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Transverse Forces Associated with Massage-Like Loading Following Eccentric Exercise Injury in a Rabbit Model

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Massage-based therapies are one of the most popular complementary and alternative modalities [1,2]. Despite the growing use of this therapy for a wide variety of clinical problems, the evidence-base for massage efficacy is somewhat contradictory. Additionally, standardized protocols for prescriptions of massage therapy are elusive due partially to the numerous different approaches utilized in studies as well as the lack of quantification of tissue forces associated with the massage sessions [3].

Massage utilizes various techniques, but a combination of compressive and transverse (along the tissue) forces are typically applied. In an effort to advance massage research, our lab has developed a mechanical massage device capable of mimicking Swedish massage while quantifying both compressive and transverse forces applied along the tibialis anterior muscle of rabbits. Previous studies have shown that recovery of muscle function as estimated by joint torque (active properties) following a damaging bout of eccentric exercise (ECC) was dose-dependent on massage parameters (magnitude of force, duration, and frequency of tissue loading) [4]. Furthermore, active property recovery was also dependent on time course of application of massage, wherein massage applied immediately after ECC was more beneficial than massage delayed by 48 hours [5]. As such, in the current study we 1) Investigated the effects of magnitude and frequency on transverse force values and 2) Compared the effects of immediate versus delayed massage on transverse forces following eccentric exercise in our rabbit model.

Animals were subjected to a damaging bout of ECC resulting in 61% and 51% reduction in peak isometric torque in Aims 1 and 2, respectively. In Aim 1, animals were then randomly assigned to an immediate massage protocol with a combination of either 0.25 or 0.5 Hz loading frequency (stroke velocity of 3.1 mm/s or 6.2 mm/s, respectively) at a constant compressive force of either 5 or 10 N. In Aim 2, animals were randomly assigned to massage commencing either immediately after ECC or delayed by 48 hours using the optimal massage parameters (10 N, 0.5 Hz, 15 min) in promoting recovery of joint torque determined from Aim 1. The rabbit's exercised leg was massaged daily for 4 consecutive days in both aims. Transverse forces were measured and the peak-to-peak amplitude was quantified for all animals and massage sessions.

In Aim 1, we observed that resultant transverse forces were inversely proportional to loading frequency (forces decreased with increasing loading frequency) and directly proportional to compressive force (forces increased with increased compressive forces). In Aim 2, we investigated the effects of transverse forces as a function of massage timing, between massage sessions, and between massage conditions (immediate vs. delayed). We observed that transverse forces in the first 5 min were an average 16% and 5% different between days in the immediate and delayed groups, respectively. Transverse forces were an average 10% and 5% different in the second 5 min in the immediate and delayed massage conditions, respectively. Finally, we observed that there was a significant difference for transverse forces between the first massage bout and all subsequent massage bouts in both conditions.

This study showed that forces along the muscle belly during massage were dependent upon the massage stroke velocity, the compressive forces, and the time application of massage. These findings provide the first quantifiable evidence of massage forces applied along the muscle and therefore are a starting point in identifying tissue response to mechanical loading. Studies have recently addressed the physiological benefits of massage in attenuating the inflammatory response following exercise-induced injury [6,7]. Additionally, *in vitro* studies have shown that modifications to the intracellular regulatory signaling pathways are dependent upon the magnitude of tensile strain at the individual muscle fiber level [8]. We believe that the transverse forces associated with massage induce localized tissue strains in the direction of the cyclic strokes applied by our device. In response to these mechanical signals, the intracellular pathways modify gene expression, protein synthesis, and muscle metabolism thereby increasing the release of various growth factors responsible for muscle regeneration and repair [9]. It is also possible that our massage protocol decreases muscle edema [5] and results in faster clearing of inflammatory cells mitigating the secondary injury caused by the inflammatory response [10]. Thus, the transverse forces associated with massage may be an important indicator of muscle recovery following exercise-induced muscle injury. Finally, our work begins to address the issue of prescriptive dosages of massage therapies by quantifying the various forces associated with this therapy.

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