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Original article

The immediate effect of atlanto-axial high velocity thrust techniques on blood flow in the vertebral artery: A randomized controlled trial☆

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ABSTRACT

Background: High velocity thrust (HVT) cervical techniques have been associated with serious vertebral artery (VA) trauma. Despite numerous studies, the nature of this association is uncertain. Previous studies have failed to demonstrate haemodynamic effects on the VA in simulated pre-thrust positions. No study has investigated haemodynamic affects during or immediately following HVT, nor sufficiently controlled for the influence of the thrust.
Objectives: To investigate the immediate effects of HVT of the atlanto-axial joint upon haemodynamics in the sub-occipital portion of the vertebral artery (VA3).
Design: Randomized Controlled Trial.
Method: Twenty-three healthy participants (14 women, 9 men; mean age 40, range 27–69 years of age) were randomly assigned to two groups: an intervention group (MANIP, $n = 11$) received HVT to the atlanto-axial segment whilst a control group (CG, $n = 12$) was held in the pre-manipulative hold position. Colour-flow Doppler ultrasound was used to measure VA3 haemodynamics. Primary outcome measures were peak systolic (PSV) and end diastolic velocities (EDV) of three cardiac cycles measured at neutral (N1), pre-HVT (PreMH), post-HVT (PostMH), post-HVT-neutral (N2) positions.
Results: Test-retest reliability for the Doppler measures demonstrated intra-class correlation coefficient (ICC) of 0.99 (95% CI 0.98–1.0) for PSV and 0.91 (95% CI 0.84–0.96) for EDV. Visually, EDV were lower in the MANIP group than in the CONTROL group across the four measurements. However, there were no significantly different changes (at $p \leq 0.01$) between the MANIP and CONTROL groups for any measurement variable.
Conclusions: HVT to the atlanto-axial joint segment does not affect the haemodynamics of the sub-occipital portion of the vertebral artery during or immediately following HVT in healthy subjects.
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1. Introduction

High velocity thrust (HVT) of the spinal joints has been a part of physical therapy practice since the early 1800's in Europe and the 1920's in America (Pettman, 2006). HVT is included in the pre-professional curricula in the United States, is commonly used in the clinical setting, and its effectiveness has been demonstrated in comparative studies, albeit with a moderate quality of evidence (Miller et al., 2010). HVT of the atlanto-axial joint is utilized by physical therapists to decrease pain and increase range of motion in the upper cervical spine (Yu et al., 2011). Further, effects on the autonomic nervous system, sensory system, and disability levels

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have been identified (e.g. Martinez-Segura et al., 2006; Dunning and Rushton, 2009). Important neural and vertebral structures lie in close proximity to the atlanto-axial joint, theoretically introducing a level of neurovascular risk with HVT of this articulation, e.g. arterial dysfunction leading to central ischaemia. Therefore, use of this technique should be based upon sound clinical reasoning: a thorough physical therapy examination, an evidence-based interpretation of the clinical state and circumstances, patient preferences and actions, and the research literature (Rushton et al., 2012, 2013).

The estimated risk of serious complications resulting from HVT of the cervical spine has been reported to range between 1 in 4500 (Dunne et al., 2000) to 6 in10 million (Hurwitz et al., 1996). The precise risk of injury is indeterminable due to the unknown number of unreported cases (Ernst, 2004; Carlesso et al. 2010a) and the paucity of methodologically sound research studies (Kerry et al., 2008). Although the number of patients experiencing minor to moderate adverse events following manual therapy may be as high as 50%, the risk of major adverse events with manual therapy is reported to be low (Carlesso et al., 2010b). Nevertheless, given the limitations of known prevalence and the serious nature of the adverse event, HVT of the upper cervical spine remains a contentious issue (e.g. Cassidy et al., 2012; Wand et al., 2012).

One potential adverse event associated with manual therapy of the atlanto-axial joint is the development of a small tear or lesion (dissection) of the vertebral artery (VA) (Mann and Refshauge, 2001). Multiple factors may increase the risk of events, including anatomical anomalies or hypoplasia of the vertebral arteries, prior injury, and a history of previous ischaemic episodes (Taylor and Kerry, 2010). Biomechanically, cranio-cervical rotation is the movement most likely to be associated with arterial damage, specifically to the VA3 portion of the vessel system (Mitchell, 2009; Malo-Urriés et al., 2012). The VA3 extends from the point of exit from the axis to its entry into the spinal canal, (Roberts and Demetriades, 2001) and is reported to be the structure most vulnerable to mechanical insult and injury (Terrett, 1987; Grant et al., 1994; Refshauge et al., 1995; Macchi et al., 1996; Kuether et al., 1997; Johnson et al., 2000). One underlying concern is that HVT involving rotation may, at least momentarily, alter the velocity of blood flow in one or both of the vertebral arteries. The relationship between alteration of blood flow and adverse event is not fully understood, although flow changes are reported in patients who experience VA stroke (Sturzenegger et al., 1993; Sengelhoff et al., 2008; Baracchini et al., 2010). The mechanistic reasoning for measuring blood flow in relation to adverse events is principled initially in the idea of altered haemodynamics being a fundamental component of vessel pathology (Cecchi et al., 2011). Further, flow change is considered to be indicative of the sorts of mechanical stresses responsible for the type of micro-trauma in question (Mitchell, 2007). Thus blood flow measurement remains a valid procedure to understand vascular tissue stress in the VA.

Clinical relevance is of utmost importance to the practicing physical therapist. In this context, clinical relevance may be described as the net flow volume at or below which patients become symptomatic with vertebrobasilar ischaemia (Bendick and Glover, 1987). Although blood flow volume is the primary measure affecting brain perfusion (Ganong, 2005), the measure of interest in this study was blood flow velocity. Changes in blood flow velocity may be used to reflect changes in volume (Aaslid et al., 1986; Newell and Aaslid, 1992; Mitchell, 2007). Blood flow velocity and volume vary proportionally (Aaslid et al., 1986; Newell and Aaslid, 1992) in part due to the low pulsatility index of the VA, and during normal laminar blood flow the VA internal diameter does not change (Mitchell, 2009). Therefore, blood flow velocity changes from spinal movement can be considered a good indicator of related changes in blood flow volume (Mitchell, 2007).

Previous studies have reported on the nature of blood flow during passive physiological movements such as rotation (Thiel et al., 1994; Haynes, 1995; Mitchell, 2003; Mitchell et al., 2004; Mitchell and Kramschuster, 2008). Although findings have varied, a meta-analysis of the data reported that normal, physiological rotation compromised blood flow in the contralateral vessel (Mitchell, 2009). There are very few studies examining flow in positions more closely associated with HVT. Placing the cervical spine in a simulated HVT position has not been shown to adversely affect blood flow in vertebral arteries (Licht et al., 1998; Licht et al 1999; Bowler et al., 2011). A recent MRI flow study reported no changes in flow after the execution of HVT (Quesnele et al., 2014). Information pertaining to blood flow during a cervical HVT technique may enhance the clinical decision making of the manual physical therapist. Therefore, the purpose of this study is to quantify changes in blood flow velocity in the VA during HVT of the atlanto-axial joint. Based on previous findings, it was hypothesized that in healthy adults, HVT of the atlanto-axial joint would not result in altered blood flow velocity in the VA3 compared to the pre-manipulation hold position.

2. Methods

2.1. Trial design

A placebo-controlled, randomized trial was carried out to investigate the effect of a cervical spine HVT on VA blood-flow. This study was approved by the Institutional Review Board at Pacific University, Forest Grove, Oregon.

2.2. Participants

Twenty-three healthy participants (14 females; 9 males) were recruited from the local community by word of mouth for this study over a period of 4 weeks. The principle investigator reached out in person or by phone to friends and family of clinic staff and current or former patients of the clinic. Participants who agreed to take part reported to Erhardt Physical Therapy and Sports Medicine (an outpatient physical therapy clinic) and were screened for exclusion criteria. Participants were excluded if they had a history of known VA anomalies, hypoplasia or previous injury, undiagnosed dizziness, hypertension (140/90 or greater), head or neck trauma within the last six weeks, known upper or mid-cervical instability, recent cervical spine HVT, prior cervical spine surgery, or cerebrovascular events of any kind. Participants were also excluded if they had a history of cervical spinal cord compression, osteoporosis, were currently pregnant, or reported a history of current or previous systemic steroid intake or prescription anticoagulants, chronic upper respiratory infection, cancer, trisomy 21, Klippel Feil, Erlos Danlos syndrome or any other arthritides in its inflammatory state. Finally, participants were excluded if the VA3 could not be visualized on ultrasound. All participants signed a written informed consent form approved by the Pacific University Institutional Review Board prior to participating in this study. Fig. 1 demonstrates the method process.

2.3. Sample size

Based on previous blood flow data as reported in Bowler et al. (2011), it was calculated that the study would require at least 11 subjects per group. The study used a significance level of 5%; power of 80%; a standard deviation in blood flow velocity of 18 cm/s and a mean percentage change in blood flow velocity of 26%, considering Doppler variation, volume flow rate as a function of average velocity and area, and ultrasound machine variability.

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