LONG-TERM OVERACTIVITY IN THE ABDOMINAL OBLIQUE MUSCLES AFTER 8 WEEKS BED-REST - POSSIBLE IMPLICATIONS FOR MUSCULOSKELETAL HEALTH.

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ABSTRACT

Changes in the human lumbo-pelvic (LP) muscles with unloading has received little attention in microgravity research, even though this body region has evolved with the development of upright posture in 1-g. This study used a specific movement task to examine the function of four LP muscles during 8-weeks of bed-rest and one-year follow-up. The main finding was the development of overactivity in the abdominal internal oblique muscle in the follow-up period. This finding implies that the L-P muscle changes occurring during bedrest do not recover on return to the 1-g environment. These results may have implications for musculo-skeletal health for those in sedentary lifestyles on Earth.

1. BACKGROUND

The lumbo-pelvic (LP) region of the human body has evolved for erect posture and bi-pedal locomotion under normo-gravity [1]. Out of necessity, the protection of LP structures from injury evolved concurrently. The stabilisation and protection of the LP region is thought to depend upon effective neural control of LP musculature [2]. Studies have shown that different muscles fulfil different tasks in the overall goal of LP stability, specifically a separation between shorter, deeper "local" muscles and larger, broader spanning, "global" muscles [3]. This paper focuses upon the effect of prolonged removal of weight-bearing (e.g. spaceflight, bed-rest) on the body’s ability to stabilise the LP region.

Non-weight bearing has been shown to have a differential effect on a muscle system depending upon its functional role. In bed-rest, the lumbar extensors have been shown to undergo atrophy, whereas the flexor, psoas, does not [4]. This general pattern of greater atrophy in the postural anti-gravity extensors than in the flexors is also evident in the lower-limb [5]. Owing to greater participation in postural control, the soleus muscle atrophies more than the gastrocnemius in response to unloading [6]. Concurrent changes in motor control have been observed in the Rhesus monkey [7]. Hence, whilst a little studied field, prolonged non-weight-bearing could have differential effects on muscles involved in stabilising the LP region. This could also have implications for injury occurrence and low-back health.

The aim of the current investigation was, therefore, to examine the changes of the function of four LP muscles during prolonged (8 weeks) bed-rest and a 1-year follow-up period.

2. MATERIALS AND METHODS

10 male subjects underwent 8-weeks of bed-rest (with no exercise countermeasure) and 1-year follow-up as part of the "Berlin Bed-Rest Study" based at the Charité - Campus Benjamin Franklin, in Berlin, Germany. This study was approved by the institutional ethics committee.

To test muscle function and control, a test involving a standardized movement task of the knee at different speeds was used to elicit activity of the right-sided medial and lateral lumbar erector spinae (mLES and ILES) and the external and internal oblique (EO and IO) muscles. Muscle activity was measured via electromyography. Subjects were positioned in prone with a spring attached to the right ankle to negate the gravitational moment of the lower leg [8]. Straps were placed over the distal thigh and buttocks in order to restrict body motion at these points.

Right knee movement was conducted between zero and forty degrees of flexion at four speeds: 50, 75, 100 and 125 cycles of knee flexion and extension per minute. Knee movement was recorded simultaneously with electromyographic data via use of an electrogoniometer. Tests were performed on specific days of bed-rest (BRn) and recovery (R+n). Root-mean-square (RMS) values for
each muscle were calculated for specific data epochs based upon analysis of goniometric data.

To indicate muscle activity increase over each "step" of increased knee movement speed, ratios of RMS values were calculated between each speed of movement (i.e. 75/50, 100/75, 125/100). "Date clusters" were created from intra- and then inter-testing day median values (Baseline [BR1], early bed-rest [early BR: BR4, BR13], late bed-rest [late BR: BR27, BR41, BR53], early recovery [early REC: R+3, R+7, R+14] and late recovery [late REC: R+28, R+90, R+180, R+360]). Linear mixed models were used in statistical analysis.

3. RESULTS

In the IO muscle, the 125/100 ratio increased from the early BR phase (p=0.011) onwards (late BR, p=0.001; early REC, p<0.001; late REC, p=0.002). The 100/75 showed a trend to be increased in late BR (p=0.08) and was significantly increased in both early REC (p=0.018) and late REC (p=0.001). The 75/50 showed a trend to be increased in late BR (p=0.083) and was significantly increased in both early REC (p=0.008) and late REC (p=0.001).

In the EO muscle, the 125/100 ratio showed a trend to be increased at early REC (p=0.098) and was significantly increased at late REC (p=0.034). The 125/100 ratio of the ILES muscle was increased at both early BR (p=0.008) and late REC (p=0.21). The mLES muscle exhibited no changes.

4. DISCUSSION AND CONCLUSIONS

The primary task of the muscles during our test was stabilisation of the LP region to provide a "stable base" for efficient and rapid movement of the leg. The test was performed in a non-weight-bearing position, rather than in upright posture, and our findings must be understood from these points of view.

The strongest effect observed in this study was a gradual increase IO RMS-activity ratios especially with the re-introduction of weight-bearing. Our interpretation of this finding is that muscle "overactivity" occurs, where greater levels of activity are needed for the demands of the standardised task.

Less consistent changes were observed in the other muscles. The EO muscle showed an increased 125/100 ratio after R+28 and exhibited a trend to increase prior to that. This change could fit into a general pattern of increased "load-sharing" by the abdominal flexors (though specifically the IO). Limited, if any, changes were detected in the mLES and ILES in this particular non-weight-bearing movement task.

Recent findings of abnormal motor control in low-back pain help to understand our findings. Muscle over-activity has been observed in the superficial "global" trunk muscles whereas the deeper musculature show atrophy and delay in activation time. For a review of research in this field, see Richardson and co-workers [9]. Our findings of IO overactivity could imply a greater burden upon this muscle for stabilisation of the lumbar spine. Changes in the deeper musculature are currently under investigation.

Abnormal motor control in LP stabilisation developing during and after bed-rest, without long-term recovery, could be detrimental to long-term low-back health. Furthermore, other inactivity protocols, such as sedentary lifestyle on Earth, could also have these negative health effects.