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Ultra Short-Term Heart Rate Recovery After Maximal Exercise in Two Different Body Positions in Elite Male Judokas Compared to Students of the Sport Faculty

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A B S T R A C T

Heart Rate Recovery response to exercise has been recognized as a marker of physical fitness. Therefore, the aim of this study was to determine the effects of two different recovery protocols (supine and standing position) on heart rate during the first minute of recovery with a group of elite male judokas and group of students, after maximal progressive treadmill test.

Twenty-four male participants took part in this study, twelve (n=12) judokas (Serbian national team) and twelve (n=12) students as a control group. They were exposed to maximal progressive exercise treadmill test in order to record HR (bpm) during the test and during the first minute of recovery. One-way analysis of variance with repeated measures is used to test the differences between subjects' responses over time. Statistical significance was assessed using ANCOVA and Student's t-test for dependent samples.

HR_{max} was similar in both trials for investigated groups. The results of Student's t test showed significant differences between applied protocols in all HR levels for both groups. In addition, the within subjects effects for supine protocol showed significant differences between groups (F=14.172, P=0.0001), where the group of judokas revealed lower HR than students for 10s and 20s of recovery period (F=18.801 and F=19.668, p<0.01, respectively).

Obtained data could suggest better adaptation to exercise for trained judokas in exerting better potentials with faster recovery HR immediately after the exercise in supine position, consequently revealing better adaptation to training load.

Key words: *Ultra short-term recovery, heart rate, judo, elite athletes*

Introduction

Dynamic exercise is characterized by increase in heart rate and systolic blood pressure. The body's main goal after intensive activity is to return to its previous state in shortest time - that is to recover. HR recovery is defined as the rate at which heart rate decreases to a resting rate after cessation of moderate to heavy exercise (Buchheit et al., 2007). It is usually measured during the first minute after exercise, and is highly correlated with vagal reactivation, especially during the first 30 seconds (Imai et al., 1994). Furthermore, HR recovery values are often taken as one of few indicators commonly used in noninvasive assessment procedures for the determination of cardiovascular parasympathetic function (Cole et al., 1999; Buchheit & Gindre, 2006; Kannankeril et al., 2004; Dewland et al., 2007).

In many competitive sports, performance is based on maintaining high-level physical outputs during repeated bouts (McAinch et al., 2004; Siegler et al., 2006; Spierer et al., 2004). Judo represents a dynamic, high-intensity intermittent sport that requires complex skills for success (Degout et al., 2003). In order to be effective, judo techniques should be applied with accuracy, strength, velocity and power. These short bursts of energy are supplied mainly by anaerobic metabolism. Marcon et al. (2010) in their study reported an average of eleven action sequences per match, with four of them being on the ground. Even though anaerobic power is predominant in judo (for quick and brief power outbursts during match), aerobic capacity is responsible for judokas ability to sustain maximal efforts throughout match as well as to recover during low intensity parts of the match and between matches (Franchini, 2011; Bala & Drid, 2010; Drid et al., 2015). Level of aerobic fitness and different training load changes are some of the variables that can influence on HR response to exercise (Buchheit & Gindre, 2006). However, even though HR is sensitive to change as a response to training load, still there are no clear data, for HRR to be used as an index representing the body's capacity to training respond in different sports (Ostojic et al., 2011). The faster dynamics of the recovery HR is important in judo sport, where athletes have several maximal activities in bout and competition with a brief time for recovery in-between. Up to date, there have been reported different values of HR for elite judo athletes after the maximal treadmill test: 191.1±3.7 (Trivic et al., 2009) opposed to 198.2±0.7 (Degoutte et al., 2003) after a simulated 5 - minute judo match. In addition, a different study reported a first minute HR recovery values to be from 130±10 to 162±10 after a SJFT (*Special Judo Fitness Test),* (Franchini et al.,

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2007). To our knowledge, no investigation in short terms of HRR was conducted on judo athletes yet.

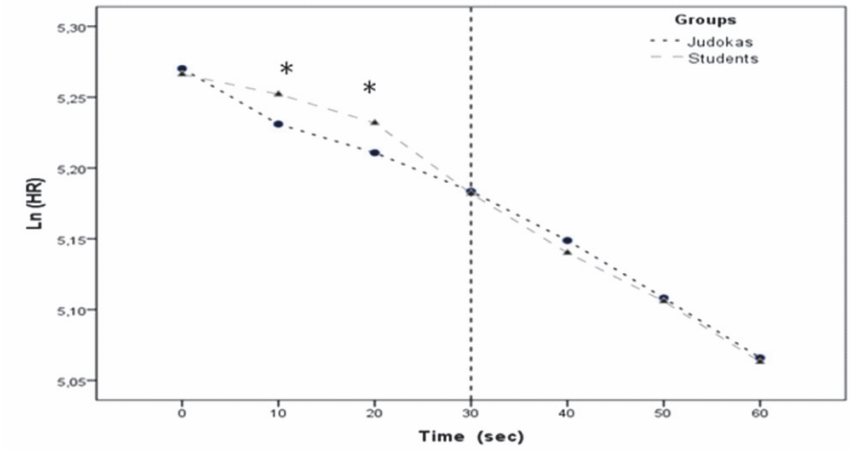
A proper post-exercise cool-down period is an essential part of any workout in order to avoid hypotension (*i.e.* post-exercise hypotension is common after moderate-intensity dynamic exercise). Different authors suggest the use of both active and a passive recovery, seeing as both help facilitate venous blood flow back towards the heart (Crisafulli et al., 2003). The active and passive recoveries take different approaches to providing the nutrient rich blood that enhances energy regeneration and removal of lactate or H^+ ions (Larson et al., 2013). Due to a structure movement in sport, athletes should select the most adequate position that ensures the most effective recovery. In a standing position, gravity significantly affects the distribution of the blood volume in the body (Takahashi et al., 2000). On the other hand, in a supine position, a balanced distribution of blood causes weaker peripheral resistance. Parasympathetic activity and weaker resistance cause the heart to have a lower heart rate and higher stroke volume (Takahashi et al., 2000).

Since competitive judo has actions in standing position and some of them being on the ground, the aim of this study was to determine and compare the effects of two different recovery protocols (supine and standing position) on heart rate during the first minute of recovery with elite male judokas and group of students.

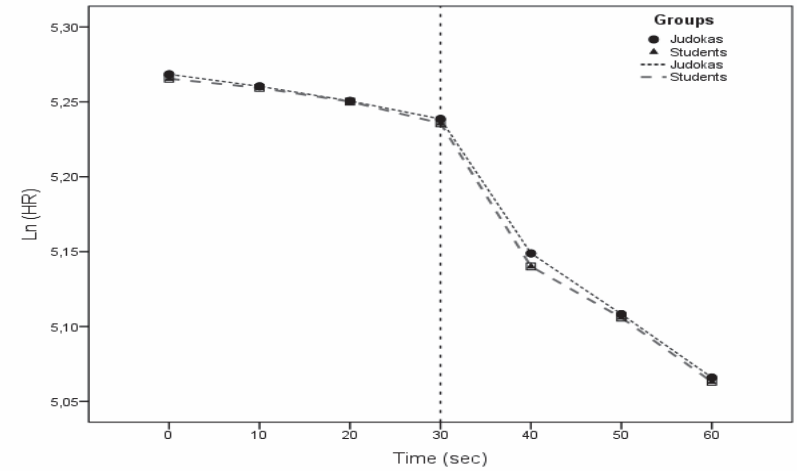
Methods

Study sample

Measurements took place at the time of competitive preparation period for judokas. Twenty-four (N=24) healthy, young, male athletes participated in this study. Athletes were divided into two groups. First group consisted of Serbian university judokas national team (n = 12; age: 20.33±3.70 years; height: 176.95±7.43 cm; weight: 78.62±15.65 kg; BMI: 24.93±3.33 kg/m^2). Second group consisted of students (n = 12; age: 20.58±0.79 years; height: 182.92±6.20 cm; weight: 81.32 ±11.15 kg; BMI: 24.28±2.92 kg/m^2) of the Faculty of Sport and Physical Education (FSPE) as a control group.



Graph 1. Natural log-transformed heart rate (HR) with data averaged across participants during recovery in supine position following the maximal exercise in judokas and group of students (with statistical significance in 10s and 20s, $p<0.01$)



Graph 2. Natural log-transformed heart rate (HR) with data averaged across participants during recovery in standing position following the maximal exercise in judokas

All the subjects underwent a maximal progressive test on treadmill for measuring maximal oxygen uptake. Judo athletes had a mean value of absolute oxygen uptake (VO_{2max}): 3.90±0.59 ml min^{-1}, relative oxygen uptake ($VO_{2max/kg}$): 51.13±3.34 ml kg^{-1}min^{-1}, whereas students had VO_{2max} values 3.47±0.60 ml min^{-1} and $VO_{2max/kg}$ values 42.4±4.85 ml kg^{-1}min^{-1}. At the time of the study,

none of the university students was a professional athlete. The level of their physical fitness reflected in the regular program's curriculum of third year activity on FSPE in summary of 180 minutes activity per week: including swimming (2x45 min/week) and judo (1x90 min/week). The intensity workload for group of students was low to moderate, and involved basic training for swimming and judo (*i.e.* learning techniques). Elite judokas had 12 training sessions per week (4 - physical preparation and 8 - judo combined training) in duration of 90 min per session in a competitive preparation period.

Study protocol

The experimental protocol consisted of two sessions performed on separate days. Twenty-four hours prior to both testing, subjects were instructed to perform no strenuous exercise, not to consume alcohol nor caffeine beverages, and to have a solid night's rest between 8 and 10 hours. One week prior to testing subjects performed Spiro-ergometry test to familiarize with the testing procedure. Afterward, each participant took two maximal graded exercise tests on a treadmill - TSR protocol – that included 0.5 km/h speed increments every 30 seconds, until exhaustion, on treadmill T-170 (COSMED, Italy) with a breath-by-breath gas analyzer (CPET, Italy), and five days between two measurements.

The University Ethic Committee approved the protocols. Basic measurements were undertaken in a quiet room, air temperature ranging from 22-25ºC between 9 a.m. and 13 p.m. Before the experimental session, body mass and height were obtained for each participant.

For gathering data on heart rate, following variables was recorded: Maximal heart rate (HRmax; bpm), and HR recovery period for 60s in 10s intervals (HRR 10, 20, 30, 40, 50, 60 s) in standing and supine position at the end of test. HR was recorded using a HR monitor at beat-to-beat interval (wireless Cosmed HR monitor, Italy). For data on oxygen consumption, we recorded maximal oxygen uptake (VO_2max; ml/min) and relative oxygen uptake (VO_2/kg; ml/min/kg), as the highest average 30 seconds' values.

Statistical procedures

One-way analysis of variance with repeated measures was used to test the differences between subjects' responses over time. Statistical significance was assessed using Student's t-test for dependent samples. The HR data were transformed in natural logarithm values. P values less than 0.05 were considered statistically significant. The data were analyzed using the statistical package SPSS, PC program, version 20.0 (IBM Inc., USA).

Results

The time between exercise cessation and undertaking supine body position was similar for both group of subjects (4.9±1.7 s and 5.1±1.3 s for judokas and student group, respectively). In addition, HR recorded at the end of exercise (*i.e.,* the start of recovery) was similar for both groups and protocols. The results of Student's t-test for dependent samples showed that in both groups there were significant differences found between applied protocols for all HR values (Graph 1), except for starting level (HRmax). Furthermore, the within subjects effects for supine protocol showed significant differences between groups ($F = 14.172$, $P = 0.0001$). Analysis of covariance revealed lower HR values ($F = 18.801$ and $F = 19.668$, $p<0.01$, respectively) in judokas compared to students for 10s and 20s of supine recovery period (Graph 2). However, no differences between two groups were found at later stages of the analyzed HRR for supine position. In contrast, no differences between recovery HR for judokas and students were found in standing position (Graph 2). Supine protocol proofed as superior compared to standing protocol for both groups.

Discussion

To our knowledge, this is the first study that directly reveals the influence of two different body positions on the ultra short-term post exercise HR in judokas. It is recognized that HR recovery after exercise represents the reactivation of parasympathetic activity and a reduction in sympathetic activity that typically occurs during the 30 sec after exercise (Carreira et al., 2013). The general finding of present study is that body position influences the speed of recovery in heart rate during recovery after exercise, especially in first 30 seconds. Comparing two protocols, slower HRR results are shown for both groups in the standing recovery compared to recovery in supine position for the first minute of recovery for all tested subjects. This is not surprising, given the fact that in supine position, blood is being redistributed towards the heart-increasing preload, where the increased central blood volume imposes a greater vagal activation and reduces heart rate and cardiac output, leading to a faster decrease of HR values (Takahashi et al., 2000).

Present study showed significant differences between groups for supine recovery protocol, where judokas revealed significantly lower ($p < 0.01$) HR values in 10s and 20s of the observed recovery. Up to date, only few recent researches dealt with athletes in ultra short-terms for heart rate recovery (UST-HRR) for supine recovery position only (Ostojic et al., 2010, 2011) with elite and non-elite athletes. Findings of present study are partially in line with previous ones obtained (Barak et al., 2011; Buchheit, 2006; Olguin et al., 2013; Ostojic et al., 2011) who reported faster HRR after exercise test in supine recovery, particularly over the first 10 and 20s. Similar to our study, Buchheit et al. (2009) reported that lying supine during recovery, might be an effective way of transiently restoring HR and vagal modulation after the exercise. The results obtained for supine recovery applied in this study gave better recovery for both groups, and thus might have its practical use, especially in sport such as judo for having parts of bouts in ground floor.

Finally, the limitations of the present study should be taken into consideration. Firstly, a relatively small number of tested subjects could lead to overestimation of describing the differences between judokas and group of students in post-exercise HRR. The passive recovery protocol applied in this study has been used frequently in the past (Ostojic et al., 2011; Shetler et al., 2002; Javorka et al., 2001) but it does not reflect the real situation during judo competition. Secondly, the use of different tests, more specific to judo demands (*i.e.* SJFT or arm Wingate test, Franchini et al., 2009) could be more appropriate in obtaining results that more clearly could describe mechanisms that occurs during judo matches (Drid et al., 2009; Stojanovic et al., 2009; Drid et al., 2012) Finally, the present study is only descriptive and does not address any of the possible physiological mechanism of the observed phenomenon. Further investigation should include tests that are more specific to judo sport, including athletes of different gender and weight categories.

Judokas had faster HRR decrease in supine position immediately after the exercise test, particularly over the first 10 and 20 seconds. These findings might suggest that trained judokas could be better adapted to exercise exerting better potentials with faster recovery HR immediately after the exercise in supine position

revealing better adaptation to training load. Even though recovery in supine position is associated with accelerated HRR, faster lactate elimination is associated with recovery in standing position, which is more relevant in development of judokas individual tactical performance. The choice of adequate athlete's recovery should be left to coaches, as long as they rely on scientific achievements in this field, regarding individual characteristics of the athletes as well as a structure demand of sport activity.

Statement

Authors hereby declare no conflict of interests, and have no funds to report. This paper has not been send elsewhere for publishing.

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