of physical activity (Lüdenscheider Aktivitätsfragebogen) and body mass index (BMI) for pre- and post-test evaluation.

HRV parameter	**Coefficients**	**PC use at home Pre-test**	**PC use at home Post-test**	**PC use at school Pre-test**	**PC use at school Post-test**
Mean HR	*r*	.131	.024	.025	.021
	p	.371	.871	.862	.886
SDNN	*r*	-.103	-.017	-.002	.087
	p	.479	.909	.987	.551
r-MSSD	*r*	-.106	-.028	-.105	-.032
	p	.470	.850	.471	.827
pNN50	*r*	-.069	-.005	-.085	.041
	p	.637	.975	.562	.781
LF power	*r*	-.037	.155	.046	.005
	p	.803	.288	.752	.974
HF power	*r*	-.011	-.123	.018	-.004
	p	.939	.400	.901	.977
Total power	*r*	-.104	.034	.106	.135
	p	.478	.818	.468	.354
Log LF/HF	*r*	-.008	**.328***	.211	.146
	p	.955	**.021**	.146	.318
Atrial mean	*r*	.373	**.365***	.211	.060
	p	.008	**.010**	.146	.680
Atrial median	*r*	.202	**.330***	-.153	.106
	p	.164	**.021**	.294	.470
Psychological data					
BMI	*r*	**.289***	.167	.213	.225
	p	**.044**	.252	.141	.120
Extent of physical activity (Lüdenscheider Aktivitätsfragebogen)	*r*	.105	.186	**-.292***	-.152
	p	.475	.202	**.042**	.298

***correlation is significant at the .05 level (two-tailed)

4 Discussion and interpretation

The aim of the study was to evaluate and document HRV trends under different physical and mental activities. Fields of interest were: potential impacts of a so called "laptop teaching style" and a "traditional teaching style" (without the use of laptops in school) as well as effects of different performed sport educations (traditional physical education and rhythmic education). Additionally, with the help of questionnaires, psychological indicators are evaluated to test the associations between self-reported measures and objective parameters of HRV during baseline condition (rest period). The following chapter discusses and interprets the relevant results in combination with previous research.

4.1 HRV trends during the physical and mental study protocol

Significant differences in HRV variables mainly result from complex interactions between the two sport education groups, the two teaching style classes and the time, when measurements were conducted. In general, non laptop students demonstrate considerably more variations in HRV components during post-test recordings than laptop students. This is shown particularly in increased heart rates, depressed pNN50 and reduced total power. Concerning the sport education groups, RE students demonstrate significant differences in HRV measures during pre-test evaluation compared to PE students. The RE group exhibit reduced heart rates, higher pNN50 and increased high-frequency power. Significant variations in HRV measures are shown within the fitness condition. However, no significant influence in sport education and teaching style, respectively, can be demonstrated after termination of the rhythmic education intervention. This applies for the baseline condition as well as for the fitness condition. Furthermore, no difference is detected during the mental stress task between the laptop students and the non laptop students in any of the HRV variables measured. Except for the atrial mean measure, where laptop students demonstrate significant higher levels than non laptop students. Concerning psychological indicators, no difference in body discomfort between laptop students and non laptop students is identified. The extent of physical activity (Lüdenscheider Aktivitätsfragebogen) demonstrates a positive relationship with atrial mean and atrial median. BMI and mean heart rate indicate a significant positive relationship. Moreover, computer use at home correlates positively with log LF/HF, atrial mean and atrial median.

4.1.1 Physical conditions

Time-domain parameters

Minimal, mean and maximum heart rate reveal significant interaction effects between TOT, sport education and class teaching style during the 5-minute baseline recording and significant 4-way interactions between TOT, fitness condition, sport education and teaching style. In general, PE groups exhibit higher heart rates than RE students which demonstrate significant differences during pre-test measurements. This may be due to the preceding gym lesson which are presumably more exhausting than the RE lessons. Hence, it is possible that PE students were still in recovery phase during BL recordings. Additionally, a significant effect exists between LT and NLT students during post-test recordings. NLT students from the RE group show higher heart rates during post-test baseline recordings. This trend contrasts the baseline measurements in all other classes and might be caused by class-specific influences such as tests, homework, and other stress-induced parameters which couldn't be considered. Both, sport education groups and teaching classes, demonstrate similar heart rate profiles across the fitness condition with the highest heart rate levels during KB exercise.

HRV which is measured by the parameter SDNN reveals a significant interaction effect between TOT and teaching style during the baseline condition. NLT students performing RE show reduced SDNN compared to LT students from the RE group during post-test recording. As aforementioned assumed non laptop RE students may be exposed to higher class-related stress and pressure during post-test measurements compared to their LT counterparts. There is also a significant effect between TOT, fitness and class teaching style, which occurs at pre-test KB exercise and recovery R1. Whereas NLT students exhibit a fall in SDNN at KB exercise and a rise at R1, LT students show a rise at KB exercise and a fall at R1. But it has to be mentioned that this effect may result from time delayed KB performance in the LT rhythmic education class. Additionally, there is a significant interaction effect between fitness, sport education and teaching style. LT students performing RE demonstrate higher SDNN values than their PE counterparts. As a whole, a fall in HRV represented by the SDNN parameter is observed at KB exercise with an increase across the recovery phase.

The r-MSSD component shows significant interaction effects between TOT, teaching style and sport education. Consistent with the previous assumption that physical education

is more exhausting than rhythmic education, the PE group presents reduced r-MSSD compared to their RE counterparts during baseline recordings. Regarding TOT measurements, laptop RE students demonstrate higher r-MSSD values during post-test compared to pre-test. Non laptop RE students, however, exhibit reduced r-MSSD during post-test recording compared to their pre-test values. This indicates reduced parasympathetic activity and goes along with reduced SDNN and increased heart rates in this class. Compliant with the r-MSSD parameter, HRV represented by the pNN50 component reveals a significant interaction effect between TOT, teaching style and sport education. Post hoc recheck tests show significant differences between RE and PE during pre-test baseline recordings and significant differences between NLT and LT students during post-test baseline measurement. R-MSSD and pNN50 components indicate parasympathetic activity. According to Jouven et al. (2005) reduced vagal activity is associated with higher heart rates during exercise and early recovery. Although effects are detected during BL condition no significant effects are identified during the fitness condition. Therefore, it is not possible to speak of an influence of sport education or teaching style on HRV time-domain parameters addressing parasympathetic modulation under the fitness condition.

Frequency-domain parameters

Regarding frequency domain parameters, the LF power component demonstrates a significant interaction effect between TOT, teaching style and sport education. Particularly, the RE group compared to the PE group shows increased LF power during pre-test recordings. A shift in the LF component from pre- to post-test is observed in non laptop PE students. They show increased LF power during post-test recordings compared to their NLT counterparts who demonstrated a fall in LF power during post-tests. Considering the normalized LF component, which reflects mainly sympathetic modulation (Pagani et al., 1986), a significant interaction between TOT, sport education and teaching style, is revealed. The interaction graph (figure 3.11) depicts differences between non laptop RE and PE students during post-test measurements. The PE group demonstrate higher normalized LF values during post-test measurements than RE students. All other groups present reduced normalized LF values during post-test recordings. LF power during the fitness condition reveals a significant interaction effect between TOT and fitness. A

decrease in LF power at pre-test recording is identified towards baseline end, across KB exercise and until early recovery with an increase in LF power in the middle of the recovery period. Post-test recordings demonstrate a fall in LF power after KB exercises and rises again right after the first recovery minute (R1). However approximately two minutes recording time is needed to address the LF component (Task Force, 1996). Therefore, effects are questionable and may imply random fluctuations in LF power. With respect to the normalized LF parameter, no significant effects across the fitness conditions are identified. Evidently, recordings of only one minute duration time are most likely too short to observe significant results.

The HF component reveals significant differences between PE and RE during baseline pre-test recordings as well as during baseline post-test recordings. Students performing the RE intervention demonstrate higher HF power than their PE counterparts. No significant effects are detected between the two classes during both baseline measurements. Likewise, the normalized HF component shows a similar trend with a significant sport education effect. With regard to the fitness condition, no significant effects in the HF power component are identified. Focussing on the normalized HF variable, significant interaction effects are revealed between fitness, sport education and teaching style, between TOT, fitness and teaching style, and between TOT, fitness and sport education, respectively. In general, RE students demonstrate higher normalised HF values compared to PE students. More precisely, the laptop RE group show higher normalised HF during pre-test baseline condition and recovery period. The non laptop RE group demonstrate higher normalised HF during the post-test recovery period. Relevant differences between the two sport groups concerning pre-test and post-test measurements are revealed during pre-test baseline and during post-test baseline and KB exercise. Additionally, significant effects are detected between NLT and LT students during post-test recovery session.

Total power of HRV presents significant differences between LT and NLT students during baseline post-test measurements. While LT students demonstrate a minor rise in TP from pre-test to post-test, results from NLT students present a remarkable fall in TP during post-test recordings. Regarding the fitness condition, total power demonstrates a significant effect between LT and NLT class at post-test baseline 3. Whereas LT students demonstrate a rise in TP during post-test baseline condition, NLT students show a decrease in TP during post-test baseline condition and therefore, exhibit reduced TP during baseline recordings. In

general, TP profile demonstrates a similar trend across the fitness condition which means a rise during baseline with a major fall at KB exercise and a rise again during recovery phase. This finding goes along with Hoos' postulation (2006) that the variability of TP can dramatically reduce with exercise.

No significant effects are revealed concerning the logarithmic LF/HF component during 5-minute baseline recordings. Generally speaking, a reduction in log LF/HF from pre-test to post-test is observed, except for non laptop PE students who demonstrate a rise during post-test measurements but the effects are to small to identify significant results. The log LF/HF component across the fitness condition shows a significant 4-way interaction effect between TOT, fitness condition, sport education and teaching style. This effect is mainly caused by differences between the two sport groups during post-test recordings (see appendix table 7.34). In general, laptop PE students demonstrate higher log LF/HF values during the fitness condition than their RE counterparts.

Atrial values

There is no significant effect in atrial mean during baseline, but atrial median demonstrates a significant interaction effect between TOT, sport education and teaching style. Graphical representation (figure 3.14) only shows minor changes regarding pre- and post-test recordings. Laptop RE students show a small rise in atrial median during post-test measurements. The PE group demonstrates a small fall in atrial median. Regarding the fitness condition, atrial mean shows a significant interaction effect between TOT and fitness. A remarkable increase in atrial mean is observed at KB exercise during pre-test recording. No rise in atrial mean at KB exercise is detected during post-test recording. This is possible due to increased sympathetic activity during pre-test KB exercise. At post-test measurements students already knew about the fitness protocol which may have led to stable sympathetic modulation across the whole fitness conditions. Concerning atrial median, significant effects are demonstrated within the different fitness stages.

4.1.2 Mental stress condition

The exploration of cardiovascular and subjective stress responses to a mental calculating test (MS condition) shows no differences between laptop and non laptop students in any of the HRV variables measured. This also applies to TOT measurement (pre- and post-test). However, laptop students exhibit significant higher atrial mean values than non laptop

students. Broadly speaking, both classes demonstrate lower heart rates during post-test measurements. Presumably, impact of stress due to a mental maths task decreases during post-test evaluation. The trend can also be observed in other HRV variables, especially in increased SDNN, r-MSSD, pNN50, normalized LF and log LF/HF during post-tests. But as mentioned before they don't show significant results. Presumably, effects of the two teaching classes were too small to elicit significant changes in HRV during the mental stress condition. Furthermore, knowledge and learning effects may reduce stress sensation.

Generally speaking, significant effects in HRV parameters during physical and mental conditions mainly result in complex interactions between the two sport education groups, the two teaching style classes and the time on task, when measurements were conducted. Significant differences between laptop students and non laptop students during post-test baseline recordings revealed increased heart rates, reduced parasympathetic activity and reduced HRV in terms of total power variability amongst non laptop students. This may be due to confounding variables which were not considered, such as increased stress-related factors towards the end of the school term in this class. Concerning the two sport education groups, significant differences in HRV variables during the pre-test baseline condition are probably due to preceding gym lesson, which was more exhausting for PE students than the preceding RE lesson. Moreover, no significant effect in HRV is detected after termination of the RE intervention. It has to be noted that some students showed infrequent participation in rhythmic education during the school term. Additionally, RE intervention could only be held every second gym lesson. Internal school events and holidays reduced RE intervention as well. Consequently, no constant rhythmic education could be guarantied. Only an abridgement of RE was applied, which was considered a "trial lesson". On this account, impact and effects of rhythmic were too small to address HRV components.

Broadly speaking, this study shows that HRV parameters are sensitive indicators of physical health measured under different physical conditions. This is consistent with a number of other investigations using HRV indices to demonstrate cardiovascular activity during rest, exercise and recovery (Arai et al., 1989; Hottenrott, 2002; Hoos, 2006). They suggested a fall in parasympathetic modulation during exercise and increased sympathetic activity during recovery. This mechanism is combined with a rise in heart rate during exercise and a fall in heart rate during recovery. HRV parameters in this study demonstrate

a similar fitness-trend especially regarding pre-test measurements. During KB exercise HRV variables show reduced parasympathetic activity by depressed HF power and normalized HF. Minimum, mean and maximum heart rates increased and total power levels decreased with exercise. Additionally, enlarged atrial mean und atrial median during pre-test measurements may indicate sympathetic activation during KB exercise. Frequency-domain component recordings of 1-minute duration may be too short to address the LF range. Nevertheless, significant variations are found across the fitness condition with a rise in the LF variable at KB exercise. This goes along with Arai et al. (1989) who demonstrated a marked reduction in the LF component during exercise.

4.2 Psychological data

Previous reports have suggested that prolonged poor sitting habits which are due to increased laptop use play an important role in musculoskeletal symptoms and body discomfort such as head, neck, back, arms, eyes and hands (Trimmel & Bachmann, 2004; Harris & Straker, 2000). Although, no significant differences between LT and NLT students concerning body discomfort occurred in the present study, average rated frequencies presumes stronger feelings of body discomfort in LT students. Particularly locations such as head, neck, arms and hands indicate higher mean values.

Moreover, correlations between self-reported measures such as extent of physical activity (Lüdenscheider Aktivitätsfragebogen), body discomfort, computer use and BMI, and objective HRV components are evaluated. The extent of physical activity significantly correlates with atrial mean and atrial median, respectively. BMI indicates a positive relationship with heart rate and correlates significantly with mean heart rate during pre-test evaluation. Concerning computer use, there are significant correlations between computer use at home during post-test evaluation and following HRV parameters: log LF/HF, atrial mean and atrial median. All objective measures indicate sympathetic activity. The longer the rated frequency of laptop use at home, the higher seems sympathetic activation, which may indicate not considered stress-induced influences. This effect may probably be due to school stress, such as homework, tests, etc. during post-test evaluation.

In conclusion, detected significant variations in HRV measures during physical conditions result in complex interaction effects between the two sport education groups, the

two class teaching styles, and the time, when measurement were conducted. Furthermore, too many confounding variables may influence the dependent variable and distort the results. Concerning the mental stress task, no impacts of different teaching styles can be demonstrated in any of the evaluated HRV components. Hence, class-related effects are most likely too small to elicit significant changes in HRV variables. Effects of class teaching styles have no impacts in feelings of body discomfort. Examination of correlations between self-reported psychological measures and objective HRV indices reveal bigger atrial mean and atrial median values for students who indicate higher levels of physical activity. Students with higher BMI show higher mean heart rates during baseline recordings. Moreover, higher levels of computer use at home are positively associated with higher sympathetic activation.

5 Abstract

HRV is discussed as an important indicator for health and fitness. Many studies have shown that the cardiovascular system benefits from physical activity. Additionally, positive impacts of exercise result in reduced muscle tension and reduced body discomfort. At present, the number of self-reported musculoskeletal injuries and pain increase. This rise might be related to student's frequent use of computers and mental stress at school. Purpose of this investigation was to explore the effects of rhythmic and physical education, as well as the effects of laptop and non laptop teaching style on HRV parameters. The study investigated 49 female students from the 9th and 10th grade of a Vienna Business School. Time- and frequency domain parameters of HRV during mental and physical conditions were analyzed before and after the school term. Furthermore relationships to self-reported psychological indicators (extent of physical activity, body discomfort and computer use) to HRV parameters at rest were evaluated. Results: The effects of different kinds of sport education and teaching styles on HRV parameters during mental and physical conditions were insignificant. Furthermore, no significant differences between body discomfort and teaching style are detected. The following correlation between psychological indicators and HRV variables during 5-min recordings at rest can be demonstrated: Higher BMI shows higher mean heart rates during baseline recordings. High self-reported physical activity results in increased sympathetic activity which is represented by atrial mean and atrial median parameter. Increased laptop use at home implicates increased sympathetic activity. This is shown by log LF/HF, atrial mean and atrial median parameters. Overall, the results are difficult to compare, because class-related effects as well as sport group-related effects, measured during the school term, are most likely too little to be representative. Moreover, variations during baseline measurements of the sport groups are rather large. This is caused by the preceding, more exhausting physical education compared to rhythmic education.

5.1 Abstrakt

HRV Maße werden als Indikatoren für Gesundheit und körperliche Fitness diskutiert. Sportliche Aktivität ist bekannt für seine positive Wirkung auf das kardiovaskuläre System und verringert Muskelspannungen und körperliche Schmerzen. In letzter Zeit nahm die Anzahl der Beschwerden des Muskel- und Bewegungsapparates vor allem unter Schülern

und Studenten immer mehr zu und viele Studien bringen dies mit erhöhter Computer und Laptop Anwendung sowie Stress und mentale Herausforderungen in Verbindung. Ziel dieser Studie war es die Auswirkungen einer rhythmisch-musikalischen Bewegungserziehung und einer traditionellen Leibeserziehung auf Parameter der HRV zu erforschen. Außerdem wurde die HRV von Schülerinnen aus Laptop-Klassen mit jenen Schülerinnen aus Nicht-Laptop-Klassen miteinander verglichen. Insgesamt nahmen an der Studie 49 Schülerinnen aus der 9. und 10. Klasse einer Wiener Handelsakademie teil. HRV Parameter des Zeit- und Frequenzbereichs wurden während eines mentalen und körperlichen Studienprotokolls zu Beginn und am Ende des Schulsemesters analysiert. Daneben wurden psychologische Indikatoren (Ausmaß sportlicher Aktivität, körperliche Beschwerden und Computerverwendung) mittels PDA-Fragebögen erhoben und ihre Beziehung zu HRV Parameter in Ruhebedingung untersucht. Ergebnisse: Es konnten keine signifikanten Auswirkungen von unterschiedlichen Bewegungserziehungsstilen, sowie unterschiedlichen Unterrichtsarten, mit oder ohne Laptop, auf Parameter der HRV festgestellt werden. Weiters konnten keine Unterschiede zwischen Laptop-Schülerinnen und Nicht-Laptop-Schülerinnen hinsichtlich ihres körperlichen Beschwerdeempfindens beobachtet werden. Bezüglich der psychologischen Indikatoren ergaben die Korrelationen mit der HRV in Ruhebedingung folgende signifikante Ergebnisse: Je höher der BMI, desto höher die durchschnittliche Herzrate. Höhere subjektive sportliche Aktivität wirkt sich durch erhöhte Sympathikusaktivität in Form von längeren Atrial Werten aus. Längere Computernutzung zu Hause führt ebenfalls zu erhöhter Sympathikusaktivität in Form von erhöhter log LF/HF Komponente und verlängerten Atrial Werten. Insgesamt ist es schwierig die Ergebnisse zu vergleichen, da die Effekte der Sportgruppen und der Klassen über ein Semester gemessen sehr gering sind. Außerdem unterscheiden sich die Sportgruppen in der Baseline sehr stark durch den vorangegangenen, unterschiedlich anstrengenden Sportunterricht.

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7 Appendix

7.1 Supplementation to results: HRV at baseline condition

7.1.1 Time domain parameters

7.1.1.1 Minimum heart rate

Table 7.1: Minimum heart rate: sample size (N), mean value, standard error and confidence interval for the sport groups (RE and PE) and the class (LT and NLT) at pre-test and post-test (TOT) during baseline recordings.

sport education	Class teaching	TOT	N	Mean value	Standard error	95% confidence interval	
						lower limit	upper limit
Rhythmic education	Laptop	1	17	71.751	3.558	64.584	78.917
		2	17	69.965	3.299	63.321	76.609
	Non laptop	1	11	75.198	4.424	66.289	84.108
		2	11	86.943	4.101	78.683	95.202
Physical education	Laptop	1	9	88.434	4.890	78.585	98.284
		2	9	89.240	4.534	80.109	98.371
	Non laptop	1	12	81.824	4.235	73.294	90.354
		2	12	76.813	3.926	68.905	84.720

7.1.1.2 Mean heart rate

Table 7.2: Mean heart rate: sample size (N), mean value, standard error and confidence interval for the sport groups (RE and PE) and the class (LT and NLT) at pre-test and post-test (TOT) during baseline recordings.

Sport education	Class teaching	TOT	N	Mean value	Standard error	95% confidence interval	
						lower limit	upper limit
Rhythmic education	Laptop	1	17	91.802	3.111	85.536	98.069
		2	17	87.797	2.931	81.894	93.701
	Non laptop	1	11	96.077	3.868	88.287	103.868
		2	11	103.320	3.644	95.981	110.659
Physical education	Laptop	1	9	105.216	4.276	96.603	113.828
		2	9	102.951	4.028	94.838	111.065
	Non laptop	1	12	106.202	3.703	98.743	113.660
		2	12	97.119	3.489	90.093	104.146

Table 7.3: Mann-Whitney U-Test: Significant effect of mean HR and teaching style for post-test recording.

Baseline Mean HR	Teaching style	N	Mean Rank	**Z**	**Sig.**
Post-test	Laptop class Non laptop class	26 23	21.04 29.48	-2.063	**.039**

7.1.1.3 Maximum heart rate

Table 7.4: Maximum heart rate: sample size (N), mean value, standard error and confidence interval for the sport groups (RE and PE) and the class (LT and NLT) at pre-test and post-test (TOT) during baseline recordings.

Sport education	Class teaching	TOT	N	Mean value	Standard error	95% confidence interval	
						lower limit	upper limit
Rhythmic education	Laptop	1	17	114.445	3.518	107.358	121.531
		2	17	111.149	4.323	102.443	119.855
	Non laptop	1	11	118.595	4.374	109.786	127.405
		2	11	128.585	5.374	117.762	139.408
Physical education	Laptop	1	9	125.364	4.836	115.625	135.104
		2	9	126.100	5.941	114.135	138.065
	Non laptop	1	12	131.321	4.188	122.886	139.755
		2	12	119.984	5.145	109.622	130.346

Table 7.5: Mann-Whitney U-Test: Significant effect of minimum, mean and maximum HR and sport education for pre-test recording.

Baseline Heart Rate	Sport education	N	Mean Rank	**Z**	**Sig.**
Pre-test min HR	Rhythmic education	28	20.46	-2.566	**.010**
	Physical education	21	31.05		
Pre-test mean HR	Rhythmic education	28	19.39	-3.172	**.002**
	Physical education	21	32.48		
Pre-test max HR	Rhythmic education	28	20.18	-2.728	**.006**
	Physical education	21	31.43		

7.1.1.4 SDNN

Table 7.6: SDNN: sample size (N), mean value, standard error and confidence interval for the sport groups (RE and PE) and the class (LT and NLT) at pre-test and post-test (TOT) during baseline recordings.

sport education	Class teaching	TOT	N	Mean value	Standard error	95% confidence interval	
						lower limit	upper limit
Rhythmic education	Laptop	1	17	55.618	4.979	45.590	65.645
		2	17	56.165	4.500	47.101	65.228
	Non laptop	1	11	59.327	6.189	46.862	71.793
		2	11	36.609	5.594	25.342	47.876
Physical education	Laptop	1	9	37.867	6.842	24.085	51.648
		2	9	38.667	6.185	26.210	51.123
	Non laptop	1	12	46.992	5.926	35.057	58.927
		2	12	43.200	5.356	32.412	53.988

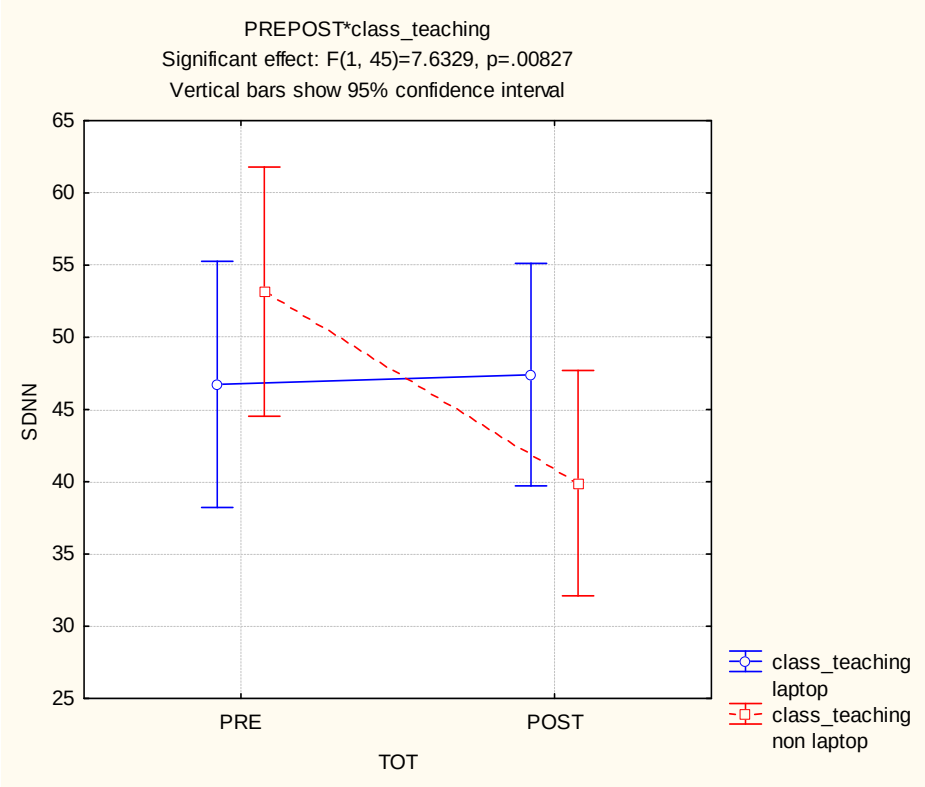

Figure 7.1: 2-way interaction between TOT * teaching style. SDNN at pre-test and post-test recording for laptop students and non laptop students.

7.1.1.5 r-MSSD

Table 7.7 r-MSSD: sample size (N), mean value, standard error and confidence interval for the sport groups (RE and PE) and the class (LT and NLT) at pre-test and post-test (TOT) during baseline recordings.

sport education	Class teaching	TOT	N	Mean value	Standard error	95% confidence interval	
						lower limit	upper limit
Rhythmic education	Laptop	1	17	34.135	3.376	27.337	40.934
		2	17	37.400	3.486	30.379	44.421
	Non laptop	1	11	33.591	4.196	25.139	42.043
		2	11	20.518	4.334	11.789	29.247
Physical education	Laptop	1	9	19.778	4.639	10.434	29.122
		2	9	20.167	4.791	10.517	29.817
	Non laptop	1	12	21.992	4.018	13.900	30.084
		2	12	24.525	4.149	16.168	32.882

7.1.1.6 pNN50

Table 7.8: pNN50: sample size (N), mean value, standard error and confidence interval for the sport groups (RE and PE) and the class (LT and NLT) at pre-test and post-test (TOT) during baseline recordings.

sport education	Class teaching	TOT	N	Mean value	Standard error	95% confidence interval	
						lower limit	upper limit
Rhythmic education	Laptop	1	17	12.664	2.294	8.043	17.284
		2	17	17.582	2.649	12.247	22.917
	Non laptop	1	11	13.239	2.852	7.496	18.983
		2	11	4.352	3.293	-2.280	10.984
Physical education	Laptop	1	9	5.739	3.153	-.611	12.089
		2	9	6.496	3.640	-.836	13.827
	Non laptop	1	12	4.456	2.730	-1.043	9.955
		2	12	7.703	3.153	1.353	14.052

Table 7.9: Mann-Whitney U-Test: Significant effect of pNN50 and teaching style for post-test recording.

Baseline pNN50	Teaching style	N	Mean Rank	**Z**	**Sig.**
Post-test	Laptop class Non laptop class	26 23	28.96 20.52	-2.065	**.039**

Table 7.10: Mann-Whitney U-Test: Significant effect of pNN50 and sport education for pre-test recording.

Baseline pNN50	Sport education	N	Mean Rank	**Z**	**Sig.**
Pre-test	Rhythmic education Physical education	28 21	29.68 18.76	-2.647	**.008**

7.1.2 Frequency domain parameters

7.1.2.1 LF power

Table 7.11: Low frequency power: sample size (N), mean value, standard error and confidence interval for the sport groups (RE and PE) and the class (LT and NLT) at pre-test and post-test (TOT) during baseline recordings.

sport education	Class teaching	TOT	N	Mean value	Standard error	95% confidence interval	
						lower limit	upper limit
Rhythmic education	Laptop	1	17	953.871	140.808	670.268	1237.473
		2	17	888.312	137.617	611.137	1165.486
	Non laptop	1	11	791.600	175.048	439.036	1144.164
		2	11	459.309	171.080	114.736	803.882
Physical education	Laptop	1	9	522.967	193.523	133.192	912.741
		2	9	278.100	189.136	-102.840	659.040
	Non laptop	1	12	269.708	167.595	-67.846	607.263
		2	12	694.017	163.797	364.113	1023.920

7.1.2.2 HF power

Table 7.12: High frequency power: sample size (N), mean value, standard error and confidence interval for the sport groups (RE and PE) and the class (LT and NLT) at pre-test and post-test (TOT) during baseline recordings.

sport education	Class teaching	TOT	N	Mean value	Standard error	95% confidence interval	
						lower limit	upper limit
Rhythmic education	Laptop	1	17	437.671	66.180	304.377	570.964
		2	17	499.365	70.630	357.108	641.621
	Non laptop	1	11	272.664	82.273	106.958	438.370
		2	11	170.664	87.805	-6.184	347.512
Physical education	Laptop	1	9	132.100	90.956	-51.095	315.295
		2	9	70.456	97.072	-125.057	265.968
	Non laptop	1	12	97.500	78.770	-61.151	256.151
		2	12	185.442	84.067	16.123	354.761

Table 7.13: Mann-Whitney U-Test: Significant effect of high frequency (HF) and sport education for pre-test and post-test recording.

Baseline HF	Sport education	N	Mean Rank	**Z**	**Sig.**
Pre-test	Rhythmic education	28	30.89	-3.334	**.001**
	Physical education	21	17.14		
Post-test	Rhythmic education	28	29.64	-2.626	**.009**
	Physical education	21	18.81		

7.1.2.3 Total power

Table 7.14: Total power: sample size (N), mean value, standard error and confidence interval for the sport groups (RE and PE) and the class (LT and NLT) at pre-test and post-test (TOT) during baseline recordings.

sport education	Class teaching	TOT	N	Mean value	Standard error	95% confidence interval	
						lower limit	upper limit
Rhythmic education	Laptop	1	17	4245.971	778.571	2677.849	5814.093
		2	17	4361.688	450.066	3455.210	5268.167
	Non laptop	1	11	4617.318	967.890	2667.887	6566.750
		2	11	2484.673	559.505	1357.772	3611.574
Physical education	Laptop	1	9	1525.344	1070.043	-629.833	3680.522
		2	9	2121.722	618.556	875.886	3367.558
	Non laptop	1	12	2496.433	926.685	629.995	4362.872
		2	12	2002.625	535.685	923.700	3081.550

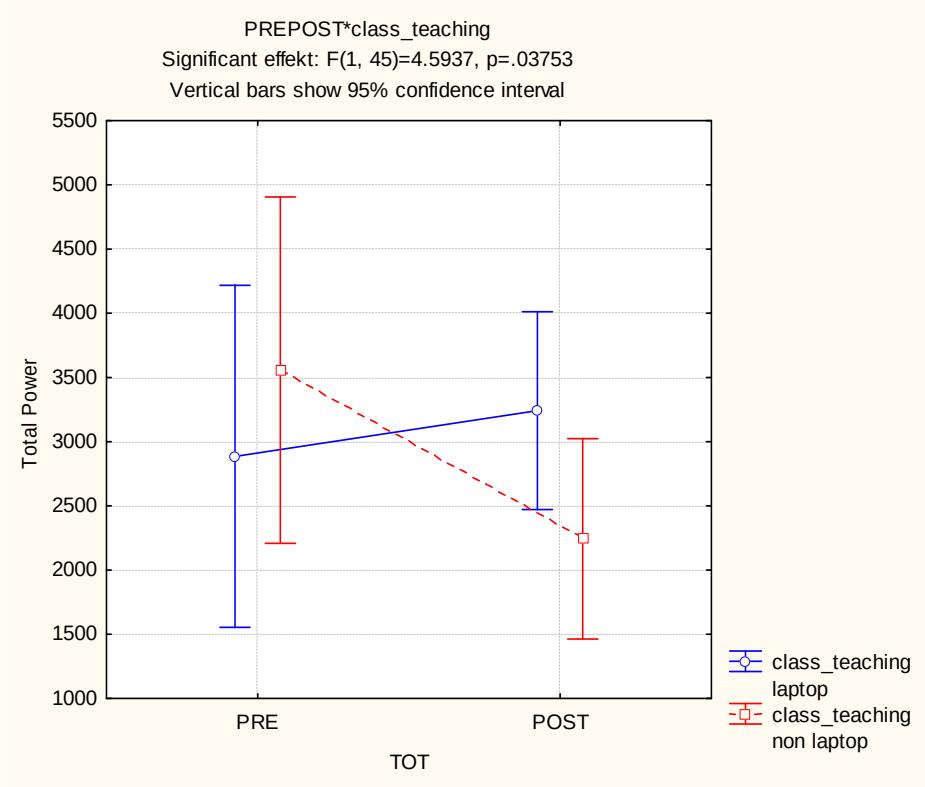

Figure 7.2: 2-way interaction between TOT * teaching style. Total power at pre-test and post-test recording for laptop students and non laptop students.

Table 7.15: Mann-Whitney U-Test: Significant effect of total power (TP) and teaching style for post-test recording.

Baseline TP	Teaching style	N	Mean Rank	**Z**	**Sig.**
Post-test	Laptop class Non laptop class	26 23	29.35 20.09	-2.264	**.024**

7.1.2.4 Log LF/HF

Table 7.16: Log LF/HF: sample size (N), mean value, standard error and confidence interval for the sport groups (RE and PE) and the class (LT and NLT) at pre-test and post-test (TOT) during baseline recordings.

sport education	Class teaching	TOT	N	Mean value	Standard error	95% confidence interval	
						lower limit	upper limit
Rhythmic education	Laptop	1	17	.429	.057	.314	.543
		2	17	.330	.082	.165	.495
	Non laptop	1	11	.534	.071	.392	.676
		2	11	.485	.102	.279	.691
Physical education	Laptop	1	9	.612	.078	.455	.769
		2	9	.527	.113	.300	.754
	Non	1	12	.405	.068	.269	.541

	laptop	2	12	.607	.098	.410	.804

7.1.2.5 Normalized LF

Table 7.17: Normalized LF: sample size (N), mean value, standard error and confidence interval for the sport groups (RE and PE) and the class (LT and NLT) at pre-test and post-test (TOT) during baseline recordings.

Sport education	Class teaching	TOT	N	Mean value	Standard error	95% confidence interval	
						lower limit	upper limit
Rhythmic education	Laptop	1	17	.268	.036	.196	.340
		2	17	.220	.035	.149	.292
	Non laptop	1	11	.258	.045	.169	.348
		2	11	.183	.044	.094	.272
Physical education	Laptop	1	9	.270	.049	.171	.369
		2	9	.154	.049	.056	.252
	Non laptop	1	12	.171	.043	.085	.257
		2	12	.307	.042	.222	.392

7.1.2.6 Normalized HF

Table 7.18: Normalized HF: sample size (N), mean value, standard error and confidence interval for the sport groups (RE and PE) and the class (LT and NLT) at pre-test and post-test (TOT) during baseline recordings.

sport education	Class teaching	TOT	N	Mean value	Standard error	95% confidence interval	
						lower limit	upper limit
Rhythmic education	Laptop	1	17	.109	.014	.080	.138
		2	17	.131	.021	.089	.173
	Non laptop	1	11	.077	.018	.041	.113
		2	11	.085	.026	.033	.137
Physical education	Laptop	1	9	.065	.020	.025	.105
		2	9	.038	.029	-.020	.096
	Non laptop	1	12	.074	.017	.039	.109
		2	12	.074	.025	.024	.124

7.1.3 Atrial mean

Table 7.19: Atrial mean: sample size (N), mean value, standard error and confidence interval for the sport groups (RE and PE) and the class (LT and NLT) at pre-test and post-test (TOT) during baseline recordings.

sport education	Class teaching	TOT	N	Mean value	Standard error	95% confidence interval	
						lower limit	upper limit
Rhythmic education	Laptop	1	17	.129	.007	.114	.144
		2	17	.134	.004	.126	.142
	Non	1	11	.131	.009	.112	.149

	laptop	2	11	.123	.005	.113	.133
Physical education	Laptop	1	9	.137	.010	.116	.157
		2	9	.123	.005	.113	.134
	Non laptop	1	12	.142	.009	.125	.160
		2	12	.134	.005	.124	.144

7.1.3 Atrial median

Table 7.20: Atrial median: sample size (N), mean value, standard error and confidence interval for the sport groups (RE and PE) and the class (LT and NLT) at pre-test and post-test (TOT) during baseline recordings.

sport education	Class teaching	TOT	N	Mean value	Standard error	95% confidence interval	
						lower limit	upper limit
Rhythmic education	Laptop	1	17	.126	.004	.118	.135
		2	17	.131	.004	.123	.140
	Non laptop	1	11	.121	.005	.110	.131
		2	11	.121	.005	.111	.131
Physical education	Laptop	1	9	.128	.006	.116	.140
		2	9	.123	.006	.112	.135
	Non laptop	1	12	.128	.005	.118	.138
		2	12	.130	.005	.120	.139

7.2 Supplementation to results: HRV at fitness condition

7.2.1 Time domain parameters

7.2.1.1 Minimum heart rate

Table 7.21: Minimum HR: sample size (N), mean value, standard error and confidence interval for TOT pre-test (1) and post-test (2) across the fitness condition separated for laptop (LT) and non laptop (NLT) students and rhythmic education (RE) and physical education (PE).

Sport education	Class	TOT	Fitness	N	Mean value	Standard error	95% confidence interval	
							lower limit	upper limit
RE	LT	1	BL1	26	76.732	4.005	68.665	84.799
			BL2	26	78.909	3.560	71.739	86.079
			BL3	26	76.125	3.369	69.340	82.911
			BL4	26	76.296	3.208	69.836	82.757
			BL5	26	75.524	3.646	68.181	82.867
			KB	26	87.767	4.494	78.715	96.819
			R1	26	119.491	5.670	108.071	130.911
			R2	26	88.718	5.349	77.943	99.492
			R3	26	77.386	4.727	67.866	86.907
			R4	26	78.061	4.412	69.174	86.947
			R5	26	79.035	4.066	70.845	87.225
		2	BL1	26	77.060	3.802	69.402	84.718
			BL2	26	74.344	3.411	67.474	81.213
			BL3	26	75.162	3.284	68.549	81.776

			BL4	26	72.930	3.278	66.327	79.533
			BL5	26	72.685	3.289	66.062	79.309
			KB	26	96.757	4.056	88.587	104.927
			R1	26	94.898	5.110	84.606	105.189
			R2	26	80.254	4.444	71.303	89.204
			R3	26	76.350	4.366	67.557	85.143
			R4	26	78.342	4.123	70.037	86.646
			R5	26	77.090	3.862	69.311	84.869
	NLT	1	BL1	23	83.028	4.979	73.000	93.057
			BL2	23	82.856	4.426	73.943	91.770
			BL3	23	83.627	4.188	75.192	92.063
			BL4	23	84.239	3.988	76.208	92.270
			BL5	23	75.190	4.532	66.061	84.319
			KB	23	126.971	5.587	115.718	138.224
			R1	23	105.699	7.049	91.502	119.896
			R2	23	89.897	6.650	76.503	103.291
			R3	23	84.059	5.876	72.224	95.894
			R4	23	83.782	5.485	72.735	94.829
			R5	23	84.418	5.055	74.237	94.600
		2	BL1	23	89.995	4.727	80.475	99.516
			BL2	23	93.889	4.240	85.349	102.429
			BL3	23	90.765	4.082	82.544	98.987
			BL4	23	91.126	4.076	82.918	99.335
			BL5	23	91.195	4.088	82.961	99.429
			KB	23	109.630	5.043	99.473	119.787
			R1	23	93.285	6.352	80.491	106.080
			R2	23	88.620	5.524	77.493	99.747
			R3	23	83.887	5.427	72.957	94.818
			R4	23	87.310	5.126	76.986	97.634
			R5	23	90.142	4.801	80.472	99.812
PE	LT	1	BL1	26	97.717	5.505	86.630	108.804
			BL2	26	96.534	4.893	86.680	106.389
			BL3	26	91.646	4.630	82.320	100.971
			BL4	26	91.966	4.408	83.087	100.844
			BL5	26	91.120	5.011	81.028	101.212
			KB	26	127.889	6.177	115.449	140.329
			R1	26	107.061	7.793	91.366	122.756
			R2	26	91.674	7.352	76.867	106.482
			R3	26	90.480	6.496	77.396	103.564
			R4	26	87.194	6.064	74.981	99.407
			R5	26	89.926	5.589	78.669	101.182
		2	BL1	26	97.623	5.226	87.098	108.149
			BL2	26	93.500	4.688	84.058	102.942
			BL3	26	91.682	4.513	82.593	100.771
			BL4	26	90.982	4.506	81.907	100.057
			BL5	26	91.262	4.520	82.159	100.365
			KB	26	110.019	5.575	98.790	121.247
			R1	26	102.008	7.023	87.863	116.152
			R2	26	91.036	6.107	78.735	103.336
			R3	26	89.980	6.000	77.896	102.064
			R4	26	88.663	5.667	77.250	100.077
			R5	26	87.411	5.308	76.720	98.102
	NLT	1	BL1	23	99.553	4.767	89.952	109.155

			BL2	23	96.005	4.237	87.471	104.539
			BL3	23	95.948	4.010	87.871	104.024
			BL4	23	86.243	3.818	78.553	93.932
			BL5	23	87.359	4.339	78.619	96.099
			KB	23	120.020	5.349	109.246	130.794
			R1	23	104.678	6.749	91.085	118.270
			R2	23	94.584	6.367	81.760	107.408
			R3	23	83.873	5.626	72.542	95.205
			R4	23	85.348	5.251	74.771	95.924
			R5	23	84.770	4.840	75.022	94.518
		2	BL1	23	85.250	4.526	76.135	94.365
			BL2	23	87.151	4.060	78.974	95.328
			BL3	23	85.773	3.908	77.901	93.644
			BL4	23	83.189	3.902	75.330	91.048
			BL5	23	80.253	3.914	72.369	88.136
			KB	23	110.776	4.828	101.052	120.500
			R1	23	83.273	6.082	71.023	95.522
			R2	23	78.401	5.289	67.748	89.054
			R3	23	76.747	5.196	66.281	87.212
			R4	23	76.924	4.907	67.040	86.808
			R5	23	78.030	4.597	68.771	87.289

7.2.1.2 Mean heart rate

Table 7.22: Mean HR: sample size (N), mean value, standard error and confidence interval for TOT pre-test (1) and post-test (2) across the fitness condition separated for laptop (LT) and non laptop (NLT) students and rhythmic education (RE) and physical education (PE).

Sport education	Class	TOT	Fitness	N	Mean value	Standard error	95% confidence interval	
							lower limit	upper limit
RE	LT	1	BL1	26	91.842	3.728	84.334	99.351
			BL2	26	92.446	3.171	86.059	98.833
			BL3	26	91.286	3.035	85.174	97.398
			BL4	26	92.189	3.013	86.121	98.258
			BL5	26	91.016	3.122	84.728	97.304
			KB	26	110.746	3.920	102.851	118.640
			R1	26	146.415	4.470	137.412	155.418
			R2	26	115.392	4.807	105.710	125.074
			R3	26	96.850	4.305	88.179	105.521
			R4	26	92.112	3.943	84.171	100.052
			R5	26	93.230	3.504	86.172	100.288
		2	BL1	26	89.863	3.470	82.875	96.851
			BL2	26	88.029	3.085	81.816	94.242
			BL3	26	88.022	2.861	82.260	93.785
			BL4	26	87.091	2.870	81.310	92.871
			BL5	26	85.948	2.776	80.356	91.539
			KB	26	140.152	3.268	133.569	146.735
			R1	26	122.731	4.740	113.183	132.278
			R2	26	97.811	3.863	90.031	105.592
			R3	26	92.155	3.732	84.639	99.672
			R4	26	93.116	3.538	85.991	100.242

			R5	26	92.914	3.394	86.078	99.749
	NLT	1	BL1	23	96.165	4.635	86.830	105.499
			BL2	23	96.114	3.942	88.174	104.053
			BL3	23	97.133	3.773	89.534	104.731
			BL4	23	98.471	3.746	90.927	106.015
			BL5	23	93.272	3.881	85.455	101.089
			KB	23	151.585	4.873	141.771	161.400
			R1	23	131.451	5.557	120.259	142.643
			R2	23	105.777	5.976	93.741	117.813
			R3	23	96.946	5.352	86.166	107.726
			R4	23	95.565	4.901	85.694	105.437
			R5	23	97.571	4.357	88.796	106.345
		2	BL1	23	105.892	4.313	97.204	114.580
			BL2	23	104.645	3.835	96.921	112.368
			BL3	23	103.117	3.557	95.953	110.281
			BL4	23	101.948	3.568	94.762	109.134
			BL5	23	101.231	3.451	94.280	108.182
			KB	23	135.731	4.063	127.547	143.915
			R1	23	119.462	5.893	107.593	131.331
			R2	23	102.377	4.802	92.705	112.050
			R3	23	98.922	4.639	89.578	108.266
			R4	23	99.257	4.398	90.399	108.115
			R5	23	102.517	4.219	94.019	111.015
PE	LT	1	BL1	26	110.162	5.124	99.843	120.482
			BL2	26	108.250	4.358	99.472	117.028
			BL3	26	104.140	4.171	95.739	112.541
			BL4	26	102.131	4.141	93.791	110.471
			BL5	26	101.849	4.291	93.207	110.491
			KB	26	155.204	5.387	144.354	166.054
			R1	26	132.832	6.143	120.459	145.205
			R2	26	107.273	6.607	93.967	120.580
			R3	26	103.086	5.917	91.168	115.003
			R4	26	101.557	5.418	90.643	112.470
			R5	26	105.552	4.816	95.852	115.253
		2	BL1	26	108.653	4.769	99.049	118.258
			BL2	26	104.224	4.240	95.685	112.763
			BL3	26	101.414	3.932	93.494	109.335
			BL4	26	100.462	3.944	92.518	108.407
			BL5	26	99.986	3.815	92.301	107.670
			KB	26	140.638	4.492	131.590	149.685
			R1	26	126.070	6.515	112.948	139.192
			R2	26	104.454	5.309	93.761	115.148
			R3	26	100.940	5.129	90.610	111.270
			R4	26	99.740	4.862	89.947	109.533
			R5	26	101.031	4.665	91.636	110.426
	NLT	1	BL1	23	115.110	4.437	106.173	124.047
			BL2	23	107.700	3.774	100.098	115.302
			BL3	23	107.606	3.612	100.331	114.881
			BL4	23	102.655	3.586	95.432	109.878
			BL5	23	100.857	3.716	93.373	108.341
			KB	23	144.295	4.665	134.899	153.691
			R1	23	131.249	5.320	120.534	141.965
			R2	23	110.674	5.721	99.151	122.198

			R3	23	101.359	5.124	91.038	111.680
			R4	23	101.571	4.693	92.120	111.022
			R5	23	98.754	4.171	90.353	107.155
		2	BL1	23	98.258	4.130	89.940	106.575
			BL2	23	97.433	3.672	90.038	104.828
			BL3	23	97.891	3.405	91.032	104.750
			BL4	23	96.999	3.416	90.119	103.879
			BL5	23	94.978	3.304	88.322	101.633
			KB	23	136.054	3.890	128.219	143.889
			R1	23	106.238	5.642	94.874	117.602
			R2	23	96.649	4.598	87.388	105.910
			R3	23	94.103	4.442	85.156	103.049
			R4	23	94.392	4.211	85.911	102.873
			R5	23	96.081	4.040	87.945	104.217

Table 7.23: Mann-Whitney U-Test: Significant effect of mean HR and sport education for pre-test and recording.

Baseline_1 Mean HR	Sport education	N	Mean Rank	**Z**	**Sig.**
Pre-test	Rhythmic education Physical education	28 21	18.32 33.90	-3.778	**.000**
Baseline_2 Mean HR	Sport education	N	Mean Rank	**Z**	**Sig.**
Pre-test	Rhythmic education Physical education	28 21	19.07 32.90	-3.354	**.001**
Baseline_3 Mean HR	Sport education	N	Mean Rank	**Z**	**Sig.**
Pre-test	Rhythmic education Physical education	28 21	19.14 32.81	-3.313	**.001**
Baseline_4 Mean HR	Sport education	N	Mean Rank	**Z**	**Sig.**
Pre-test	Rhythmic education Physical education	28 21	21.14 30.14	-2.182	**.029**
Baseline_5 Mean HR	Sport education	N	Mean Rank	**Z**	**Sig.**
Pre-test	Rhythmic education Physical education	28 21	20.61 30.86	-2.485	**.013**
Knee bending Mean HR	Sport education	N	Mean Rank	**Z**	**Sig.**
Pre-test	Rhythmic education Physical education	28 21	19.80 31.93	-2.940	**.003**

Table 7.24: Mann-Whitney U-Test: Significant effect of mean HR and teaching style at pre-test and post-test recording.

KB exercise Mean HR	Teaching style	N	Mean Rank	**Z**	**Sig.**
Pre-test	Laptop class Non laptop class	26 23	19.13 31.63	-3.055	**.002**
Baseline_3 Mean HR	Teaching style	N	Mean Rank	**Z**	**Sig.**

Post-test	Laptop class Non laptop class	26 23	20.77 29.78	-2.204	**.028**
Baseline_4 Mean HR	Teaching style	N	Mean Rank	**Z**	**Sig.**
Post-test	Laptop class Non laptop class	26 23	21.00 29.52	-2.083	**.037**
Baseline_5 Mean HR	Teaching style	N	Mean Rank	**Z**	**Sig.**
Post-test	Laptop class Non laptop class	26 23	20.77 29.78	-2.204	**.028**

7.2.1.3 Maximum heart rate

Table 7.25: Maximum HR: sample size (N), mean value, standard error and confidence interval for TOT pre-test (1) and post-test (2) across the fitness condition separated for laptop (LT) and non laptop (NLT) students and rhythmic education (RE) and physical education (PE).

Sport education	Class	TOT	Fitness	N	Mean value	Standard error	95% confidence interval	
							lower limit	upper limit
RE	LT	1	BL1	26	107.158	3.832	99.441	114.875
			BL2	26	108.980	3.056	102.825	115.135
			BL3	26	107.091	3.305	100.434	113.748
			BL4	26	108.894	3.264	102.320	115.467
			BL5	26	107.324	3.282	100.713	113.934
			KB	26	139.135	4.431	130.211	148.059
			R1	26	175.036	5.753	163.448	186.624
			R2	26	142.248	4.975	132.228	152.268
			R3	26	115.559	4.220	107.059	124.058
			R4	26	107.406	4.105	99.139	115.673
			R5	26	107.185	3.307	100.525	113.846
		2	BL1	26	106.795	4.348	98.037	115.553
			BL2	26	102.976	3.696	95.533	110.419
			BL3	26	102.236	2.510	97.180	107.292
			BL4	26	99.994	3.168	93.613	106.375
			BL5	26	99.722	2.751	94.181	105.263
			KB	26	182.358	4.923	172.442	192.273
			R1	26	157.291	6.028	145.150	169.432
			R2	26	115.208	3.413	108.335	122.082
			R3	26	108.599	3.243	102.068	115.131
			R4	26	107.230	3.312	100.560	113.900
			R5	26	107.321	3.134	101.009	113.634
	NLT	1	BL1	23	113.025	4.763	103.432	122.619
			BL2	23	111.944	3.799	104.292	119.595
			BL3	23	110.501	4.109	102.225	118.776
			BL4	23	115.018	4.057	106.846	123.190
			BL5	23	111.265	4.080	103.047	119.483
			KB	23	175.761	5.508	164.667	186.855
			R1	23	161.991	7.152	147.585	176.397
			R2	23	124.992	6.185	112.535	137.448
			R3	23	113.842	5.246	103.276	124.408
			R4	23	110.321	5.103	100.044	120.598

			R5	23	113.590	4.111	105.310	121.870
		2	BL1	23	126.130	5.406	115.242	137.018
			BL2	23	117.656	4.594	108.403	126.910
			BL3	23	115.751	3.121	109.465	122.037
			BL4	23	113.305	3.939	105.371	121.238
			BL5	23	111.296	3.420	104.408	118.184
			KB	23	162.497	6.120	150.170	174.824
			R1	23	151.232	7.494	136.139	166.325
			R2	23	118.486	4.242	109.942	127.031
			R3	23	112.956	4.031	104.837	121.076
			R4	23	114.675	4.117	106.384	122.967
			R5	23	117.171	3.896	109.323	125.018
PE	LT	1	BL1	26	123.549	5.266	112.943	134.155
			BL2	26	121.919	4.200	113.459	130.378
			BL3	26	115.117	4.542	105.968	124.266
			BL4	26	112.931	4.485	103.897	121.965
			BL5	26	113.489	4.511	104.404	122.574
			KB	26	182.652	6.089	170.387	194.917
			R1	26	157.904	7.907	141.978	173.831
			R2	26	124.620	6.837	110.849	138.391
			R3	26	119.132	5.800	107.451	130.814
			R4	26	119.286	5.641	107.924	130.647
			R5	26	119.153	4.545	109.999	128.308
		2	BL1	26	124.232	5.976	112.195	136.269
			BL2	26	115.420	5.079	105.190	125.650
			BL3	26	113.766	3.450	106.816	120.715
			BL4	26	111.357	4.354	102.586	120.127
			BL5	26	113.690	3.781	106.075	121.305
			KB	26	167.104	6.766	153.476	180.732
			R1	26	161.458	8.284	144.772	178.144
			R2	26	120.772	4.690	111.326	130.219
			R3	26	112.823	4.457	103.847	121.800
			R4	26	112.850	4.551	103.683	122.017
			R5	26	113.697	4.308	105.021	122.372
	NLT	1	BL1	23	129.228	4.560	120.043	138.414
			BL2	23	118.020	3.637	110.694	125.346
			BL3	23	123.219	3.934	115.296	131.142
			BL4	23	115.368	3.885	107.545	123.192
			BL5	23	112.845	3.907	104.977	120.713
			KB	23	171.646	5.274	161.024	182.268
			R1	23	160.276	6.848	146.483	174.068
			R2	23	125.613	5.921	113.686	137.539
			R3	23	117.070	5.023	106.954	127.186
			R4	23	117.960	4.885	108.120	127.800
			R5	23	110.383	3.936	102.455	118.310
		2	BL1	23	116.113	5.176	105.689	126.538
			BL2	23	110.164	4.399	101.305	119.024
			BL3	23	109.662	2.988	103.643	115.680
			BL4	23	112.598	3.771	105.003	120.194
			BL5	23	110.141	3.274	103.546	116.736
			KB	23	164.472	5.860	152.669	176.274
			R1	23	131.053	7.175	116.603	145.504
			R2	23	115.393	4.062	107.212	123.574

			R3	23	109.893	3.860	102.120	117.667
			R4	23	110.978	3.942	103.039	118.916
			R5	23	113.849	3.730	106.336	121.363

7.2.1.4 SDNN

Table 7.26: SDNN: sample size (N), mean value, standard error and confidence interval for TOT pre-test (1) and post-test (2) across the fitness condition separated for laptop (LT) and non laptop (NLT) students and rhythmic education (RE) and physical education (PE).

Sport education	Class	TOT	Fitness	N	Mean value	Standard error	95% confidence interval	
							lower limit	upper limit
RE	LT	1	BL1	26	50.306	4.907	40.423	60.189
			BL2	26	48.082	4.360	39.301	56.863
			BL3	26	52.471	4.322	43.765	61.176
			BL4	26	51.888	4.168	43.494	60.283
			BL5	26	55.541	5.624	44.215	66.868
			KB	26	71.271	5.315	60.566	81.976
			R1	26	33.924	5.763	22.316	45.531
			R2	26	65.671	7.775	50.012	81.329
			R3	26	62.600	8.205	46.075	79.125
			R4	26	47.871	7.265	33.237	62.504
			R5	26	44.935	5.841	33.171	56.700
		2	BL1	26	48.324	5.347	37.555	59.092
			BL2	26	49.718	5.143	39.358	60.077
			BL3	26	49.365	5.139	39.015	59.714
			BL4	26	48.653	4.419	39.752	57.554
			BL5	26	50.994	5.118	40.685	61.303
			KB	26	61.871	4.156	53.499	70.242
			R1	26	61.212	6.796	47.523	74.900
			R2	26	51.594	8.348	34.780	68.408
			R3	26	51.900	7.408	36.979	66.821
			R4	26	44.876	6.411	31.963	57.790
			R5	26	50.476	6.700	36.982	63.971
	NLT	1	BL1	23	51.464	6.100	39.177	63.750
			BL2	23	49.009	5.420	38.093	59.925
			BL3	23	45.091	5.373	34.269	55.913
			BL4	23	48.655	5.181	38.219	59.090
			BL5	23	67.045	6.991	52.965	81.126
			KB	23	34.655	6.607	21.346	47.963
			R1	23	54.545	7.164	40.116	68.975
			R2	23	55.482	9.665	36.015	74.948
			R3	23	51.018	10.200	30.474	71.562
			R4	23	49.600	9.032	31.409	67.791
			R5	23	48.727	7.261	34.102	63.352
		2	BL1	23	45.209	6.647	31.822	58.597
			BL2	23	28.527	6.394	15.649	41.406
			BL3	23	31.418	6.388	18.552	44.284
			BL4	23	28.718	5.494	17.653	39.783
			BL5	23	26.482	6.363	13.666	39.297
			KB	23	39.636	5.167	29.230	50.043
			R1	23	64.818	8.449	47.801	81.835

			R2	23	48.682	10.378	27.779	69.585
			R3	23	48.582	9.210	30.032	67.132
			R4	23	39.500	7.970	23.447	55.553
			R5	23	40.727	8.329	23.951	57.503
PE	LT	1	BL1	26	29.700	6.744	16.117	43.283
			BL2	26	31.822	5.992	19.754	43.890
			BL3	26	32.067	5.940	20.103	44.031
			BL4	26	29.233	5.728	17.696	40.770
			BL5	26	31.800	7.729	16.233	47.367
			KB	26	29.511	7.305	14.798	44.224
			R1	26	48.356	7.921	32.403	64.308
			R2	26	49.244	10.685	27.724	70.765
			R3	26	47.856	11.277	25.143	70.568
			R4	26	46.222	9.985	26.111	66.334
			R5	26	42.956	8.028	26.787	59.124
		2	BL1	26	31.089	7.348	16.289	45.889
			BL2	26	31.478	7.069	17.240	45.716
			BL3	26	34.622	7.062	20.398	48.846
			BL4	26	29.122	6.074	16.889	41.355
			BL5	26	27.844	7.034	13.676	42.013
			KB	26	44.156	5.712	32.650	55.661
			R1	26	59.222	9.341	40.409	78.035
			R2	26	44.456	11.474	21.347	67.564
			R3	26	36.200	10.182	15.692	56.708
			R4	26	33.578	8.812	15.830	51.325
			R5	26	43.478	9.208	24.931	62.024
	NLT	1	BL1	23	30.325	5.840	18.562	42.088
			BL2	23	25.808	5.189	15.357	36.260
			BL3	23	28.158	5.144	17.797	38.520
			BL4	23	37.583	4.961	27.592	47.575
			BL5	23	40.383	6.693	26.902	53.864
			KB	23	37.910	6.326	25.168	50.652
			R1	23	46.092	6.859	32.276	59.907
			R2	23	34.808	9.254	16.171	53.446
			R3	23	43.667	9.766	23.997	63.336
			R4	23	47.133	8.647	29.716	64.550
			R5	23	40.175	6.952	26.172	54.178
		2	BL1	23	45.425	6.364	32.608	58.242
			BL2	23	34.350	6.122	22.020	46.680
			BL3	23	33.517	6.116	21.198	45.835
			BL4	23	36.900	5.260	26.306	47.494
			BL5	23	46.000	6.092	33.730	58.270
			KB	23	43.950	4.947	33.986	53.914
			R1	23	61.375	8.089	45.083	77.667
			R2	23	66.650	9.936	46.637	86.663
			R3	23	58.350	8.818	40.590	76.110
			R4	23	60.875	7.631	45.505	76.245
			R5	23	59.825	7.975	43.763	75.887

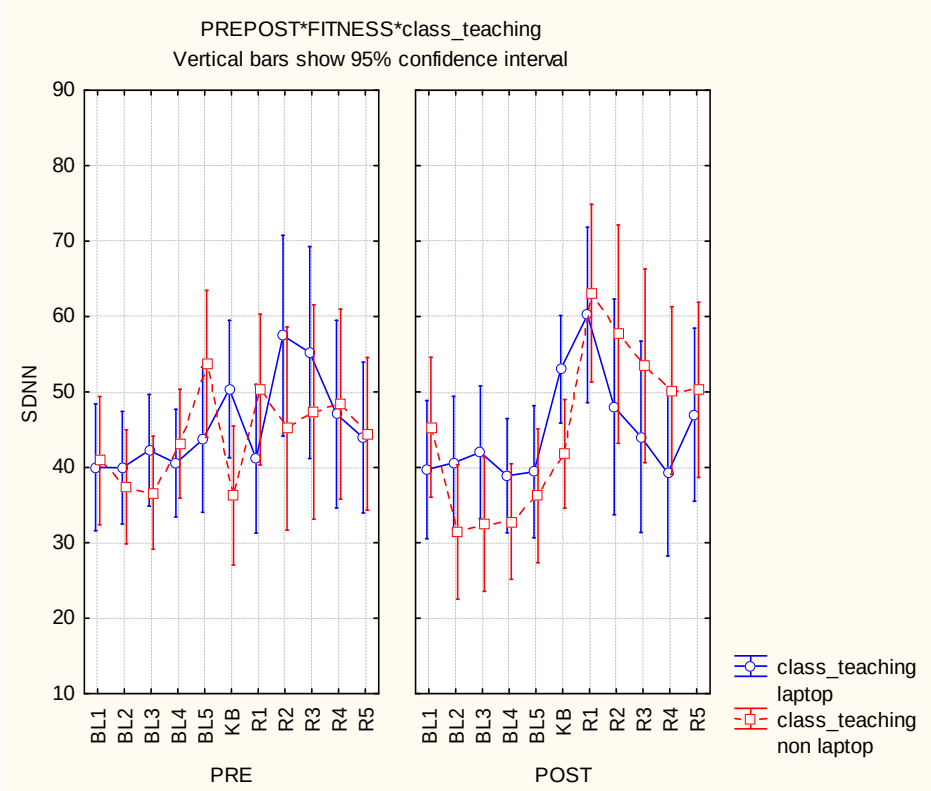

Figure 7.3: Significant 3-way interaction graph: SDNN during fitness condition for laptop and non laptop students demonstrated for pre-test and post-test recordings.

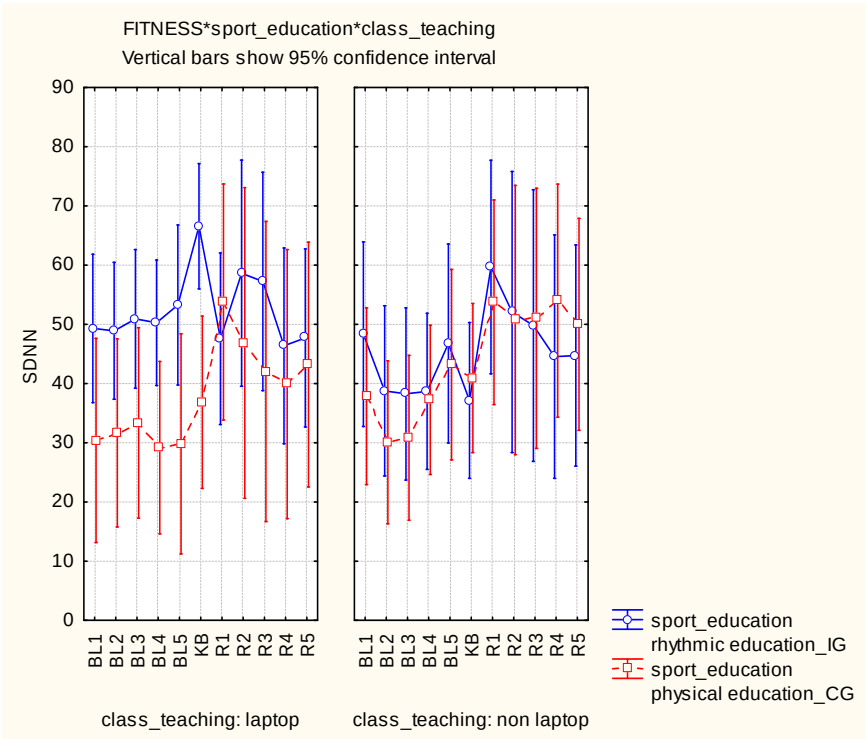

Figure 7.4: Significant 3-way interaction graph: SDNN during fitness condition for laptop and non laptop students demonstrated for rhythmic education group (RE) and physical education group (PE).

7.2.1.5 r-MSSD

Table 7.27: r-MSSD: sample size (N), mean value, standard error and confidence interval for TOT pre-test (1) and post-test (2) across the fitness condition separated for laptop (LT) and non laptop (NLT) students and rhythmic education (RE) and physical education (PE).

Sport education	Class	TOT	Fitness	N	Mean value	Standard error	95% confidence interval	
							lower limit	upper limit
RE	LT	1	BL1	26	34.465	3.824	26.763	42.166
			BL2	26	31.253	3.290	24.627	37.879
			BL3	26	31.347	3.118	25.066	37.628
			BL4	26	35.029	3.799	27.378	42.681
			BL5	26	37.382	4.099	29.127	45.638
			KB	26	28.865	2.233	24.368	33.362
			R1	26	18.482	2.826	12.790	24.174
			R2	26	34.718	7.179	20.259	49.176
			R3	26	44.282	6.784	30.619	57.946
			R4	26	38.629	6.299	25.943	51.315
			R5	26	31.418	4.828	21.694	41.141
		2	BL1	26	36.394	3.621	29.100	43.688
			BL2	26	38.229	4.086	29.999	46.460
			BL3	26	35.876	3.583	28.659	43.094
			BL4	26	37.106	3.123	30.815	43.397
			BL5	26	37.547	3.702	30.090	45.004
			KB	26	29.259	2.229	24.770	33.748
			R1	26	23.624	4.534	14.492	32.755
			R2	26	46.018	7.332	31.251	60.784
			R3	26	47.053	6.818	33.320	60.786
			R4	26	38.394	5.802	26.708	50.081
			R5	26	35.024	5.185	24.581	45.466
	NLT	1	BL1	23	33.009	4.754	23.435	42.583
			BL2	23	31.882	4.090	23.645	40.119
			BL3	23	26.845	3.877	19.037	34.654
			BL4	23	27.736	4.723	18.224	37.249
			BL5	23	38.609	5.095	28.347	48.872
			KB	23	16.009	2.776	10.419	21.599
			R1	23	19.564	3.513	12.487	26.640
			R2	23	39.582	8.924	21.608	57.556
			R3	23	43.591	8.433	26.605	60.577
			R4	23	40.691	7.830	24.920	56.462
			R5	23	37.045	6.002	24.957	49.134
		2	BL1	23	22.627	4.502	13.560	31.695
			BL2	23	20.673	5.080	10.441	30.905
			BL3	23	19.745	4.455	10.773	28.718
			BL4	23	19.273	3.883	11.452	27.093
			BL5	23	18.455	4.602	9.185	27.724
			KB	23	19.136	2.771	13.556	24.717
			R1	23	30.855	5.636	19.502	42.207
			R2	23	38.818	9.114	20.461	57.175
			R3	23	36.664	8.476	19.591	53.736
			R4	23	29.936	7.213	15.408	44.465

			R5	23	26.673	6.446	13.691	39.655
PE	LT	1	BL1	26	19.856	5.255	9.271	30.440
			BL2	26	18.733	4.521	9.627	27.840
			BL3	26	18.589	4.286	9.957	27.221
			BL4	26	19.722	5.221	9.206	30.239
			BL5	26	19.356	5.633	8.010	30.701
			KB	26	18.978	3.069	12.797	25.158
			R1	26	20.356	3.884	12.533	28.179
			R2	26	41.500	9.866	21.629	61.371
			R3	26	39.722	9.323	20.944	58.501
			R4	26	36.222	8.657	18.787	53.658
			R5	26	28.833	6.635	15.469	42.197
		2	BL1	26	18.689	4.977	8.665	28.713
			BL2	26	19.156	5.616	7.844	30.467
			BL3	26	20.422	4.925	10.503	30.342
			BL4	26	20.033	4.293	11.387	28.679
			BL5	26	21.067	5.088	10.818	31.315
			KB	26	20.033	3.063	13.864	26.203
			R1	26	22.678	6.231	10.127	35.228
			R2	26	34.122	10.076	13.828	54.417
			R3	26	30.367	9.371	11.493	49.241
			R4	26	30.078	7.975	14.016	46.139
			R5	26	28.000	7.126	13.648	42.352
	NLT	1	BL1	23	17.958	4.551	8.792	27.125
			BL2	23	15.108	3.916	7.222	22.995
			BL3	23	19.608	3.712	12.132	27.084
			BL4	23	23.442	4.522	14.334	32.549
			BL5	23	23.383	4.878	13.558	33.209
			KB	23	21.510	2.657	16.158	26.862
			R1	23	18.850	3.364	12.075	25.625
			R2	23	23.533	8.544	6.324	40.742
			R3	23	30.058	8.074	13.796	46.321
			R4	23	28.300	7.497	13.201	43.399
			R5	23	24.792	5.746	13.218	36.365
		2	BL1	23	25.867	4.310	17.185	34.548
			BL2	23	24.558	4.864	14.762	34.355
			BL3	23	22.033	4.265	13.443	30.624
			BL4	23	23.567	3.718	16.079	31.054
			BL5	23	24.775	4.407	15.900	33.650
			KB	23	19.958	2.653	14.615	25.301
			R1	23	38.400	5.396	27.531	49.269
			R2	23	39.583	8.726	22.008	57.159
			R3	23	36.500	8.116	20.155	52.845
			R4	23	35.717	6.906	21.807	49.627
			R5	23	37.525	6.171	25.096	49.954

7.2.1.9 pNN50

Table 7.28: pNN50: sample size (N), mean value, standard error and confidence interval for TOT pre-test (1) and post-test (2) across the fitness condition separated for laptop (LT) and non laptop (NLT) students and rhythmic education (RE) and physical education (PE).

Sport education	Class	TOT	Fitness	N	Mean value	Standard error	95% confidence interval	
							lower limit	upper limit
RE	LT	1	BL1	26	14.073	2.827	8.378	19.768
			BL2	26	11.754	2.487	6.745	16.762
			BL3	26	11.269	2.413	6.409	16.130
			BL4	26	12.584	2.273	8.006	17.162
			BL5	26	13.888	2.547	8.758	19.017
			KB	26	9.984	1.747	6.466	13.503
			R1	26	3.859	1.085	1.673	6.045
			R2	26	13.981	4.654	4.607	23.354
			R3	26	19.254	5.085	9.012	29.496
			R4	26	18.587	4.666	9.189	27.985
			R5	26	12.289	3.497	5.246	19.333
		2	BL1	26	18.285	2.919	12.406	24.163
			BL2	26	18.912	3.192	12.483	25.341
			BL3	26	16.565	3.023	10.475	22.654
			BL4	26	17.577	2.405	12.733	22.422
			BL5	26	16.999	2.753	11.455	22.543
			KB	26	10.466	1.584	7.275	13.657
			R1	26	5.489	2.792	-.135	11.113
			R2	26	22.645	5.197	12.178	33.113
			R3	26	23.288	4.968	13.282	33.293
			R4	26	17.726	4.437	8.790	26.663
			R5	26	13.011	3.753	5.451	20.570
	NLT	1	BL1	23	15.733	3.515	8.653	22.812
			BL2	23	13.860	3.091	7.634	20.086
			BL3	23	10.538	3.000	4.496	16.580
			BL4	23	9.959	2.825	4.268	15.650
			BL5	23	15.947	3.166	9.570	22.324
			KB	23	3.578	2.172	-.796	7.952
			R1	23	4.961	1.349	2.244	7.678
			R2	23	20.046	5.786	8.394	31.699
			R3	23	24.037	6.322	11.305	36.770
			R4	23	21.910	5.801	10.226	33.594
			R5	23	18.615	4.348	9.858	27.371
		2	BL1	23	5.845	3.628	-1.463	13.152
			BL2	23	4.443	3.968	-3.550	12.435
			BL3	23	3.974	3.759	-3.597	11.544
			BL4	23	3.786	2.990	-2.236	9.809
			BL5	23	3.493	3.422	-3.399	10.385
			KB	23	4.875	1.970	.908	8.843
			R1	23	11.271	3.471	4.279	18.262
			R2	23	18.825	6.461	5.811	31.838
			R3	23	18.295	6.175	5.857	30.734
			R4	23	14.840	5.516	3.731	25.949
			R5	23	9.217	4.666	-.181	18.615
PE	LT	1	BL1	26	5.703	3.886	-2.123	13.530
			BL2	26	4.411	3.418	-2.472	11.295
			BL3	26	5.800	3.316	-.880	12.480
			BL4	26	6.688	3.124	.396	12.979
			BL5	26	6.264	3.500	-.785	13.314
			KB	26	5.763	2.401	.927	10.599
			R1	26	4.422	1.492	1.418	7.426

			R2	26	21.091	6.396	8.209	33.974
			R3	26	23.009	6.989	8.932	37.085
			R4	26	18.868	6.413	5.951	31.785
			R5	26	11.257	4.806	1.576	20.937
		2	BL1	26	5.510	4.011	-2.569	13.589
			BL2	26	6.430	4.387	-2.406	15.266
			BL3	26	7.118	4.155	-1.252	15.487
			BL4	26	6.849	3.306	.191	13.507
			BL5	26	6.687	3.783	-.933	14.306
			KB	26	4.589	2.178	.203	8.975
			R1	26	6.430	3.838	-1.299	14.159
			R2	26	16.678	7.143	2.291	31.064
			R3	26	15.662	6.827	1.911	29.413
			R4	26	14.443	6.098	2.162	26.725
			R5	26	11.808	5.159	1.418	22.198
	NLT	1	BL1	23	3.142	3.365	-3.637	9.920
			BL2	23	1.799	2.960	-4.162	7.761
			BL3	23	3.363	2.872	-2.422	9.147
			BL4	23	5.554	2.705	.106	11.003
			BL5	23	5.519	3.031	-.586	11.624
			KB	23	7.731	2.079	3.543	11.919
			R1	23	4.036	1.292	1.434	6.637
			R2	23	7.763	5.539	-3.394	18.919
			R3	23	11.131	6.053	-1.060	23.321
			R4	23	9.680	5.554	-1.506	20.866
			R5	23	7.943	4.162	-.441	16.326
		2	BL1	23	9.138	3.474	2.142	16.135
			BL2	23	7.419	3.799	-.233	15.071
			BL3	23	6.745	3.599	-.503	13.993
			BL4	23	6.685	2.863	.919	12.451
			BL5	23	9.042	3.276	2.443	15.640
			KB	23	6.402	1.886	2.603	10.200
			R1	23	16.790	3.323	10.096	23.484
			R2	23	16.311	6.186	3.852	28.770
			R3	23	15.904	5.913	3.996	27.813
			R4	23	15.061	5.281	4.425	25.697
			R5	23	15.903	4.467	6.905	24.900

7.2.2 Frequency domain parameters

7.2.2.1 LF power

Table 7.29: LF power: sample size (N), mean value, standard error and confidence interval for TOT pre-test (1) and post-test (2) across the fitness condition separated for laptop (LT) and non laptop (NLT) students and rhythmic education (RE) and physical education (PE).

Sport education	Class	TOT	Fitness	N	Mean value	Standard error	95% confidence interval	
							lower limit	upper limit
RE	LT	1	BL1	26	445.647	72.830	298.959	592.335
			BL2	26	507.449	85.837	334.566	680.333
			BL3	26	610.376	101.330	406.286	814.467

			BL4	26	602.800	116.250	368.660	836.940
			BL5	26	709.482	136.933	433.685	985.280
			KB	26	550.241	87.178	374.656	725.826
			R1	26	222.236	40.910	139.839	304.633
			R2	26	179.144	93.159	-8.488	366.777
			R3	26	827.389	185.248	454.281	1200.498
			R4	26	572.704	154.125	262.281	883.126
			R5	26	493.165	130.556	230.211	756.118
		2	BL1	26	473.371	91.784	288.508	658.233
			BL2	26	505.229	109.322	285.044	725.415
			BL3	26	344.493	54.496	234.731	454.254
			BL4	26	507.549	80.253	345.910	669.188
			BL5	26	462.853	75.251	311.289	614.417
			KB	26	593.528	124.935	341.895	845.161
			R1	26	203.971	86.604	29.540	378.401
			R2	26	408.229	145.430	115.319	701.140
			R3	26	476.147	146.403	181.276	771.018
			R4	26	459.600	132.818	192.090	727.110
			R5	26	375.859	128.726	116.591	635.126
	NLT	1	BL1	23	475.136	90.540	292.779	657.494
			BL2	23	370.785	106.709	155.863	585.708
			BL3	23	547.725	125.970	294.007	801.442
			BL4	23	475.473	144.518	184.398	766.548
			BL5	23	961.472	170.230	618.611	1304.333
			KB	23	285.400	108.376	67.119	503.681
			R1	23	75.345	50.858	-27.087	177.778
			R2	23	454.309	115.812	221.051	687.567
			R3	23	725.636	230.293	261.802	1189.471
			R4	23	484.618	191.602	98.712	870.525
			R5	23	536.373	162.302	209.479	863.267
		2	BL1	23	329.100	114.103	99.286	558.914
			BL2	23	222.264	135.905	-51.463	495.990
			BL3	23	185.482	67.748	49.030	321.933
			BL4	23	262.818	99.768	61.875	463.761
			BL5	23	199.064	93.550	10.645	387.482
			KB	23	308.164	155.315	-4.657	620.984
			R1	23	279.527	107.663	62.682	496.372
			R2	23	540.018	180.793	175.883	904.153
			R3	23	596.424	182.003	229.851	962.997
			R4	23	532.028	165.115	199.470	864.587
			R5	23	445.427	160.027	123.116	767.739
PE	LT	1	BL1	26	274.522	100.096	72.919	476.126
			BL2	26	307.200	117.971	69.594	544.806
			BL3	26	369.100	139.265	88.605	649.595
			BL4	26	272.278	159.771	-49.518	594.073
			BL5	26	275.644	188.197	-103.403	654.692
			KB	26	268.078	119.814	26.760	509.396
			R1	26	51.222	56.225	-62.021	164.466
			R2	26	303.727	128.035	45.850	561.603
			R3	26	500.500	254.599	-12.288	1013.288
			R4	26	704.778	211.824	278.142	1131.413
			R5	26	379.257	179.432	17.862	740.651
		2	BL1	26	154.989	126.145	-99.081	409.058

			BL2	26	243.300	150.249	-59.316	545.916
			BL3	26	172.642	74.898	21.789	323.495
			BL4	26	219.961	110.298	-2.190	442.112
			BL5	26	232.300	103.423	23.996	440.604
			KB	26	386.256	171.707	40.419	732.092
			R1	26	105.656	119.026	-134.076	345.387
			R2	26	387.822	199.874	-14.744	790.389
			R3	26	399.822	201.212	-5.439	805.084
			R4	26	295.267	182.541	-72.391	662.924
			R5	26	404.011	176.917	47.682	760.340
	NLT	1	BL1	23	141.713	86.686	-32.880	316.307
			BL2	23	179.683	102.166	-26.090	385.456
			BL3	23	195.633	120.607	-47.282	438.549
			BL4	23	220.367	138.366	-58.316	499.050
			BL5	23	315.833	162.983	-12.431	644.098
			KB	23	216.650	103.762	7.662	425.638
			R1	23	137.725	48.693	39.653	235.797
			R2	23	217.495	110.882	-5.832	440.822
			R3	23	343.268	220.489	-100.820	787.355
			R4	23	609.096	183.445	239.619	978.573
			R5	23	378.058	155.393	65.080	691.035
		2	BL1	23	352.543	109.245	132.512	572.573
			BL2	23	452.317	130.119	190.243	714.390
			BL3	23	235.107	64.864	104.464	365.749
			BL4	23	321.900	95.521	129.511	514.289
			BL5	23	322.698	89.567	142.301	503.095
			KB	23	487.667	148.703	188.164	787.170
			R1	23	312.375	103.080	104.762	519.988
			R2	23	593.095	173.096	244.462	941.728
			R3	23	738.550	174.255	387.583	1089.517
			R4	23	739.663	158.085	421.262	1058.063
			R5	23	812.804	153.215	504.214	1121.394

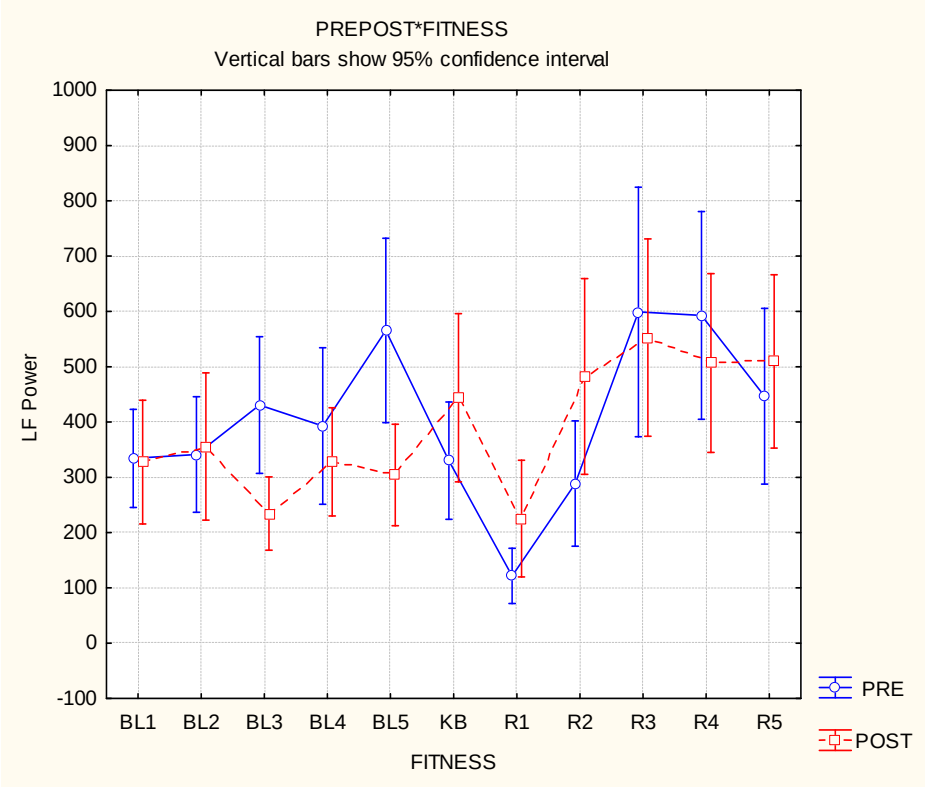

Figure 7.5: 2-way interaction between Fitness * TOT. Low frequency power across the fitness condition demonstrated for pre- and post-test recordings.

7.2.2.2 HF power

Table 7.30: HF power: sample size (N), mean value, standard error and confidence interval for TOT pre-test (1) and post-test (2) across the fitness condition separated for laptop (LT) and non laptop (NLT) students and rhythmic education (RE) and physical education (PE).

Sport education	Class	TOT	Fitness	N	Mean value	Standard error	95% confidence interval	
							lower limit	upper limit
RE	LT	1	BL1	26	319.306	50.067	218.466	420.146
			BL2	26	248.231	38.687	170.311	326.150
			BL3	26	227.547	37.098	152.829	302.265
			BL4	26	206.808	38.622	129.018	284.597
			BL5	26	264.647	54.407	155.066	374.228
			KB	26	145.447	20.900	103.353	187.541
			R1	26	52.600	12.665	27.092	78.108
			R2	26	178.209	72.708	31.767	324.651
			R3	26	276.729	113.218	48.696	504.763
			R4	26	250.727	83.296	82.960	418.494
			R5	26	233.086	76.329	79.351	386.822
		2	BL1	26	221.482	42.800	135.279	307.686
			BL2	26	305.576	56.741	191.294	419.859
			BL3	26	280.535	45.852	188.185	372.885
			BL4	26	273.241	46.209	180.171	366.311
			BL5	26	293.600	51.294	190.288	396.912

			KB	26	149.829	30.152	89.101	210.558
			R1	26	74.971	39.596	-4.780	154.721
			R2	26	271.000	82.261	105.318	436.682
			R3	26	450.688	119.495	210.012	691.364
			R4	26	354.712	87.842	177.789	531.635
			R5	26	250.447	82.037	85.217	415.677
	NLT	1	BL1	23	174.664	62.242	49.303	300.025
			BL2	23	142.691	48.094	45.825	239.557
			BL3	23	186.946	46.118	94.059	279.834
			BL4	23	164.940	48.014	68.235	261.645
			BL5	23	319.601	67.637	183.373	455.828
			KB	23	63.491	25.982	11.161	115.821
			R1	23	31.727	15.744	.016	63.438
			R2	23	176.173	90.388	-5.878	358.224
			R3	23	438.027	140.749	154.544	721.510
			R4	23	436.687	103.551	228.125	645.249
			R5	23	310.827	94.890	119.709	501.945
		2	BL1	23	90.382	53.207	-16.783	197.547
			BL2	23	119.645	70.539	-22.426	261.717
			BL3	23	57.845	57.001	-56.960	172.651
			BL4	23	87.255	57.446	-28.447	202.956
			BL5	23	89.273	63.767	-39.161	217.706
			KB	23	113.936	37.483	38.441	189.432
			R1	23	156.936	49.224	57.794	256.079
			R2	23	344.491	102.264	138.521	550.461
			R3	23	454.936	148.552	155.737	754.136
			R4	23	261.453	109.202	41.509	481.397
			R5	23	226.300	101.985	20.892	431.708
PE	LT	1	BL1	26	71.667	68.811	-66.925	210.258
			BL2	26	64.344	53.170	-42.745	171.434
			BL3	26	110.267	50.986	7.576	212.957
			BL4	26	90.478	53.081	-16.434	197.389
			BL5	26	83.611	74.775	-66.994	234.216
			KB	26	58.551	28.724	.698	116.404
			R1	26	32.522	17.406	-2.536	67.580
			R2	26	259.722	99.928	58.457	460.987
			R3	26	550.322	155.604	236.920	863.724
			R4	26	356.956	114.480	126.381	587.530
			R5	26	330.244	104.905	118.955	541.534
		2	BL1	26	48.844	58.823	-69.631	167.320
			BL2	26	78.522	77.983	-78.544	235.589
			BL3	26	120.344	63.017	-6.578	247.267
			BL4	26	108.911	63.509	-19.002	236.824
			BL5	26	124.778	70.497	-17.211	266.767
			KB	26	69.811	41.439	-13.652	153.274
			R1	26	36.456	54.419	-73.151	146.062
			R2	26	167.689	113.057	-60.019	395.397
			R3	26	240.589	164.231	-90.189	571.367
			R4	26	209.567	120.727	-33.590	452.724
			R5	26	199.489	112.749	-27.598	426.576
	NLT	1	BL1	23	52.933	59.592	-67.092	172.957
			BL2	23	51.500	46.046	-41.242	144.242
			BL3	23	52.475	44.155	-36.458	141.408

			BL4	23	99.000	45.970	6.412	191.588
			BL5	23	254.942	64.757	124.514	385.370
			KB	23	51.833	24.876	1.731	101.935
			R1	23	47.808	15.074	17.447	78.169
			R2	23	94.317	86.540	-79.984	268.617
			R3	23	192.671	134.757	-78.743	464.085
			R4	23	184.784	99.142	-14.899	384.467
			R5	23	142.177	90.850	-40.805	325.158
		2	BL1	23	129.258	50.942	26.656	231.861
			BL2	23	147.883	67.535	11.860	283.907
			BL3	23	110.533	54.574	.615	220.452
			BL4	23	144.533	55.000	33.758	255.309
			BL5	23	170.892	61.052	47.926	293.858
			KB	23	82.833	35.888	10.552	155.115
			R1	23	111.658	47.129	16.737	206.580
			R2	23	248.210	97.910	51.009	445.411
			R3	23	300.500	142.228	14.038	586.962
			R4	23	334.935	104.553	124.355	545.515
			R5	23	279.101	97.643	82.438	475.764

7.2.2.3 Total power

Table 7.31: Total power: sample size (N), mean value, standard error and confidence interval for TOT pre-test (1) and post-test (2) across the fitness condition separated for laptop (LT) and non laptop (NLT) students and rhythmic education (RE) and physical education (PE).

Sport education	Class	TOT	Fitness	N	Mean value	Standard error	95% confidence interval	
							lower limit	upper limit
RE	LT	1	BL1	26	1008,994	132,728	741,667	1276,321
			BL2	26	1114,444	198,036	715,579	1513,308
			BL3	26	1118,218	167,667	780,519	1455,916
			BL4	26	1001,629	188,333	622,307	1380,951
			BL5	26	1278,271	248,475	777,815	1778,726
			KB	26	1060,924	191,802	674,614	1447,234
			R1	26	426,241	69,867	285,522	566,961
			R2	26	443,702	172,308	96,655	790,748
			R3	26	1542,959	362,866	812,109	2273,809
			R4	26	1018,471	281,699	451,099	1585,842
			R5	26	822,312	213,167	392,972	1251,652
		2	BL1	26	1105,953	212,748	677,456	1534,450
			BL2	26	1024,665	183,531	655,014	1394,315
			BL3	26	828,335	114,034	598,659	1058,011
			BL4	26	1187,859	207,919	769,089	1606,629
			BL5	26	1178,571	189,756	796,382	1560,759
			KB	26	1306,247	205,739	891,867	1720,628
			R1	26	514,335	181,543	148,690	879,981
			R2	26	918,394	275,223	364,067	1472,721
			R3	26	1226,576	351,758	518,100	1935,053
			R4	26	965,241	263,909	433,701	1496,781
			R5	26	950,882	229,064	489,523	1412,242
	NLT	1	BL1	23	899,305	165,002	566,974	1231,637
			BL2	23	995,082	246,190	499,229	1490,935

			BL3	23	1172,969	208,438	753,154	1592,784
			BL4	23	1157,635	234,129	686,075	1629,194
			BL5	23	1865,895	308,896	1243,747	2488,042
			KB	23	756,309	238,442	276,063	1236,555
			R1	23	271,491	86,856	96,554	446,428
			R2	23	984,482	214,207	553,047	1415,917
			R3	23	1347,500	451,102	438,934	2256,066
			R4	23	1278,309	350,198	572,974	1983,644
			R5	23	1139,636	265,001	605,897	1673,376
		2	BL1	23	986,355	264,481	453,663	1519,046
			BL2	23	593,009	228,159	133,473	1052,545
			BL3	23	310,364	141,763	24,839	595,888
			BL4	23	499,636	258,477	-20,963	1020,235
			BL5	23	343,345	235,898	-131,778	818,469
			KB	23	831,327	255,768	316,185	1346,470
			R1	23	752,155	225,687	297,597	1206,712
			R2	23	1123,527	342,147	434,409	1812,646
			R3	23	1429,891	437,292	549,139	2310,643
			R4	23	1174,336	328,082	513,545	1835,127
			R5	23	779,882	284,764	206,337	1353,427
PE	LT	1	BL1	26	506,267	182,417	138,860	873,673
			BL2	26	579,500	272,174	31,314	1127,686
			BL3	26	686,689	230,436	222,566	1150,812
			BL4	26	543,722	258,839	22,394	1065,051
			BL5	26	636,700	341,497	-51,110	1324,510
			KB	26	645,210	263,607	114,278	1176,142
			R1	26	175,167	96,023	-18,234	368,567
			R2	26	667,644	236,815	190,675	1144,614
			R3	26	1220,578	498,712	216,121	2225,035
			R4	26	1418,078	387,159	638,300	2197,855
			R5	26	687,044	292,970	96,973	1277,116
		2	BL1	26	360,278	292,394	-228,635	949,190
			BL2	26	403,678	252,239	-104,358	911,714
			BL3	26	375,744	156,724	60,085	691,404
			BL4	26	690,067	285,757	114,523	1265,611
			BL5	26	470,133	260,795	-55,135	995,402
			KB	26	761,878	282,762	192,366	1331,389
			R1	26	440,700	249,507	-61,832	943,232
			R2	26	674,389	378,257	-87,460	1436,238
			R3	26	846,667	483,445	-127,041	1820,374
			R4	26	583,511	362,708	-147,021	1314,043
			R5	26	704,967	314,819	70,889	1339,044
	NLT	1	BL1	23	299,822	157,978	-18,361	618,005
			BL2	23	321,425	235,709	-153,318	796,168
			BL3	23	371,283	199,564	-30,659	773,225
			BL4	23	410,792	224,161	-40,692	862,275
			BL5	23	738,692	295,745	143,031	1334,353
			KB	23	418,217	228,291	-41,584	878,018
			R1	23	341,433	83,158	173,944	508,923
			R2	23	396,233	205,088	-16,834	809,301
			R3	23	812,967	431,897	-56,919	1682,852
			R4	23	1000,658	335,289	325,351	1675,965
			R5	23	724,025	253,719	213,008	1235,042

		2	BL1	23	875,708	253,221	365,695	1385,721
			BL2	23	734,983	218,446	295,011	1174,956
			BL3	23	480,175	135,727	206,806	753,544
			BL4	23	638,700	247,473	140,264	1137,136
			BL5	23	820,767	225,855	365,871	1275,662
			KB	23	1222,925	244,879	729,714	1716,136
			R1	23	659,150	216,079	223,945	1094,355
			R2	23	1316,383	327,580	656,602	1976,164
			R3	23	1696,917	418,675	853,661	2540,172
			R4	23	1443,083	314,115	810,424	2075,743
			R5	23	1302,517	272,641	753,389	1851,644

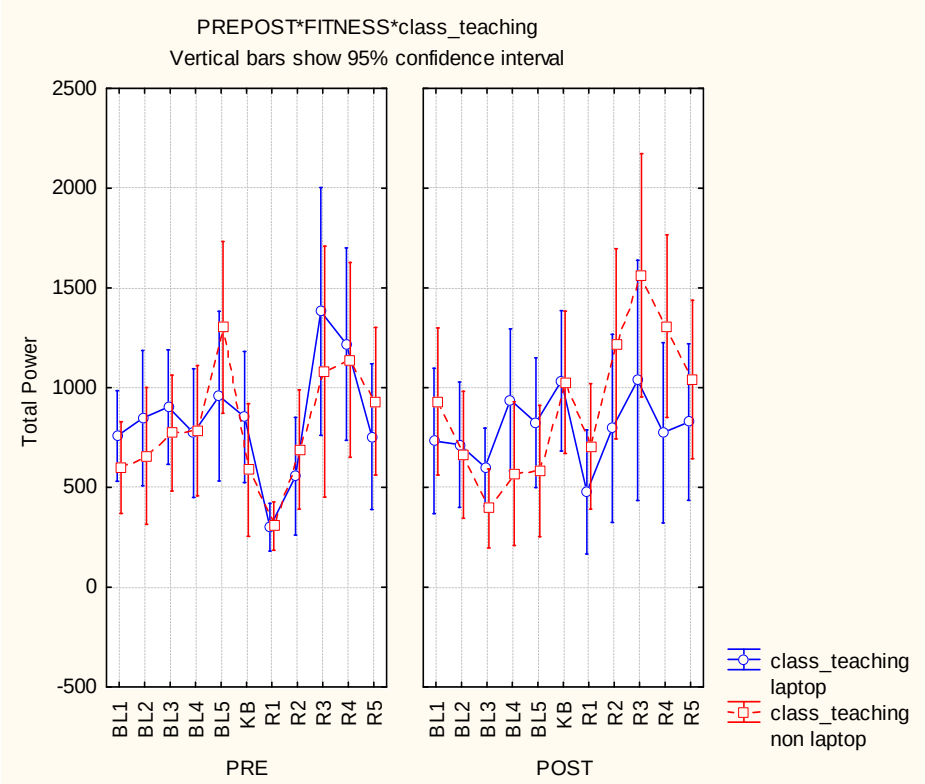

Figure 7.6: 3-way interaction between TOT * Fitness* teaching style. Total Power across the fitness condition at pre- and post-test recordings demonstrated for laptop and non laptop students.

Table 7.32: Mann-Whitney U-Test: Significant effect of total power (TP) and teaching style for baseline 3 at post-test recording.

Baseline 3 TP	Teaching style	N	Mean Rank	**Z**	**Sig.**
Post-test	Laptop class Non laptop class	26 23	28.85 20.65	-2.003	**.045**

7.2.2.4 Log LF/HF

Table 7.33: Log LF/HF: sample size (N), mean value, standard error and confidence interval for TOT pre-test (1) and post-test (2) across the fitness condition separated for laptop (LT) and non laptop (NLT) students and rhythmic education (RE) and physical education (PE).

Sport education	Class	TOT	Fitness	N	Mean value	Standard error	95% confidence interval	
							lower limit	upper limit
RE	LT	1	BL1	26	.272	.084	.103	.440
			BL2	26	.406	.074	.258	.555
			BL3	26	.459	.063	.331	.587
			BL4	26	.513	.065	.381	.644
			BL5	26	.458	.066	.326	.590
			KB	26	.557	.096	.364	.751
			R1	26	.448	.090	.267	.629
			R2	26	.151	.074	.001	.301
			R3	26	.416	.077	.261	.571
			R4	26	.251	.094	.061	.441
			R5	26	.256	.092	.071	.441
		2	BL1	26	.407	.073	.260	.553
			BL2	26	.218	.105	.005	.430
			BL3	26	.173	.095	-.018	.364
			BL4	26	.319	.085	.148	.491
			BL5	26	.219	.080	.057	.381
			KB	26	.637	.069	.499	.775
			R1	26	.374	.080	.213	.535
			R2	26	.258	.073	.111	.405
			R3	26	.082	.082	-.083	.247
			R4	26	.089	.100	-.113	.291
			R5	26	.307	.087	.133	.482
	NLT	1	BL1	23	.521	.104	.312	.731
			BL2	23	.516	.092	.332	.701
			BL3	23	.504	.079	.345	.663
			BL4	23	.422	.081	.258	.585
			BL5	23	.639	.081	.475	.803
			KB	23	.679	.119	.439	.920
			R1	23	.466	.112	.241	.691
			R2	23	.393	.092	.207	.579
			R3	23	.304	.096	.112	.497
			R4	23	.307	.117	.070	.543
			R5	23	.387	.114	.157	.617
		2	BL1	23	.513	.090	.330	.695
			BL2	23	.381	.131	.117	.645
			BL3	23	.518	.118	.281	.755
			BL4	23	.468	.106	.255	.681
			BL5	23	.343	.100	.142	.544
			KB	23	.514	.085	.342	.686
			R1	23	.254	.099	.054	.454
			R2	23	.362	.091	.179	.545
			R3	23	.191	.102	-.014	.396
			R4	23	.462	.125	.211	.713
			R5	23	.378	.108	.161	.596
PE	LT	1	BL1	26	.661	.115	.430	.892

			BL2	26	.759	.102	.554	.963
			BL3	26	.696	.087	.520	.871
			BL4	26	.685	.090	.504	.866
			BL5	26	.551	.090	.370	.732
			KB	26	.312	.132	.047	.578
			R1	26	.386	.124	.137	.635
			R2	26	.498	.102	.292	.704
			R3	26	.225	.106	.012	.437
			R4	26	.345	.130	.083	.606
			R5	26	.467	.126	.213	.721
		2	BL1	26	.443	.100	.242	.645
			BL2	26	.584	.145	.293	.876
			BL3	26	.634	.130	.372	.896
			BL4	26	.524	.117	.289	.760
			BL5	26	.527	.110	.304	.749
			KB	26	.818	.094	.628	1.008
			R1	26	.435	.110	.214	.656
			R2	26	.374	.100	.172	.577
			R3	26	.418	.112	.192	.645
			R4	26	.329	.138	.051	.606
			R5	26	.380	.119	.140	.620
	NLT	1	BL1	23	.344	.099	.144	.545
			BL2	23	.441	.088	.264	.618
			BL3	23	.525	.075	.373	.677
			BL4	23	.256	.078	.099	.413
			BL5	23	.099	.078	-.059	.256
			KB	23	.586	.114	.356	.816
			R1	23	.426	.107	.210	.642
			R2	23	.338	.089	.160	.517
			R3	23	.288	.091	.104	.472
			R4	23	.465	.112	.238	.691
			R5	23	.376	.109	.156	.596
		2	BL1	23	.624	.087	.450	.799
			BL2	23	.580	.125	.327	.833
			BL3	23	.422	.113	.195	.648
			BL4	23	.497	.101	.293	.701
			BL5	23	.571	.096	.379	.764
			KB	23	.655	.082	.490	.819
			R1	23	.413	.095	.222	.605
			R2	23	.382	.087	.207	.557
			R3	23	.473	.097	.277	.669
			R4	23	.546	.119	.306	.786
			R5	23	.566	.103	.358	.774

Table 7.34: Mann-Whitney U-Test: Significant effect of log LF/HF and sport education for post-test recording.

Baseline_2 Log LF/HF	Sport education	N	Mean Rank	**Z**	**Sig.**
Post-test	Rhythmic education Physical education	28 21	20.68 30.76	-2.445	**.015**
Baseline_5	Sport education	N	Mean Rank	**Z**	**Sig.**

Log LF/HF					
Post-test	Rhythmic education Physical education	28 21	20.43 31.10	-2.586	**.010**
KB exercise Log LF/HF	Sport education	N	Mean Rank	**Z**	**Sig.**
Post-test	Rhythmic education Physical education	28 21	21.48 29.69	-1.990	**.047**
Recovery_ 3 Log LF/HF	Sport education	N	Mean Rank	**Z**	**Sig.**
Post-test	Rhythmic education Physical education	28 21	19.50 32.33	-3.111	**.002**

7.2.2.5 Normalized LF

Table 7.35: LF in nu: sample size (N), mean value, standard error and confidence interval for TOT pre-test (1) and post-test (2) across the fitness condition separated for laptop (LT) and non laptop (NLT) students and rhythmic education (RE) and physical education (PE).

Sport education	Class	TOT	Fitness	N	Mean value	Standard error	95% confidence interval	
							lower limit	upper limit
RE	LT	1	BL1	26	.467	.048	.371	.564
			BL2	26	.528	.042	.442	.613
			BL3	26	.558	.041	.477	.640
			BL4	26	.542	.040	.461	.622
			BL5	26	.539	.041	.457	.621
			KB	26	.554	.044	.466	.642
			R1	26	.303	.047	.209	.398
			R2	26	.293	.042	.209	.377
			R3	26	.459	.037	.384	.533
			R4	26	.470	.043	.384	.556
			R5	26	.468	.041	.385	.551
		2	BL1	26	.439	.043	.352	.525
			BL2	26	.463	.047	.368	.558
			BL3	26	.466	.040	.386	.546
			BL4	26	.512	.041	.430	.594
			BL5	26	.441	.036	.369	.513
			KB	26	.450	.042	.365	.536
			R1	26	.281	.047	.187	.375
			R2	26	.424	.037	.349	.498
			R3	26	.407	.035	.337	.477
			R4	26	.450	.039	.372	.529
			R5	26	.470	.040	.390	.550
	NLT	1	BL1	23	.465	.060	.345	.585
			BL2	23	.516	.053	.410	.622
			BL3	23	.426	.050	.325	.528
			BL4	23	.405	.050	.305	.504
			BL5	23	.545	.051	.443	.646
			KB	23	.400	.054	.290	.509
			R1	23	.252	.058	.135	.370
			R2	23	.344	.052	.240	.449
			R3	23	.515	.046	.422	.607

			R4	23	.451	.053	.344	.558
			R5	23	.474	.051	.371	.577
		2	BL1	23	.408	.053	.301	.516
			BL2	23	.441	.058	.323	.559
			BL3	23	.565	.050	.465	.664
			BL4	23	.538	.051	.436	.640
			BL5	23	.542	.045	.452	.632
			KB	23	.388	.053	.282	.494
			R1	23	.344	.058	.227	.460
			R2	23	.505	.046	.412	.598
			R3	23	.487	.043	.400	.574
			R4	23	.545	.049	.447	.643
			R5	23	.504	.049	.405	.603
PE	LT	1	BL1	26	.471	.066	.338	.603
			BL2	26	.530	.058	.412	.647
			BL3	26	.546	.056	.434	.659
			BL4	26	.467	.055	.356	.577
			BL5	26	.460	.056	.348	.573
			KB	26	.316	.060	.195	.437
			R1	26	.332	.065	.202	.462
			R2	26	.410	.057	.294	.525
			R3	26	.379	.051	.277	.482
			R4	26	.432	.059	.313	.550
			R5	26	.497	.056	.383	.611
		2	BL1	26	.421	.059	.302	.540
			BL2	26	.535	.065	.405	.666
			BL3	26	.487	.055	.376	.597
			BL4	26	.521	.056	.408	.633
			BL5	26	.555	.049	.456	.654
			KB	26	.478	.058	.361	.596
			R1	26	.208	.064	.079	.337
			R2	26	.441	.051	.338	.544
			R3	26	.501	.048	.404	.597
			R4	26	.489	.054	.381	.598
			R5	26	.537	.054	.427	.646
	NLT	1	BL1	23	.382	.057	.267	.497
			BL2	23	.477	.051	.375	.578
			BL3	23	.511	.048	.414	.608
			BL4	23	.475	.047	.379	.571
			BL5	23	.395	.048	.298	.493
			KB	23	.480	.052	.376	.585
			R1	23	.360	.056	.248	.473
			R2	23	.396	.050	.296	.496
			R3	23	.400	.044	.312	.489
			R4	23	.479	.051	.376	.581
			R5	23	.405	.049	.307	.503
		2	BL1	23	.518	.051	.415	.621
			BL2	23	.602	.056	.490	.715
			BL3	23	.537	.047	.442	.633
			BL4	23	.510	.048	.412	.608
			BL5	23	.492	.043	.406	.578
			KB	23	.353	.050	.251	.455
			R1	23	.433	.055	.321	.544

			R2	23	.468	.044	.378	.557
			R3	23	.442	.041	.359	.526
			R4	23	.541	.047	.447	.635
			R5	23	.573	.047	.478	.668

7.2.2.6 Normalized HF

Table 7.36: HF in nu: sample size (N), mean value, standard error and confidence interval for TOT pre-test (1) and post-test (2) across the fitness condition separated for laptop (LT) and non laptop (NLT) students and rhythmic education (RE) and physical education (PE).

Sport education	Class	TOT	Fitness	N	Mean value	Standard error	95% confidence interval	
							lower limit	upper limit
RE	LT	1	BL1	26	.284	.030	.223	.345
			BL2	26	.219	.024	.171	.267
			BL3	26	.207	.022	.162	.253
			BL4	26	.183	.026	.130	.235
			BL5	26	.196	.029	.138	.255
			KB	26	.173	.023	.126	.220
			R1	26	.105	.021	.064	.147
			R2	26	.235	.040	.154	.315
			R3	26	.194	.037	.121	.268
			R4	26	.266	.040	.185	.348
			R5	26	.294	.038	.218	.370
		2	BL1	26	.211	.030	.149	.272
			BL2	26	.319	.039	.241	.397
			BL3	26	.317	.037	.243	.390
			BL4	26	.279	.034	.211	.347
			BL5	26	.302	.033	.235	.369
			KB	26	.119	.014	.092	.146
			R1	26	.127	.023	.080	.174
			R2	26	.233	.029	.175	.292
			R3	26	.368	.037	.293	.443
			R4	26	.380	.040	.299	.461
			R5	26	.277	.037	.203	.352
	NLT	1	BL1	23	.164	.038	.088	.240
			BL2	23	.169	.030	.109	.229
			BL3	23	.138	.028	.081	.194
			BL4	23	.159	.032	.094	.225
			BL5	23	.131	.036	.059	.203
			KB	23	.087	.029	.029	.145
			R1	23	.093	.026	.041	.145
			R2	23	.154	.049	.054	.254
			R3	23	.285	.045	.194	.377
			R4	23	.297	.050	.196	.398
			R5	23	.257	.047	.163	.351
		2	BL1	23	.162	.038	.085	.238
			BL2	23	.225	.048	.128	.322
			BL3	23	.207	.045	.116	.299
			BL4	23	.224	.042	.140	.308
			BL5	23	.266	.041	.183	.350
			KB	23	.123	.017	.089	.157

			R1	23	.193	.029	.134	.252
			R2	23	.257	.036	.184	.330
			R3	23	.307	.047	.213	.401
			R4	23	.232	.050	.132	.333
			R5	23	.240	.046	.147	.333
PE	LT	1	BL1	26	.103	.042	.019	.187
			BL2	26	.100	.033	.033	.166
			BL3	26	.132	.031	.070	.195
			BL4	26	.127	.036	.054	.199
			BL5	26	.165	.040	.085	.246
			KB	26	.169	.032	.105	.233
			R1	26	.149	.029	.091	.206
			R2	26	.156	.055	.046	.266
			R3	26	.298	.050	.197	.399
			R4	26	.222	.055	.110	.333
			R5	26	.217	.052	.113	.321
		2	BL1	26	.167	.042	.082	.251
			BL2	26	.173	.053	.065	.280
			BL3	26	.146	.050	.045	.248
			BL4	26	.179	.046	.086	.272
			BL5	26	.205	.046	.113	.297
			KB	26	.077	.019	.039	.114
			R1	26	.075	.032	.011	.140
			R2	26	.196	.040	.116	.276
			R3	26	.232	.051	.129	.336
			R4	26	.287	.055	.176	.398
			R5	26	.261	.051	.159	.364
	NLT	1	BL1	23	.181	.036	.108	.253
			BL2	23	.193	.029	.136	.251
			BL3	23	.169	.027	.115	.223
			BL4	23	.277	.031	.214	.339
			BL5	23	.334	.034	.264	.403
			KB	23	.148	.028	.092	.203
			R1	23	.135	.025	.085	.185
			R2	23	.229	.047	.134	.325
			R3	23	.218	.043	.130	.305
			R4	23	.197	.048	.100	.294
			R5	23	.192	.045	.102	.282
		2	BL1	23	.142	.036	.069	.215
			BL2	23	.178	.046	.085	.271
			BL3	23	.229	.044	.141	.316
			BL4	23	.169	.040	.088	.249
			BL5	23	.162	.040	.082	.242
			KB	23	.072	.016	.039	.104
			R1	23	.165	.028	.109	.221
			R2	23	.214	.035	.144	.283
			R3	23	.169	.045	.079	.258
			R4	23	.187	.048	.090	.283
			R5	23	.168	.044	.079	.256

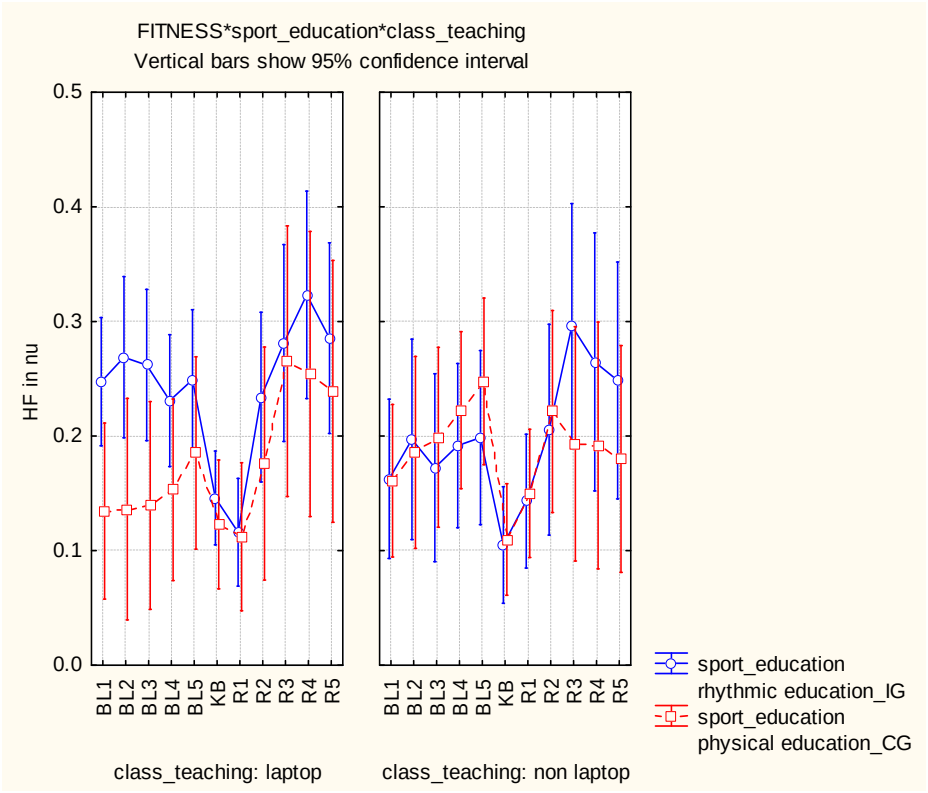

Figure 7.7: 3-way interaction between Fitness* sport education * teaching style. Normalized high frequency across the fitness condition for laptop and non laptop students demonstrated for physical education (PE) and rhythmic education (RE) group.

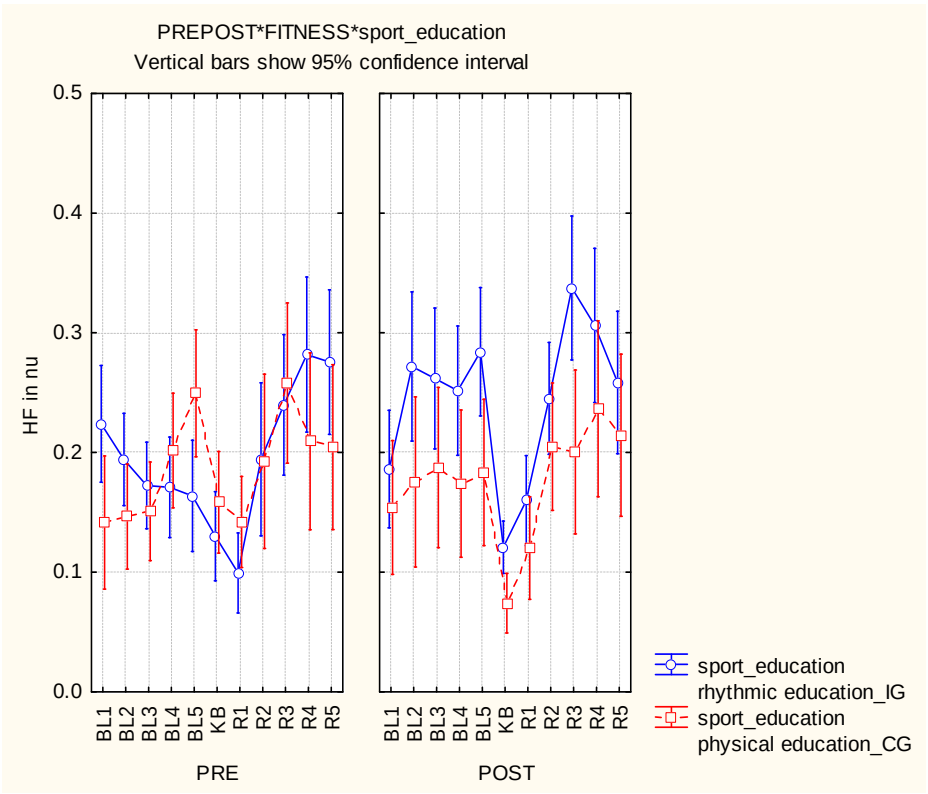

Figure 7.8: 3-way interaction between TOT * Fitness* sport education. Normalized high frequency across the fitness condition at pre- and post-test recordings demonstrated for rhythmic education (RE) and physical education (PE) group.

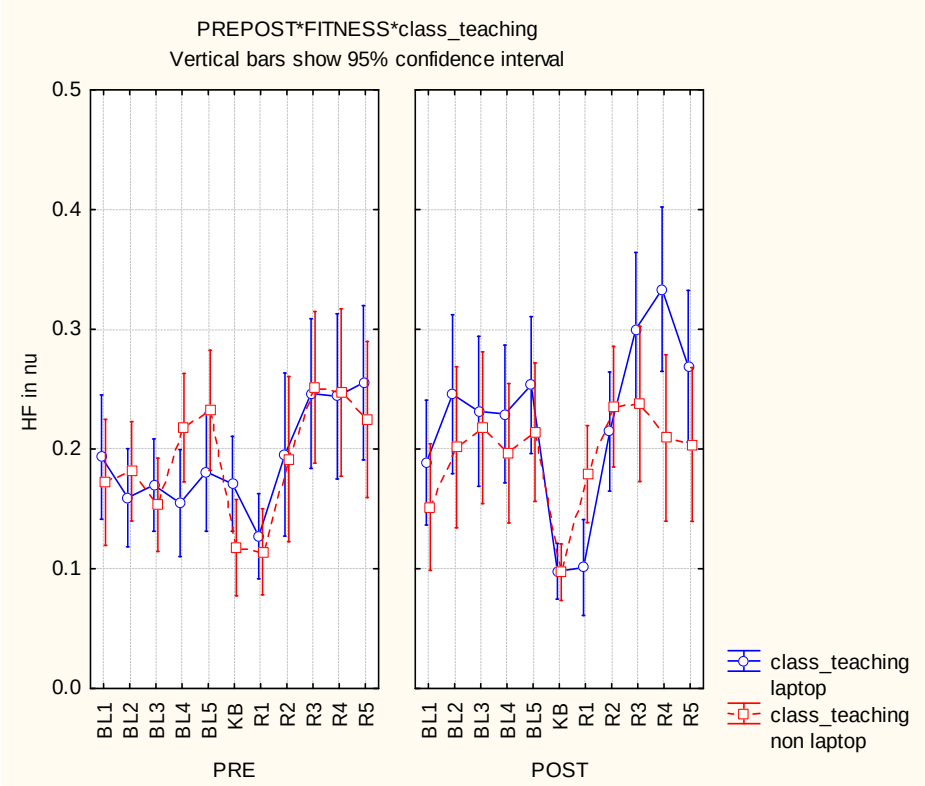

Figure 7.9: 3-way interaction between TOT * Fitness* teaching style. Normalized high frequency across the fitness condition at pre- and post-test recordings demonstrated for laptop and non laptop students.

7.2.3 Atrial mean

Table 7.37: Atrial mean: sample size (N), mean value, standard error and confidence interval for TOT pre-test (1) and post-test (2) across the fitness condition separated for laptop (LT) and non laptop (NLT) students and rhythmic education (RE) and physical education (PE).

Sport education	Class	TOT	Fitness	N	Mean value	Standard error	95% confidence interval	
							lower limit	upper limit
RE	LT	1	BL1	26	.129	.006	.116	.141
			BL2	26	.128	.010	.107	.149
			BL3	26	.132	.006	.119	.144
			BL4	26	.131	.006	.119	.144
			BL5	26	.135	.006	.123	.147
			KB	26	.149	.011	.127	.172
			R1	26	.115	.005	.106	.125
			R2	26	.129	.005	.120	.139
			R3	26	.131	.005	.122	.141
			R4	26	.132	.004	.124	.141
			R5	26	.135	.005	.126	.144
		2	BL1	26	.134	.005	.124	.144

			BL2	26	.136	.005	.126	.146
			BL3	26	.135	.004	.126	.143
			BL4	26	.134	.004	.125	.143
			BL5	26	.136	.005	.126	.145
			KB	26	.144	.005	.133	.154
			R1	26	.134	.005	.124	.145
			R2	26	.139	.006	.128	.151
			R3	26	.140	.005	.129	.151
			R4	26	.142	.005	.132	.153
			R5	26	.142	.005	.132	.152
	NLT	1	BL1	23	.133	.007	.118	.148
			BL2	23	.131	.012	.106	.156
			BL3	23	.127	.008	.112	.143
			BL4	23	.126	.007	.111	.141
			BL5	23	.128	.007	.113	.143
			KB	23	.161	.014	.134	.189
			R1	23	.113	.006	.101	.124
			R2	23	.123	.006	.112	.135
			R3	23	.124	.006	.113	.136
			R4	23	.128	.005	.118	.139
			R5	23	.128	.006	.117	.139
		2	BL1	23	.127	.006	.115	.139
			BL2	23	.121	.006	.109	.132
			BL3	23	.121	.005	.110	.131
			BL4	23	.124	.005	.113	.134
			BL5	23	.124	.006	.112	.135
			KB	23	.125	.006	.113	.138
			R1	23	.123	.006	.110	.135
			R2	23	.124	.007	.110	.137
			R3	23	.127	.007	.114	.141
			R4	23	.130	.006	.117	.143
			R5	23	.129	.006	.117	.141
PE	LT	1	BL1	26	.132	.008	.116	.149
			BL2	26	.133	.014	.105	.161
			BL3	26	.138	.008	.121	.156
			BL4	26	.140	.008	.124	.157
			BL5	26	.139	.008	.123	.156
			KB	26	.187	.015	.157	.218
			R1	26	.126	.006	.113	.139
			R2	26	.124	.006	.111	.137
			R3	26	.129	.006	.116	.142
			R4	26	.132	.006	.120	.143
			R5	26	.132	.006	.120	.145
		2	BL1	26	.122	.007	.108	.135
			BL2	26	.122	.006	.109	.135
			BL3	26	.124	.006	.112	.135
			BL4	26	.127	.006	.115	.139
			BL5	26	.124	.006	.112	.137
			KB	26	.122	.007	.108	.136
			R1	26	.114	.007	.100	.128
			R2	26	.121	.007	.106	.136
			R3	26	.133	.007	.118	.148
			R4	26	.125	.007	.111	.139

			R5	26	.124	.006	.111	.137
	NLT	1	BL1	23	.131	.007	.117	.145
			BL2	23	.148	.012	.124	.172
			BL3	23	.133	.007	.119	.148
			BL4	23	.130	.007	.116	.144
			BL5	23	.130	.007	.115	.144
			KB	23	.152	.013	.126	.179
			R1	23	.123	.006	.112	.134
			R2	23	.132	.006	.121	.144
			R3	23	.139	.005	.128	.150
			R4	23	.135	.005	.125	.145
			R5	23	.132	.005	.122	.143
		2	BL1	23	.132	.006	.121	.144
			BL2	23	.132	.006	.121	.143
			BL3	23	.132	.005	.122	.142
			BL4	23	.134	.005	.124	.144
			BL5	23	.139	.005	.128	.149
			KB	23	.130	.006	.118	.142
			R1	23	.132	.006	.120	.144
			R2	23	.138	.006	.125	.151
			R3	23	.138	.006	.125	.150
			R4	23	.139	.006	.127	.152
			R5	23	.141	.006	.129	.152

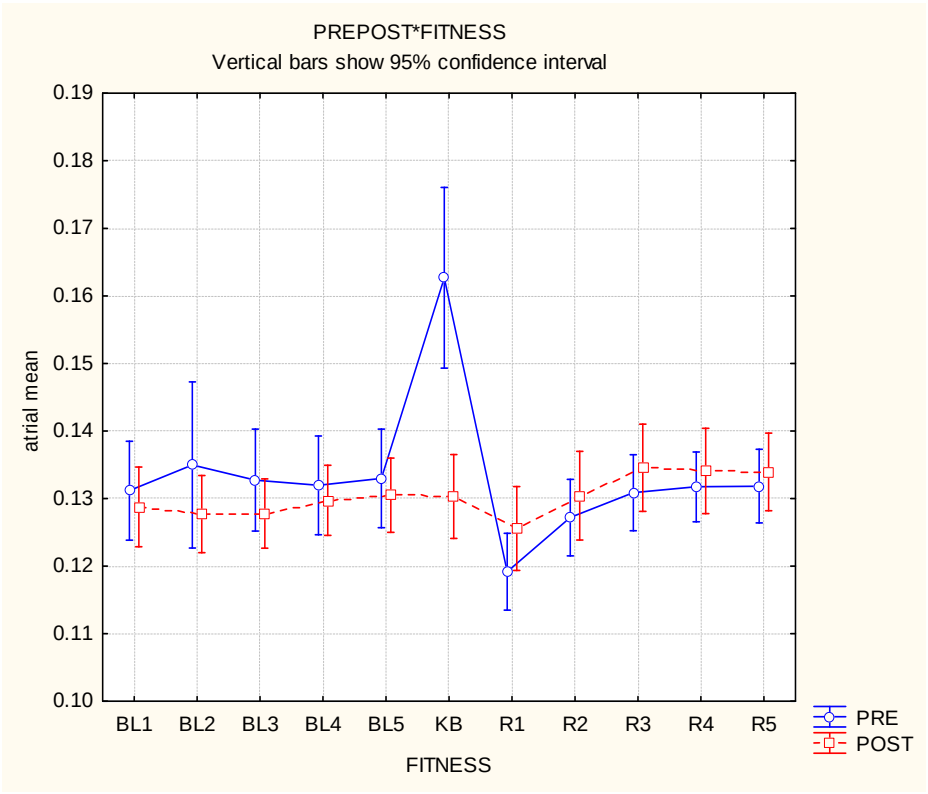

Figure 7.10: 2-way interaction between Fitness * TOT. Atrial mean across the fitness condition demonstrated for pre- and post-test recordings.

7.2.3 Atrial median

Table 7.38: Atrial median: sample size (N), mean value, standard error and confidence interval for TOT pre-test (1) and post-test (2) across the fitness condition separated for laptop (LT) and non laptop (NLT) students and rhythmic education (RE) and physical education (PE).

Sport education	Class	TOT	Fitness	N	Mean value	Standard error	95% confidence interval	
							lower limit	upper limit
RE	LT	1	BL1	26	.125	.004	.117	.134
			BL2	26	.126	.006	.114	.138
			BL3	26	.126	.004	.118	.135
			BL4	26	.126	.004	.117	.134
			BL5	26	.128	.004	.119	.136
			KB	26	.131	.004	.123	.139
			R1	26	.119	.003	.112	.125
			R2	26	.119	.004	.111	.126
			R3	26	.124	.004	.116	.132
			R4	26	.127	.004	.119	.136
			R5	26	.129	.004	.120	.137
		2	BL1	26	.129	.005	.119	.139
			BL2	26	.131	.004	.122	.139
			BL3	26	.131	.004	.123	.140
			BL4	26	.132	.004	.123	.140
			BL5	26	.132	.004	.123	.140
			KB	26	.134	.005	.125	.144
			R1	26	.126	.004	.117	.135
			R2	26	.125	.004	.118	.133
			R3	26	.129	.004	.120	.137
			R4	26	.133	.004	.124	.141
			R5	26	.131	.004	.123	.139
	NLT	1	BL1	23	.120	.005	.110	.130
			BL2	23	.128	.007	.114	.143
			BL3	23	.121	.005	.110	.131
			BL4	23	.121	.005	.111	.131
			BL5	23	.121	.005	.110	.132
			KB	23	.121	.005	.111	.131
			R1	23	.110	.004	.101	.118
			R2	23	.115	.004	.106	.124
			R3	23	.117	.005	.107	.127
			R4	23	.119	.005	.109	.130
			R5	23	.120	.005	.110	.130
		2	BL1	23	.124	.006	.112	.137
			BL2	23	.119	.005	.109	.129
			BL3	23	.121	.005	.110	.131
			BL4	23	.122	.005	.112	.132
			BL5	23	.122	.005	.112	.133
			KB	23	.123	.006	.112	.135
			R1	23	.122	.006	.111	.133
			R2	23	.120	.005	.111	.129
			R3	23	.122	.005	.111	.132
			R4	23	.123	.005	.113	.134
			R5	23	.124	.005	.114	.134
PE	LT	1	BL1	26	.126	.006	.114	.137

			BL2	26	.127	.008	.111	.143
			BL3	26	.128	.006	.116	.140
			BL4	26	.128	.006	.117	.140
			BL5	26	.129	.006	.118	.141
			KB	26	.127	.006	.116	.139
			R1	26	.118	.005	.108	.127
			R2	26	.126	.005	.116	.135
			R3	26	.128	.005	.117	.139
			R4	26	.130	.006	.118	.141
			R5	26	.128	.006	.117	.140
		2	BL1	26	.122	.007	.108	.136
			BL2	26	.122	.006	.111	.134
			BL3	26	.123	.006	.112	.135
			BL4	26	.124	.006	.113	.136
			BL5	26	.124	.006	.113	.136
			KB	26	.119	.007	.106	.133
			R1	26	.112	.006	.099	.124
			R2	26	.119	.005	.109	.129
			R3	26	.127	.006	.116	.138
			R4	26	.123	.006	.111	.135
			R5	26	.124	.006	.112	.135
	NLT	1	BL1	23	.125	.005	.115	.135
			BL2	23	.128	.007	.114	.142
			BL3	23	.128	.005	.118	.139
			BL4	23	.128	.005	.118	.138
			BL5	23	.128	.005	.118	.139
			KB	23	.127	.005	.118	.137
			R1	23	.118	.004	.109	.126
			R2	23	.122	.004	.114	.131
			R3	23	.125	.005	.116	.135
			R4	23	.126	.005	.116	.136
			R5	23	.128	.005	.118	.138
		2	BL1	23	.128	.006	.116	.140
			BL2	23	.129	.005	.120	.139
			BL3	23	.130	.005	.120	.140
			BL4	23	.130	.005	.120	.140
			BL5	23	.130	.005	.120	.140
			KB	23	.120	.006	.108	.131
			R1	23	.120	.005	.109	.131
			R2	23	.124	.004	.116	.133
			R3	23	.127	.005	.117	.137
			R4	23	.129	.005	.118	.139
			R5	23	.129	.005	.119	.139

7.3 Supplementation to results: HRV and Mental Stress

7.3.1 Time domain parameters

7.3.1.1 Minimum heart rate

Table 7.39: Minimum heart rate: sample size (N), mean value, standard error and confidence interval for the sport groups (RE and PE) and the class (LT and NLT) at pre-test and post-test (TOT) during mental stress condition.

sport education	Class teaching	TOT	N	Mean value	Standard error	95% confidence interval	
						lower limit	upper limit
Rhythmic education	Laptop	1	17	82.975	3.783	75.199	90.750
		2	17	82.861	3.569	75.524	90.198
	Non laptop	1	11	85.945	4.703	76.278	95.611
		2	11	83.285	4.437	74.164	92.406

7.3.1.2 Mean heart rate

Table 7.40: Mean heart rate: sample size (N), mean value, standard error and confidence interval for the sport groups (RE and PE) and the class (LT and NLT) at pre-test and post-test (TOT) during mental stress condition

Sport education	Class teaching	TOT	N	Mean value	Standard error	95% confidence interval	
						lower limit	upper limit
Rhythmic education	Laptop	1	17	102.396	3.100	96.024	108.768
		2	17	100.044	3.014	93.848	106.240
	Non laptop	1	11	101.715	3.854	93.794	109.637
		2	11	100.469	3.747	92.766	108.172

7.3.1.3 Maximum heart rate

Table 7.41: Maximum heart rate: sample size (N), mean value, standard error and confidence interval for the sport groups (RE and PE) and the class (LT and NLT) at pre-test and post-test (TOT) during mental stress condition.

Sport education	Class teaching	TOT	N	Mean value	Standard error	95% confidence interval	
						lower limit	upper limit
Rhythmic education	Laptop	1	17	118.939	2.986	112.800	125.077
		2	17	120.065	3.258	113.369	126.762
	Non laptop	1	11	118.424	3.713	110.792	126.055
		2	11	122.881	4.050	114.556	131.206

7.3.1.4 SDNN

Table 7.42: SDNN: sample size (N), mean value, standard error and confidence interval for the sport groups (RE and PE) and the class (LT and NLT) at pre-test and post-test (TOT) during mental stress condition.

sport education	Class teaching	TOT	N	Mean value	Standard error	95% confidence interval	
						lower limit	upper limit
Rhythmic education	Laptop	1	17	34.412	3.997	26.196	42.627
		2	17	40.235	5.422	29.090	51.380
	Non laptop	1	11	37.300	4.969	27.087	47.513
		2	11	43.673	6.740	29.818	57.528

7.3.1.5 r-MSSD

Table 7.43: r-MSSD: sample size (N), mean value, standard error and confidence interval for the sport groups (RE and PE) and the class (LT and NLT) at pre-test and post-test (TOT) during mental stress condition.

sport education	Class teaching	TOT	N	Mean value	Standard error	95% confidence interval	
						lower limit	upper limit
Rhythmic education	Laptop	1	17	17.871	2.901	11.908	23.833
		2	17	21.665	3.416	14.643	28.687
	Non laptop	1	11	26.436	3.606	19.024	33.849
		2	11	27.391	4.247	18.661	36.120

7.3.1.9 pNN50

Table 7.44: pNN50: sample size (N), mean value, standard error and confidence interval for the sport groups (RE and PE) and the class (LT and NLT) at pre-test and post-test (TOT) during mental stress condition.

sport education	Class teaching	TOT	N	Mean value	Standard error	95% confidence interval	
						lower limit	upper limit
Rhythmic education	Laptop	1	17	2.859	1.832	-.907	6.626
		2	17	5.081	2.433	.081	10.082
	Non laptop	1	11	9.508	2.278	4.826	14.190
		2	11	10.251	3.024	4.035	16.467

7.3.2 Frequency domain parameters

7.3.2.1 LF power

Table 7.45: Low frequency power: sample size (N), mean value, standard error and confidence interval for the sport groups (RE and PE) and the class (LT and NLT) at pre-test and post-test (TOT) during mental stress condition.

sport education	Class teaching	TOT	N	Mean value	Standard error	95% confidence interval	
						lower limit	upper limit
Rhythmic education	Laptop	1	17	681.182	191.498	287.553	1074.812
		2	17	602.241	243.597	101.519	1102.963
	Non laptop	1	11	972.855	238.063	483.509	1462.200
		2	11	1042.009	302.831	419.530	1664.488

7.3.2.2 HF power

Table 7.46: High frequency power: sample size (N), mean value, standard error and confidence interval for the sport groups (RE and PE) and the class (LT and NLT) at pre-test and post-test (TOT) during mental stress condition.

sport education	Class teaching	TOT	N	Mean value	Standard error	95% confidence interval	
						lower limit	upper limit
Rhythmic education	Laptop	1	17	437.094	136.710	156.083	718.105
		2	17	360.806	128.989	95.666	625.946
	Non laptop	1	11	470.891	169.953	121.549	820.233
		2	11	361.273	160.354	31.661	690.885

7.3.2.3 Total power

Table 7.47: Total power: sample size (N), mean value, standard error and confidence interval for the sport groups (RE and PE) and the class (LT and NLT) at pre-test and post-test (TOT) during mental stress condition.

sport education	Class teaching	TOT	N	Mean value	Standard error	95% confidence interval	
						lower limit	upper limit
Rhythmic education	Laptop	1	17	2406.212	654.855	1060.139	3752.285
		2	17	2719.853	1027.016	608.792	4830.914
	Non laptop	1	11	2905.764	814.091	1232.376	4579.152
		2	11	4059.991	1276.748	1435.598	6684.384

7.3.2.4 Log LF/HF

Table 7.48: Log LF/HF: sample size (N), mean value, standard error and confidence interval for the sport groups (RE and PE) and the class (LT and NLT) at pre-test and post-test (TOT) during mental stress condition.

sport education	Class teaching	TOT	N	Mean value	Standard error	95% confidence interval	
						lower limit	upper limit
Rhythmic education	Laptop	1	17	.352	.061	.226	.478
		2	17	.351	.074	.198	.505
	Non laptop	1	11	.445	.076	.288	.602
		2	11	.348	.093	.158	.539

7.3.2.5 Normalized LF

Table 7.49: Normalized LF: sample size (N), mean value, standard error and confidence interval for the sport groups (RE and PE) and the class (LT and NLT) at pre-test and post-test (TOT) during mental stress condition.

sport education	Class teaching	TOT	N	Mean value	Standard error	95% confidence interval	
						lower limit	upper limit
Rhythmic education	Laptop	1	17	.337	.029	.278	.397
		2	17	.267	.029	.208	.326
	Non laptop	1	11	.328	.036	.254	.402
		2	11	.300	.036	.227	.374

7.3.2.6 Normalized HF

Table 7.50: Normalized HF: sample size (N), mean value, standard error and confidence interval for the sport groups (RE and PE) and the class (LT and NLT) at pre-test and post-test (TOT) during mental stress condition.

sport education	Class teaching	TOT	N	Mean value	Standard error	95% confidence interval	
						lower limit	upper limit
Rhythmic education	Laptop	1	17	.158	.019	.119	.197
		2	17	.128	.021	.086	.170
	Non laptop	1	11	.136	.024	.087	.185
		2	11	.148	.026	.095	.201

7.3.3 Atrial mean

Table 7.51: Atrial mean: sample size (N), mean value, standard error and confidence interval for the sport groups (RE and PE) and the class (LT and NLT) at pre-test and post-test (TOT) during mental stress condition.

sport education	Class teaching	TOT	N	Mean value	Standard error	95% confidence interval	
						lower limit	upper limit
Rhythmic education	Laptop	1	17	.137	.004	.129	.146
		2	17	.146	.005	.136	.156
	Non laptop	1	11	.125	.005	.114	.135
		2	11	.128	.006	.116	.140

7.3.3 Atrial median

Table 7.52: Atrial median: sample size (N), mean value, standard error and confidence interval for the sport groups (RE and PE) and the class (LT and NLT) at pre-test and post-test (TOT) during mental stress condition.

sport education	Class teaching	TOT	N	Mean value	Standard error	95% confidence interval	
						lower limit	upper limit
Rhythmic education	Laptop	1	17	.132	.004	.123	.140
		2	17	.133	.004	.124	.141
	Non laptop	1	11	.120	.005	.109	.131
		2	11	.123	.005	.113	.133

7.4 List of abbreviations and acronyms

ANOVA	Analysis of variance
ANS	Autonomic nervous system
AR	Autoregressive (method for spectral analysis)
AV node	Atrioventricular node
BL	Baseline
BMI	Body mass index (weight [kg] / height² [m])
BpM	Beats per Minute
CG	Control group
ECG	Electrocardiogram
FFT	Fast Fourier Transform
HF	High frequency
HR	Heart rate
HRV	Heart rate variability
Hz	Hertz
IG	Intervention group
KB	Knee bending
LF	Low frequency
LT	Laptop (class)
MANOVA	Multivariate analysis of variance
MS	Mental stress
NLT	Non laptop (class)
NN or RR Interval	Normal to normal heart beats (R-wave to R-wave)
nu	Normalized units
PE	Physical education
PNN50	Proportion of successive NN intervals differing by more than 50 ms in the entire recording
RE	Rhythmic education
RMSSD	Square root of the mean of the sum of the squares of differences between adjacent NN intervals
SA node	Sinoatrial node

SDNN	Standard deviation of all normal heart periods
SR	Sitting recovery
TOT	Time on task
TP	Total power
ULF	Ultra low frequency
VLF	Very low frequency

7.5 Time protocols

7.5.1 First pre-test

February 26th, 2008

Time Protocol **1AK (NLT/PE): 11:40am-1:20pm**	**Commencement**	**Cessation**
Start physiological recording (all ECG applied)	12:13:00	
30 min PE or rhythmic education	12:15:00	12:45:00
5 min baseline	12:49:05	12:54:05
Respiration exercise (instruction)		
5 min fast breathing (breathing rate: 12/min = respiratory rhythm of 5 sec)	12:54:10	12:59:10
5 min slow breathing (breathing rate: 6/min = respiratory rhythm of 10 sec)	12:59:54	12:04:54
Uprise before knee bending	13:08:29	
1 min knee bending (KB)	13:08:50	13:09:50
5 min recovery (sitting)	13:09:50	13:14:50
5 min mental stress (count down at a 7-pace)	No data	
Approximately end of ECG-derivation	13:20:00	
School bell ringing		

Time Protocol **1BK (NLT/RE): 1:20pm-3:00pm**	**Commencement**	**Cessation**
Start physiological recording (all ECG applied)	~ 13:30	
30 min PE or rhythmic education	13:35:00	14:08:00
5 min baseline	14:08:33	14:13:33
Respiration exercise (instruction)		
5 min slow breathing (breathing rate: 6/min = respiratory rhythm of 10 sec)	14:14:14	14:19:14
5 min fast breathing (breathing rate: 12/min = respiratory rhythm of 5 sec)	14:19:44	14:24:44

Uprise before knee bending	14:28:29	
1 min knee bending (KB)	14:28:40	14:29:40
5 min recovery (sitting)	14:29:43	14:34:43
5 min mental stress (count down at a 7-pace)	14:36:28	14:41:28
Approximately end of ECG-derivation	14:43:00	
School bell ringing	14:25:18	

Time Protocol **Hak+ (LT/RE): 3:00pm-4:40pm**	**Commencement**	**Cessation**
Start physiological recording (all ECG applied)		
30 min PE or rhythmic education	15:27:00	
5 min baseline	16:03:41	16:08:41
Respiration exercise (instruction)		
5 min fast breathing (breathing rate: 12/min = respiratory rhythm of 5 sec)	16:10:59	16:15:59
5 min slow breathing (breathing rate: 6/min = respiratory rhythm of 10 sec)	16:16:39	16:21:39
Uprise before knee bending	16:24:48	
1 min knee bending (KB)	16:24:07	16:25:07
5 min recovery (sitting)	16:25:14	16:30:14
5 min mental stress (count down at a 7-pace)	16:31:30	16:36:30
Approximately end of ECG-derivation	16:37:00	
School bell ringing	16:15:14 16:20:10	

Time Protocol **2BK (LT/PE): 4:40pm-6:20pm**	**Commencement**	**Cessation**
Start physiological recording (all ECG applied)		
30 min PE or rhythmic education	17:06:00	17:35:00
5 min baseline	17:36:38	17:41:38
Respiration exercise (instruction)		
5 min slow breathing (breathing rate: 6/min = respiratory rhythm of 10 sec)	17:42:51	17:47:51
5 min fast breathing (breathing rate: 12/min = respiratory rhythm of 5 sec)	17:48:35	17:53:35
Uprise before knee bending	17:56:29	
1 min knee bending (KB)	17:56:46	17:57:46
5 min recovery (sitting)	17:57:50	18:02:50
5 min mental stress (count down at a 7-pace)	18:03:06	18:08:06
Approximately end of ECG-derivation	18:10:00	
School bell ringing	18:05:12	

7.5.2 Second pre-test

April 15th, 2008

Time Protocol **1AK (NLT/PE): 11:40am-1:20pm**	**Commencement**	**Cessation**
Start physiological recording (all ECG applied)	12:08:00	
30 min PE or rhythmic education	No data	
5 min baseline	12:09:00	12:14:00
Respiration exercise (instruction)		
5 min fast breathing (breathing rate: 12/min = respiratory rhythm of 5 sec)	12:14:30	12:19:30
5 min slow breathing (breathing rate: 6/min = respiratory rhythm of 10 sec)	12:20:30	12:25:30
Uprise before knee bending	12:26:00	
1 min knee bending (KB)	12:26:10	12:27:10
5 min recovery (sitting)	12:27:25	12:32:25
5 min mental stress (count down at a 7-pace)	12:32:40	12:37:40
Approximately end of ECG-derivation		
School bell ringing	12:30:10 12:35:10	

Time Protocol **1BK (NLT/RE): 1:20pm-3:00pm**	**Commencement**	**Cessation**
Start physiological recording (all ECG applied)	13:44:00	
30 min PE or rhythmic education	13:45:00	14:15:00
5 min baseline	14:15:10	14:20:10
Respiration exercise (instruction)	14:20:00	
5 min slow breathing (breathing rate: 6/min = respiratory rhythm of 10 sec)	14:20:40	14:25:40
5 min fast breathing (breathing rate: 12/min = respiratory rhythm of 5 sec)	14:26:45	14:31:45
Uprise before knee bending	14:32:20	
1 min knee bending (KB)	14:32:30	14:33:30
5 min recovery (sitting)	14:33:30	14:38:30
5 min mental stress (count down at a 7-pace)	14:38:40	14:43:40
Approximately end of ECG-derivation		
School bell ringing	14:25:15 14:30:15	

Time Protocol **Hak+ (LT/RE): 3:00pm-4:40pm**	**Commencement**	**Cessation**
Start physiological recording (all ECG	15:20:00	

applied)		
30 min PE or rhythmic education		
5 min baseline	15:49:50	15:54:50
Respiration exercise (instruction)	15:55:00	
5 min fast breathing (breathing rate: 12/min = respiratory rhythm of 5 sec)	15:55:20	16:00:20
5 min slow breathing (breathing rate: 6/min = respiratory rhythm of 10 sec)	16:01:40	16:06:40
Uprise before knee bending	16:07:20	
1 min knee bending (KB)	16:07:40	16:08:40
5 min recovery (sitting)	16:08:45	16:13:45
5 min mental stress (count down at a 7-pace)	16:14:15	16:19:15
Approximately end of ECG-derivation		
School bell ringing	16:15:10 16:20:10	

Time Protocol **2BK (LT/PE): 4:40pm-6:20pm**	**Commencement**	**Cessation**
Start physiological recording (all ECG applied)	16:55:21	
30 min PE or rhythmic education		
5 min baseline	16:55:21	17:00:21
Respiration exercise (instruction)	17:00:40	17:01:00
5 min slow breathing (breathing rate: 6/min = respiratory rhythm of 10 sec)	17:01:02	17:06:02
5 min fast breathing (breathing rate: 12/min = respiratory rhythm of 5 sec)	17:07:10	17:12:10
Uprise before knee bending	17:12:48	
1 min knee bending (KB)	17:12:50	17:13:50
5 min recovery (sitting)	17:14:02	17:19:02
5 min mental stress (count down at a 7-pace)	17:19:49	17:24:49
Approximately end of ECG-derivation		17:42:31
School bell ringing	17:10:12 17:15:13	

7.5.3 First post-test

May 27th, 2008

Time Protocol **1AK (NLT/PE): 11:40am-1:20pm**	**Commencement**	**Cessation**
Start physiological recording (all ECG applied)	12:16:35	
30 min PE or rhythmic education	12:18:50	

5 min baseline	12:44:04	12:49:04
Respiration exercise (instruction)		
5 min fast breathing (breathing rate: 12/min = respiratory rhythm of 5 sec)	12:49:20	12:54:20
5 min slow breathing (breathing rate: 6/min = respiratory rhythm of 10 sec)	12:56:14	13:01:14
Uprise before knee bending	13:01:45	
1 min knee bending (KB)	13:02:00	13:03:00
5 min recovery (sitting)	13:03:40	13:08:40
5 min mental stress (count down at a 7-pace)	13:09:58	13:14:58
Approximately end of ECG-derivation	13:19:34	
School bell ringing		

Time Protocol **1BK (NLT/RE): 1:20pm-3:00pm**	**Commencement**	**Cessation**
Start physiological recording (all ECG applied)	13:50:56	
30 min PE or rhythmic education	13:55:00	
5 min baseline	14:18:45	14:23:45
Respiration exercise (instruction)	14:23:47	
5 min slow breathing (breathing rate: 6/min = respiratory rhythm of 10 sec)	14:24:05	14:29:05
5 min fast breathing (breathing rate: 12/min = respiratory rhythm of 5 sec)	14:30:39	14:35:39
Uprise before knee bending	14:36:37	
1 min knee bending (KB)	14:36:50	14:37:50
5 min recovery (sitting)	14:38:18	14:43:18
5 min mental stress (count down at a 7-pace)	14:43:59	14:48:59
Approximately end of ECG-derivation	14:54:44	
School bell ringing	14:25:06	

Time Protocol **Hak+ (LT/RE): 3:00pm-4:40pm**	**Commencement**	**Cessation**
Start physiological recording (all ECG applied)	15:17:24	
30 min PE or rhythmic education	15:20:09	15:49:30
5 min baseline	15:51:49	15:56:49
Respiration exercise (instruction)	15:56:49	
5 min fast breathing (breathing rate: 12/min = respiratory rhythm of 5 sec)	15:57:06	16:02:06
5 min slow breathing (breathing rate: 6/min = respiratory rhythm of 10 sec)	16:03:05	16:08:05
Uprise before knee bending	16:11:44	
1 min knee bending (KB)	16:11:52	16:12:52

5 min recovery (sitting)	16:12:54	16:17:54
5 min mental stress (count down at a 7-pace)	16:18:25	16:23:25
Approximately end of ECG-derivation	16:29:44	
School bell ringing	16:15:07 16:20:04	

Time Protocol **2BK (LT/PE): 4:40pm-6:20pm**	**Commencement**	**Cessation**
Start physiological recording (all ECG applied)	16:56:24	
30 min PE or rhythmic education	16:59:09	17:25:09
5 min baseline	17:25:54	17:30:54
Respiration exercise (instruction)	17:30:55	
5 min slow breathing (breathing rate: 6/min = respiratory rhythm of 10 sec)	17:31:22	17:36:22
5 min fast breathing (breathing rate: 12/min = respiratory rhythm of 5 sec)	17:37:28	17:42:28
Uprise before knee bending	17:42:53	
1 min knee bending (KB)	17:43:15	17:44:15
5 min recovery (sitting)	17:44:24	17:49:24
5 min mental stress (count down at a 7-pace)	17:50:14	17:55:14
Approximately end of ECG-derivation	18:00:34	
School bell ringing	17:10:08	

7.5.4 Second post-test

June 10th, 2008

Time Protocol **Hak+ (LT/RE): 12:30am-13:30pm** *(supplementary recording for some students from Hak+ class (2CK girls)*	**Commencement**	**Cessation**
Start physiological recording (all ECG applied)	12:35:00	
30 min PE or rhythmic education		
5 min baseline	12:46:00	12:51:00
Respiration exercise (instruction)	12:54:15	12:54:55
5 min fast breathing (breathing rate: 12/min = respiratory rhythm of 5 sec)	12:55:01	13:00:01
5 min slow breathing (breathing rate: 6/min = respiratory rhythm of 10 sec)	13:00:57	13:05:57
Uprise before knee bending	13:06:51	13:06:59
1 min knee bending (KB)	13:07:08	13:08:08
5 min recovery (sitting)	13:08:17	13:13:17

5 min mental stress (count down at a 7-pace)	13:13:40	13:18:40
Approximately end of ECG-derivation	13:23:45	
School bell ringing		

Time Protocol **1BK (NLT/RE): 1:20pm-3:00pm**	**Commencement**	**Cessation**
Start physiological recording (all ECG applied)		
30 min PE or rhythmic education	13:35:10	14:10:00
5 min baseline	14:12:00	14:17:00
Respiration exercise (instruction)	14:17:00	
5 min slow breathing (breathing rate: 6/min = respiratory rhythm of 10 sec)	14:17:20	14:22:20
5 min fast breathing (breathing rate: 12/min = respiratory rhythm of 5 sec)	14:23:30	14:28:30
Uprise before knee bending	14:28:50	
1 min knee bending (KB)	14:29:00	14:30:00
5 min recovery (sitting)	14:30:01	14:35:01
5 min mental stress (count down at a 7-pace)	14:35:20	14:40:20
Approximately end of ECG-derivation	14:45:41	
School bell ringing	14:25:10 14:30:10	

Time Protocol **Hak+ (LT/RE): 3:00pm-4:40pm**	**Commencement**	**Cessation**
Start physiological recording (all ECG applied)		
30 min PE or rhythmic education	15:30:00	
5 min baseline	15:58:00	16:05:00
Respiration exercise (instruction)	16:05:00	
5 min fast breathing (breathing rate: 12/min = respiratory rhythm of 5 sec)	16:05:20	16:10:20
5 min slow breathing (breathing rate: 6/min = respiratory rhythm of 10 sec)	16:11:58	16:16:58
Uprise before knee bending	16:18:00	
1 min knee bending (KB)	16:18:15	16:19:15
5 min recovery (sitting)	16:19:25	16:24:25
5 min mental stress (count down at a 7-pace)	16:24:50	16:29:50
Approximately end of ECG-derivation	16:35:00	
School bell ringing	16:15:10 16:20:10	

Time Protocol	**Commencement**	**Cessation**

2BK (LT/PE): 4:40pm-6:20pm		
Start physiological recording (all ECG applied)		
30 min PE or rhythmic education	17:03:00	17:25:00
5 min baseline	17:25:20	17:30:20
Respiration exercise (instruction)	17:30:20	17:30:30
5 min slow breathing (breathing rate: 6/min = respiratory rhythm of 10 sec)	17:30:30	17:35:30
5 min fast breathing (breathing rate: 12/min = respiratory rhythm of 5 sec)	17:36:50	17:41:50
Uprise before knee bending	17:42:25	
1 min knee bending (KB)	17:42:40	17:43:40
5 min recovery (sitting)	17:43:45	17:48:45
5 min mental stress (count down at a 7-pace)	17:49:20	17:54:20
Approximately end of ECG-derivation	18:00:00	
School bell ringing		

7.6 Mental Stress Task

Rückwärtszählen in 7er Schritten **Nummer:** _____
Welche Zahlen stimmen? Bitte streichen Sie die falschen durch

1111

1104	963	824
1096	957	817
1090	951	807
1083	943	800
1074	938	796
1069	926	788
1063	922	781
1054	915	775
1046	907	768
1041	900	761
1034	893	755
1028	887	747
1021	879	740
1013	873	730
1007	869	726
999	859	717
991	850	710
985	846	705
978	838	697
969	830	691

Rückwärtszählen in 7er Schritten **Nummer:** _____
Welche Zahlen stimmen? Bitte streichen Sie die falschen durch

1413

1407	1266	1128
1399	1259	1118
1391	1251	1112
1385	1243	1104
1378	1238	1098
1369	1231	1089
1364	1224	1084
1358	1215	1077
1351	1210	1070
1345	1200	1060
1336	1197	1056
1330	1190	1048
1322	1182	1042
1315	1177	1035
1307	1168	1029
1301	1160	1021
1295	1153	1014
1288	1147	1005
1280	1140	1000
1275	1132	993

Curriculum Vitae

Persönliches

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Ausbildung

11 / 2008	Ausbildung Sportpsychologie und Mental Training
10 / 2001	Studium der Psychologie an der Hauptuniversität Wien
1995 - 1999	BORG St. Johann im Pongau
1991 - 1995	Hauptschule Großarl
1987 - 1991	Volksschule Großarl

Berufliche Tätigkeiten und Praktika

Seit Oktober 2008	Ordinationsassistentin
Seit August 2008	Taekwondo Verein Kampfkunstforum Wien
04 / 2008 – 06 / 2008	Jugendrotkreuz
08 / 2007 – 04 / 2008	Info Research Marktforschung
03 / 2007 – 07 / 2007	Praktikum am Umwelthygieneinstitut der Medizinischen Universität Wien
2000 - 2006	Diverse Ferialarbeiten und Nebenbeschäftigungen

Auslandsaufenthalte

7 / 2006 bis 2 / 2007	Auslandsstudium an der Universität Melbourne, Australien
Herbst 1999 bis 2000	AU PAIR in New York, USA