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Effects of an inverted seated position on single and sustained isometric contractions and cardiovascular parameters of trained individuals

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ABSTRACT

Previous research demonstrated higher maximal voluntary contraction (MVC) force with upright vs. inverted positions in untrained individuals. The purpose was to determine the effects of inversion on force, activation, and cardiovascular responses before and following fatigue in trained individuals. Twelve male athletes completed two trials: upright and inverted seated positions. At baseline (upright), either leg extension (LE) or elbow flexion (EF) evoked contractile properties and MVCs were performed. LE and EF contractions were randomly allocated and performed in separate sessions. The subject was then positioned for 150 s in each posture, followed by a 30 s MVC (MVC30). During each trial, stroke volume (SV), cardiac output (Q), heart rate (HR), time and frequency domain HR variability measures and mean arterial blood pressure (MAP) measurements were recorded. ANOVA showed no statistical differences in EF MVC force, but a tendency ($p = .12$) for LE MVC decline with inversion vs. upright. Evoked resting ($p = .1$) and potentiated peak twitch ($p = .04$) force were increased with inverted LE but tended to diminish with inverted EF ($p = .06$ and $p = .1$). Force–fatigue, electromyography–fatigue relationships and HR variability during MVC30 fatigue were not affected. HR and Q were significantly ($p = .01$) lower with inversion following both LE and EF fatigue. Compared to the significant inversion-induced changes associated with untrained individuals in previ-

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ously published studies, the lack of postural changes in resting force and CV measures may demonstrate that highly trained individuals adapt better to inversion.

1. Introduction

In addition to the predominant upright posture, humans may voluntarily become inverted during sporting (gymnastics), recreation (zip line) and professional (e.g., military pilot) activities or involuntarily with vehicle accidents (e.g., buses, helicopters). Previous research has demonstrated that an inverted seated position can lead to impairments of maximal voluntary contraction (MVC) force, EMG activity, heart rate and blood pressure (Hearn, Cahill, & Behm, 2009; Johar, Grover, DiSanto, Button, & Behm, 2013; Paddock & Behm, 2009). Collectively these authors suggest that these responses may be related to altered sympathetic nervous stimulation. Since only these three studies have investigated the responses to full seated inversion, further work is necessary to elucidate a greater range of physiological responses. Are the previously reported reductions in heart rate and blood pressure related to changes in stroke volume, cardiac output, heart rate variability, and mean arterial pressure? Are these parameters changed to a greater or lesser degree when an additional stress such as muscle fatigue is combined with inversion?

The previous three inversion studies utilized recreationally active individuals (Hearn et al., 2009; Johar et al., 2013; Paddock & Behm, 2009). An inverted position places unfamiliar stresses on the cardiovascular system, which may impact other physiological systems (i.e., neuromuscular responses). Since aerobically trained individuals tend to have greater cardiovascular capacities and responses (Midgley, McNaughton, Polman, & Marchant, 2007), the impact of an inverted position may not be as stressful to this population. If true, a prior background of general aerobic training might alleviate some of the neuromuscular impairments reported with inversion (i.e., decreased muscle activation and force).

The purpose of this study was to determine whether cardiovascular (heart rate, stroke volume, cardiac output, time and frequency domains of heart rate variability, mean arterial pressure) and neuromuscular (leg extension and elbow flexion muscle force, activation and fatigue) changes do occur when inverted with trained individuals. It was hypothesized that an inverted seated position would not decrease muscle force and activation and accelerate fatigue with trained individuals. Furthermore, if an inverted position inhibits sympathetic stimulation then it was hypothesized that in the present study cardiovascular measures such as the time and frequency domains of heart variability would be affected.

2. Materials and methods

2.1. Subjects

Twelve well-trained male athletes (average height = 183.41 ± 9.71 cm, weight = 82.15 ± 17.10 kg, age = 22.5 ± 1.6 years) volunteered to participate in this study. Subjects were recruited from the Memorial University of Newfoundland varsity cross-country running team, local soccer and track and field teams. All subjects were free of physical injuries, had no previous history of hypertension or cerebral-related conditions or joint and bone problems as determined by completion of the Physical Activity Readiness Questionnaire (PAR – Q) (Canadian Society for Exercise Physiology, 2003). All testing was performed in the School of Human Kinetics and Recreation Applied Physiology research laboratory and participants were fully informed of the procedures, gave written informed consent, and in accordance with Memorial University's Human Investigation Committee, university approval was obtained.