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WALKING AND RUNNING JOINT MOMENT DISTRIBUTION UNDER DIFFERENT STEP FREQUENCY CONDITIONS

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INTRODUCTION

Gait biomechanical changes have been widely reported as a result of ageing [1]. The most typical and straightforward differences presented by older individuals compared to young are slower gait speed and faster step frequency [1,2].

A more complex gait modification that has been reported and associated with ageing is the distal-to-proximal redistribution of hip-knee-ankle joint moments [3]. However, this redistribution has not been observed when the walking speed was controlled which suggests that ageing may not be causing this alteration [2]. The problem is that it is not possible to isolate the age effects since older individuals tend to adopt a faster cadence at a given speed. In fact, a recent study with only healthy young individuals found that both step length and frequency influence walking biomechanics but, unfortunately, joint moment redistribution was not reported in that study [3]. The understanding about the effects of step frequency manipulation on joint moment distribution is even more limited concerning long distance running despite the increased participation of older adults in running practice.

This study aims to examining the effect of step frequency at controlled speeds on joint moments in healthy young runners.

METHODS

Seven (six males and one female) young competitive runners (age: 32±7 years; body height: 174±5 cm and mass: 70±13 kg) were evaluated in the present study after an informed consent, approved by the university ethics committee, was obtained. The subjects were required to walk and run on an instrumented treadmill at controlled speeds of 1.2 m/s and 3.3 m/s, respectively, under three step frequency conditions: comfortable (100c), 10% slower (090c) and 10% faster (110c). An auditory feedback was provided by a metronome to control the step frequency conditions following a treadmill familiarization and warm up protocol. An explanation about the experiment procedures followed by a training session were given to the subjects to ensure they understood the task correctly.

The trajectories of 54 reflective markers attached in the body and the ground reaction forces (GRF) were collected, respectively, by a 12-camera three-dimensional motion capture system, at 150 Hz, and the instrumented treadmill, at 450 Hz. The marker trajectories and the GRF data were filtered with low-pass filter with cutoff frequencies of 6 Hz and 10 Hz, respectively. An Opensim full-body musculoskeletal model [4] with 22 rigid bodies and 37 degrees of freedom and 80 muscles was adopted. A scaled generic model was created by scaling segment lengths and inertial properties based on the individual anthropometry. Joint angles and joint moments were calculated by inverse kinematics and inverse dynamics. All the calculations were performed in the Opensim software version 3.3.

The peak joint moments (minimum values) of the hip, knee and ankle at the sagittal plane; and the support moment (Supp) were considered for the analysis. To examine the joint moment redistribution across lower extremity joints, we calculated the ratio between peak hip extensor and ankle plantar flexion moments (Hip2Ankle). These values were considered the dependent variables in the study and they were obtained for each cadence condition. One-way ANOVAs were performed to examine the effect of step frequencies on the dependent variables for walk and run condition separately at a significance level of 0.05. To compare our results with previous published findings, we calculated the effect size (ES) and the relative differences (DIFF%) of Hip2Ankle ratio between 100c and 110c conditions.

RESULTS AND DISCUSSION

The average time series curves for the hip, knee and ankle joint moments are displayed in Fig. 1. The average peak values across subjects for each step frequency condition and the Hip2Ankle ratio for each gait condition are shown in Fig. 2.

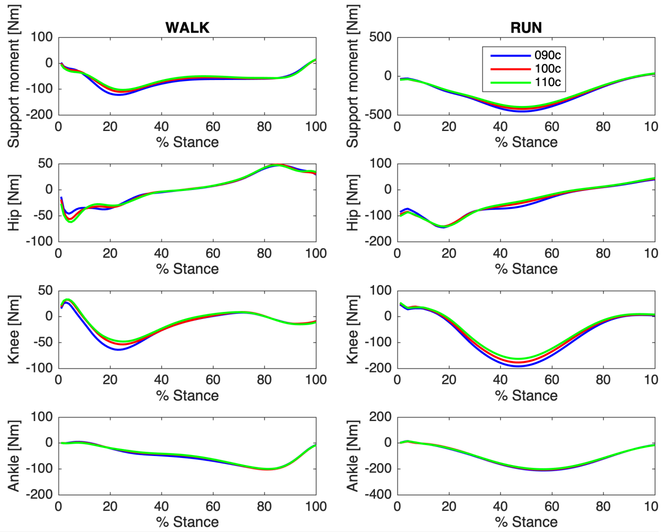

Fig. 1: Average curves across subjects for each step frequency condition during walk and run.

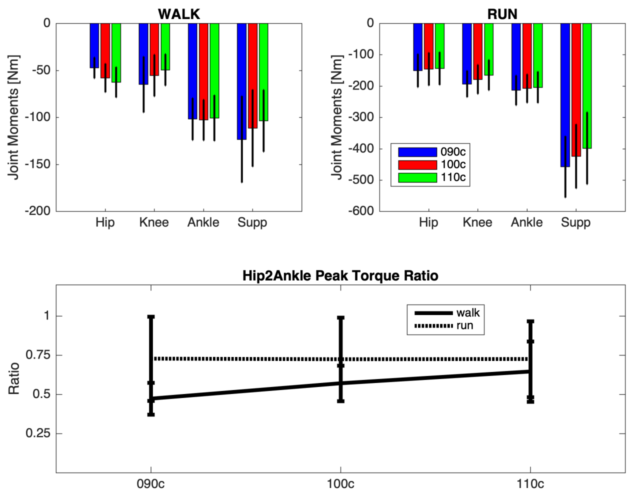

Fig. 2: The graphs on top display the average (±1SD) peak moment values of the hip, knee, ankle and support moment. The graph in the bottom shows the average (±1SD) Hip2Ankle ratio.

Although the statistical analysis revealed no significant effect of cadence on any of the dependent variables, the present average results presented similar trends compared to previous studies. For example, the average Hip2Ankle ratios increased from the comfortable (100c) to the fast (110c) cadence conditions as can be seen in Fig. 2 (ES=0.48; DIFF%=12,3%). These differences have also been observed when young individuals are compared to older adults (who typically adopt faster cadences), although the magnitude of the differences is generally higher in previous studies [3,6]. In fact, the relative differences in Hip2Ankle ratio reported in these studies ranged from 38% to 103%. Contrary to walking, the increased running cadence did not influence the Hip2Ankle ratio. The lack of previous running studies prevented to make more conclusive statements about this finding. The contrasting differences on average Hip2Ankle ratios between the present and previous walking studies [3,6] may be simply explained by the age effects or the fitness level of the participants (or both) as we only included young competitive runners. Unfortunately, a previous study with similar design did not provide the descriptive statistics data, which prevented us to calculate the relative differences in the Hip2Ankle ratio in young subjects [5].

While the results of this preliminary study need to be interpreted with cautious given the limited sample size, the direction of the present findings are, overall, in agreement with previous studies. Hence, it is reasonable to speculate that the inclusion of more runners with similar characteristics would reduce the intersubject variability and thus highlight the between group differences. To our knowledge, this is the first study to examine the effect of cadence manipulation on both walk and run conditions. In fact, the inability to identify any running studies with similar design and objectives hampered to assess the robustness of the joint moment redistribution paradigm as a function of faster running cadences.

An important limitation of the present study is that only seven runners (six males and one female) were analyzed. This fact may well have contributed to the large intersubject variability in the values and explain, at least in part, the lack of effects observed in the present study.

CONCLUSIONS

This preliminary study indicates that a joint moment redistribution may occur as a function of faster walking cadence in healthy young runners. This conclusion needs to be confirmed by future studies with a larger sample of comparable runners.

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