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Doctoral thesis abstract

Monitoring of Cardiovascular System in Exercising for Health Applying Endurance, Strength Tasks or Multimodal Exercise Programs

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1. BACKGROUND AND OBJECTIVES

Cardiovascular diseases (CVD) remain the leading cause of mortality worldwide, accounting for nearly 20 million deaths in 2022, representing approximately 32% of global mortality. Projections indicate that between 2025 and 2050, the prevalence of CVD may increase by up to 90%, with overall mortality expected to rise by 73.4% (Chong et al., 2025). Regular physical activity has been consistently associated with a reduced risk of CVD and premature death (Pavlović et al., 2022). Although numerous forms of physical activity have been shown to provide general health benefits, there is limited understanding of their specific and differential effects on the CVD, particularly in relation to both acute responses and long-term adaptations (Egan & Sharples, 2023). Nevertheless, despite continuous advancements in exercise-based interventions, rigorous evaluation of their effectiveness, physiological impact, and safety remains essential (Pelchovitz et al., 2012). Traditional monitoring approaches often rely on single physiological parameters, which may not adequately reflect the complex interactions between cardiovascular and neuromuscular systems during exercise and recovery. Recent advances in electrocardiographic (ECG) analysis, including algebraic data cointegration methods, enable the assessment of dynamic relationships between ECG parameters and may provide a more sensitive evaluation of functional adaptations. Therefore, this doctoral dissertation aimed to determine the peculiarities of cardiovascular changes during endurance, strength tasks, or multimodal exercise programmes applied for health-promoting purposes.

2. METHODS

This study was conducted at the Institute of Sport Science and Innovations of the Lithuanian Sports University following approval from the Lithuanian Bioethics Committee (Approval No. 2020-01-23, Ref. L-20-1/2). All procedures complied with the Declaration of Helsinki, and written informed consent was obtained from all participants. A total of 72 physically inactive male participants aged 20–35 years were enrolled and allocated into three groups according to exercise modality: endurance (n = 24), strength (n = 26), and multimodal (n = 22). None of the participants had engaged in structured physical training during the previous three years. The study evaluated both acute adaptation (following a single 60-minute training session (TS)) and long-term adaptation (after a 6-week supervised exercise programme (EP) performed three times per week). Training modalities included endurance exercise performed at 70–85% of heart rate (HR) reserve, strength training at approximately 70% of one-repetition maximum (1RM), and multimodal training combining aerobic exercise (70–85% HR reserve) with resistance exercise at up to

50% 1RM. Exercise intensity was individually prescribed and progressively adjusted. Measurements included anthropometric assessment, physical activity evaluation using the Global Physical Activity Questionnaire (GPAQ), arterial blood pressure, 12-lead electrocardiography (HR, JT interval, ST segment, QRS complex). Data were analysed using mixed-design ANOVA, Pearson correlation analysis, and an algebraic co-integration method. Statistical significance was set at $p < 0.05$.

3. RESULTS

Study I (ACUTE adaptation): Endurance TS induced the most pronounced HR responses during the Ruffier dosed workload, with significantly higher baseline (from 69.7 ± 5.6 bpm to 90.3 ± 3.6 bpm, $p < 0.05$), maximal (from 123.0 ± 5.7 bpm to 134.0 ± 3.2 bpm, $p < 0.05$), and second-minute recovery (from 69.9 ± 5.5 bpm to 91.0 ± 5.8 bpm, $p < 0.05$) compared values between pre-TS and 45-min after TS and lower second-minute recovery values after 24 h (from 84.6 ± 7.6 bpm to 69.0 ± 1.7 bpm, $p < 0.05$), whereas strength and multimodal TS demonstrated stable HR dynamics without significant changes. Similar tendencies were observed in DiskRR–JT: endurance TS resulted in a significant increase during the first-minute recovery after 24 h (from 0.21 ± 0.02 to 0.28 ± 0.02, $p < 0.05$), strength TS showed no significant alterations across time points, and multimodal TS revealed a significant increase at second-minute recovery post-TS (from 0.31 ± 0.01 to 0.35 ± 0.01, $p < 0.05$), while maximal responses remained largely unchanged. **Study II (LONG-TERM adaptation):** After six weeks of EP, HR responses during the Ruffier dosed workload remained largely stable across endurance, strength, and multimodal programmes, with no statistically significant changes observed, although endurance EP showed a tendency towards lower maximal HR and slightly improved recovery dynamics, while strength and multimodal EP demonstrated only small or negligible effect sizes. In contrast, DiskRR–JT responses were more sensitive to training adaptations: endurance and strength EP elicited significant increases during the first-minute recovery (from 0.21 ± 0.02 to 0.27 ± 0.01 and from 0.17 ± 0.02 to 0.23 ± 0.02, $p < 0.05$) with moderate-to-large effect sizes, whereas multimodal EP resulted in significant reductions during recovery phases (1st minute of recovery from 0.36 ± 0.01 to 0.29 ± 0.02; 2nd minute of recovery from 0.31 ± 0.01 to 0.25 ± 0.01, $p < 0.05$).

4. CONCLUSIONS

ECG measurements taken 24 hours after endurance exercise demonstrate more significant residual effects on the cardiovascular system compared to strength or multimodal training sessions. Assessment of the dynamic concatenation (interaction) between ECG parameters proves to be a sensitive method for capturing these residual training effects. Endurance, strength, and multimodal physical activity tasks applied for health promotion induce positive adaptations in both the muscular and cardiovascular systems. In individuals performing multimodal exercises, greater improvements in muscle strength were observed, whereas changes in cardiovascular indicators were not pronounced.

Keywords: Cardiovascular system, physical activity, multimodal exercise

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