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THE EFFECT OF COMPLIANT RUNNING ON IMPACT ACCELERATIONS AND ENERGY EXPENDITURE

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This study examined the effect that a compliant running style has on impact accelerations and energy expenditure, in comparison to normal running. Twelve subjects completed a three week familiarization protocol followed by two separate testing days. Impact accelerations were measured with a Myomonitor wireless system (DELSYS, USA) and oxygen kinetics were recorded during a 6 minute trial using a Vmax gas flow sensor and analyser (Vmax system, Sensor Medics, VIASYS Healthcare, Netherlands) to determine energy expenditure. Compliant running resulted in a significant decrease in sacral (27%) and head (39%) impact accelerations, a non-significant decrease in tibia (21%) impact accelerations, and a significant increase in energy expenditure (23%).

KEY WORDS: Compliant running, Groucho running, impact acceleration, energy expenditure

INTRODUCTION: There is overwhelming evidence linking chronic disease to inactivity and low levels of energy expenditure; highlighting the need to limit ones barriers to exercise and physical activity (Warburton et al., 2006; Lee and Skerret, 2001). Running has become the preferred mode of exercise for millions of people worldwide. However, it is estimated that up to 70% of both competitive and recreational runners sustain overuse injuries during any 1-year period (Hreljac, 2004). During running the body experiences high impact loads as the foot strikes the ground, resulting in an impact acceleration travelling up the musckuloskeletal system (Lafortune et al., 1996), which has been implicated in the development of numerous injuries: degenerative joint disease, spinal injuries, tendinitis, muscle tears, and stress fractures (Lafortune et al., 1996; McMahon et al., 1987).

Altering technique may decrease impact loads/accelerations experienced during running (Crowell et al., 2011; McMahon et al., 1987). From a biomechanical-principles perspective (e.g. impulse-momentum relationship), the magnitude of impact loads/accelerations can be reduced by decreasing the velocity of the body at ground strike and increasing the duration over which the body is decelerated. This may be achieved by decreasing the height the centre of mass (COM) falls prior to impact, and by increasing joint flexion angles at the hip and knee (allowing a more compliant landing phase). A running style that advocates such gait alterations is termed "compliant" or "groucho" running (McMahon et al., 1987). However, McMahon et al. (1987) only examined impact acceleration attenuation ratios between the head and tibia, but failed to analyse individual impact accelerations at specific sites.

A compliant running technique may have the additional advantage of increasing energy consumption by up to 50% (McMahon et al., 1987). However, McMahon et al. used a running technique and protocol for determining energy expenditure that seemed very severe, with only a portion of subjects completing the protocol.

The aims of this study were to investigate the effect of compliant running on impact accelerations at the tibia, sacrum, and head, as well as the effect it has on energy expenditure.

METHODS: This study implemented a randomized experimental repeated measures design to study the effect of running style (compliant versus normal) on impact accelerations and energy expenditure. A Myomonitor wireless system (DELSYS, USA) was used to measure impact accelerations during running and were strapped to: the medial aspect of the proximal tibia, the posterior sacrum between the two posterior processes of the sacro-illiac joint, and to the fore-head. Twelve healthy, male subjects between the ages of 18-31 were recruited from a university population (height, 177cm ±6.5cm; weight, 78kg ±6.5kg). All subjects had been involved in running activities for 6 months, at least three times a week.

Three weeks before the experimental trials subjects were shown on three occasions how to run using the compliant style. Each instruction session was separated by a week and the subject was required to practice compliant running a minimum of two times between each. If subjects could not adequately perform the required compliant technique within three practice sessions, further practice was performed until competency was reached. Competency was subjectively judged by the lead researcher, and was judged to be achieved if an appropriate technique was maintained for 8 minutes treadmill running, at 8km/hr. Subjects were instructed to “drop their hips slightly, to keep their feet close to ground (reducing aerial phase of gait), and to run with flexed knees”.

To measure energy expenditure, a six minute, sub-maximal, treadmill running economy protocol was used (Hausswirth and Lehenaff, 2001). For the duration of this test participants ran at a pace of 8km/hr (Skime and Boone, 2003), and at a gradient of 1%, to account for wind resistance (Jones and Doust, 1996). Breath-by-breath oxygen consumption was measured for the duration of the six minute bout using a Vmax system (Vmax system, Sensor Medics, Netherlands). Values for the last three minutes of each test were averaged to determine O_2 consumption and energy expenditure. Energy expenditure is reported relative to mass.

RESULTS:

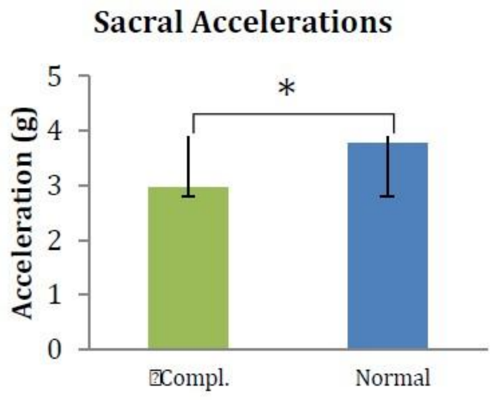

Figure 2 Compliant running Vs Normal running. *= Significant

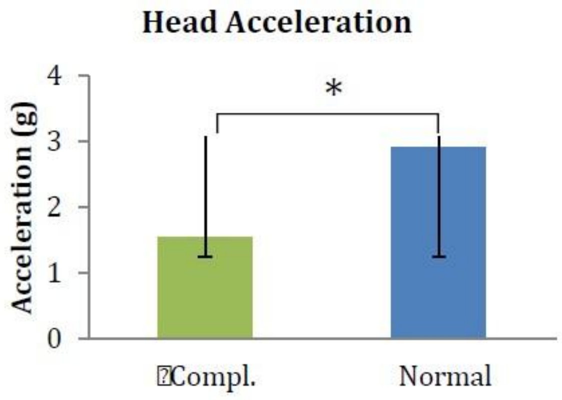

Figure 1 Compliant running Vs Normal running. *= Significant

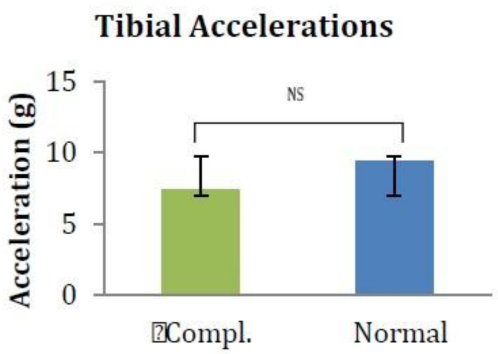

Figure 3 Compliant running Vs Normal Running. NS= Not significant

There was a significant decrease in peak acceleration at the sacrum (F=10.41, P=.009, normal > compliant by 27 %) and the head (F=7.285, P= 0.027, normal > compliant by 39%) during compliant running. There was no significant difference in peak accelerations at the tibia (F=.19, P=0.20, normal > compliant by 21%)

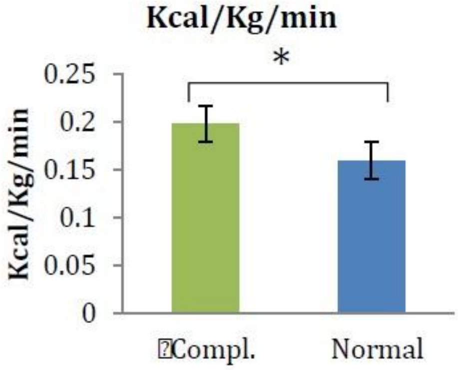

Figure 4 Compliant running Vs Normal Running. *= Significant

There was a significant increase of 23 % in energy expended per minute for compliant running over normal running (t= 2.64, P= 0.023, compliant > normal).

DISCUSSION: Results of this study indicate that adopting a more compliant running style, by increasing knee and hip flexion, reduces the magnitude of impact accelerations at the sacrum and at the head, by 27% and 39% respectively; thus decreasing the potential for injury development (Lafortune et al, 1996; McMahonet al 1987). Lafortune et al (1996) describes increasing knee flexion as the most effective and suitable method of protecting the head and back from overuse injury, however they only examined this in a seated position using a pendulum device to strike the foot, simulating impact. In contrast to the present study, McMahon et al. (1987) and Lafortune et al. (1996) found an <u>increase</u> in tibial accelerations associated with increased knee flexion (38 % and 57%, respectively). Although statistical analysis in the current study revealed no significant difference between tibial accelerations recorded for normal and compliant running, a reduction of 21% was found for compliant running. This may be of particular relevance as Milner et al (2006) suggests that even minor increases in load, which may be statistically insignificant, may still play an important role in the development of overuse injuries when repeated over thousands of foot strikes. Furthermore, according to Derrick (2003) increasing knee flexion at foot strike causes a subsequent decrease in effective mass that should increase the magnitude of tibial accelerations under compliant running conditions. Even with effective mass playing a role, tibial accelerations remain lower (although statistically insignificant) in compliant running than normal running, in the present study. This suggests that compliant running has the potential to reduce impact accelerations and thus reduce musckuloskeletal injury.
Compliant running was found to significantly increase energy consumption (Kcal/kg/min) by 23% in comparison to normal running. Although McMahon et al. (1987) recorded increases up to 50%, this magnitude was not present in all subjects. These increases in energy expenditure may be explained by the increased level of muscle action required to maintain a compliant posture and the reduced utilisation of the stretch shortening cycle. The increase in energy expenditure has numerous benefits and applications for health and wellness (e.g. increase calories burned). Increasing energy expenditure by 1000kcal a week has been shown to increase life expectancy by 20% and an average of 2000kcal expended during physical activity is associated with a decrease in morbidity and mortality of 20-30% (Warburton et al, 2006; & Lee and Skerret, 2001).

CONCLUSION: Compliant running has many applications within the injury prevention/rehabilitation professions as well as in the fitness and health industry. Due to its ability to reduce impact loading on the body, it has the potential to play a pertinent role in pre-habilitation and prevention for patients who may have a predisposition to developing overuse injuries, or as a rehabilitative tool for patients returning from injury. The increased metabolic cost of compliant running also has many applications in the health and fitness industry, in terms of weight loss and general health.

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