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DO FITNESS AND FATIGUE AFFECT GAIT BIOMECHANICS IN OVERWEIGHT AND OBESE CHILDREN?

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SUMMARY

Three dimensional motion analyses and a fatigue protocol were used to analyze the effect of cardiorespiratory fitness and fatigue on walking and jogging biomechanics in 8-11 years old overweight and obese children. A weak to moderate inverse relationship was seen between cardiorespiratory fitness and gait biomechanics, as measured by hip and knee moments. Peak knee adduction, knee extensor and hip extensor moments during walking increased after the PACER fatigue protocol. This study provides information on how level of fitness and adiposity affects biomechanical loads, which may have implications for participation in activities and long-term effects on the musculoskeletal system.

INTRODUCTION

Attention to childhood obesity is of particular importance, not only for the immediate impact obesity may have upon health and developmental factors of the child, but also for the continued impact obesity may have upon quality of life and health into adulthood. Increases in childhood obesity, while certainly emerging from a variety of causes, is associated with a lack of physical activity. As in adults, children may find it difficult to perform sufficient physical activity for a variety of reasons, some of which may have biomechanical foundations. Lower levels of physical activity have been related to decreased cardiorespiratory fitness [1]. It can be argued that fatigue exaggerates gait abnormalities in overweight and obese children, and therefore also modulates physical activity participation. While empirical clinical observation suggests cardiorespiratory fitness and fatigue in obese and overweight children are important issues that affect participation in activity, the underlying biomechanical influences have not been explored.

The purpose of this study is to determine how cardiorespiratory fitness and fatigue influence gait biomechanics in overweight and obese children (aged 8-11 years). The unique aspect of this project is the examination of cardiorespiratory fitness (an attribute) and cardiorespiratory fatigue (a temporary state), in overweight and obese children and the association with physical performance (gait biomechanics). It was hypothesized that gait biomechanics, as measured by hip and knee moments, will be inversely related to cardiorespiratory fitness in overweight and obese children, in a non-fatigued state. Secondly, introduction of cardiorespiratory fatigue will be associated with an increase in gait biomechanical measures compared to the non-fatigued condition.

METHODS

Data were collected on 29 subjects (14 females, 15 males) aged 8-11 years (9.8+/- 0.9) with BMI above 85th percentile (96.1+/- 4.1). Percentage body fat was estimated by air displacement plethysmography (Bod Pod). Markers were applied to the lower limbs, pelvis, and trunk segments. Anatomical models, used for biomechanical analysis, were generated from bony landmarks identified via a digitizing probe. Gait evaluations were conducted along an 8 m walkway using a 3D motion analysis system (Optotrak, NDI Inc., Ontario) and force plates (Kistler Instruments, Inc., NY). Cardio-respiratory fitness was assessed using an 8-minute submaximal Nemeth treadmill protocol. A PACER protocol was used to fatigue subjects [2]. Walking and jogging biomechanics were assessed prior to and immediately following the fatigue activity.

Data Analysis:

Visual 3D software (C-Motion) was used to obtain, right side, peak hip and knee moments normalized to body weight in the frontal and sagittal planes for three jogging and five walking gait cycles, pre/post fatigue. Paired t-tests ($p<0.05$) were performed to determine differences in mean peak hip and knee moments. Regression analysis was performed to determine association between fitness and biomechanics measures.

RESULTS AND DISCUSSION

Mean percentage body fat was 32.3 +/- 7.6 (range 16.2 - 46.7). Cardiorespiratory fitness assessed by Nemeth protocol was 35.3 +/- 6.5 (range 24.13 to 49.1)mL/min/kg. During the PACER fatigue protocol subjects completed 17.5+/- 8.5 (range 4-45) laps. All subject reached minimum heart rate of 170 beats per minute (range 172-206) at the end of PACER protocol. The peak hip and knee moments showed weak to moderate relationship with fitness levels (Figure 1).

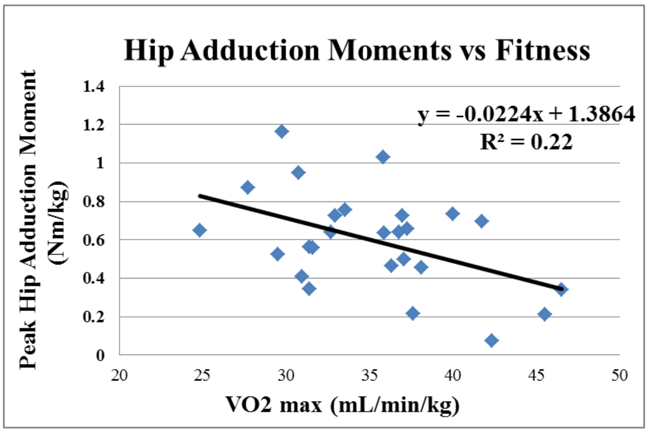

Figure 1: Shows inverse relationship between peak hip adduction moments and fitness levels, as measured by estimated VO_2 max in a non-fatigue state during walking for 29 subjects. Hip extensor moments showed no relationship with fitness level (R-square value 0.02). R-square values for peak knee adduction and extensor moments were 0.09 and 0.04 respectively.

While cardiorespiratory fitness generally declines and biomechanical stresses increase in the presence of obesity, some overweight and obese children clearly tolerate physical activity better than others. Variation in toleration of physical activity can be attributed to varying levels of adiposity in these children [3]. In the current study, hip adduction moments showed a moderate relationship (R-square 0.27) with body fat percentage suggesting that level of adiposity might be an important factor in predicting the relationship between fitness levels and gait biomechanics.

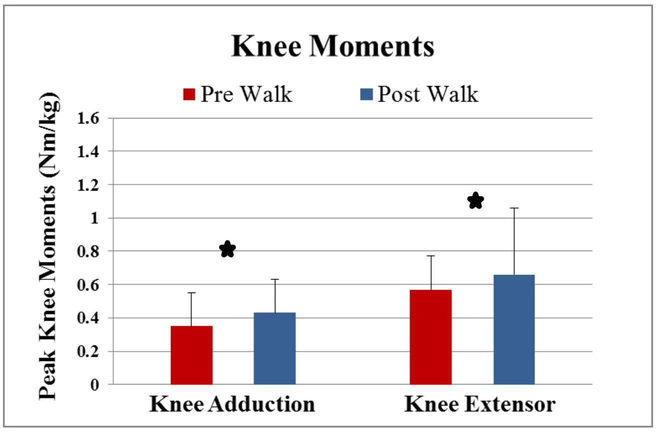

Figure 2: Mean and standard deviation for knee adduction and extensor moments for walking trials. Following fatigue there was a significant (*) increase in the knee adduction moments (p= 0.01), knee extensor moments (p= 0.02) and hip extensor moments (p=0.01. No increase was seen in hip adductor moments (p-value 0.67) (table 1).

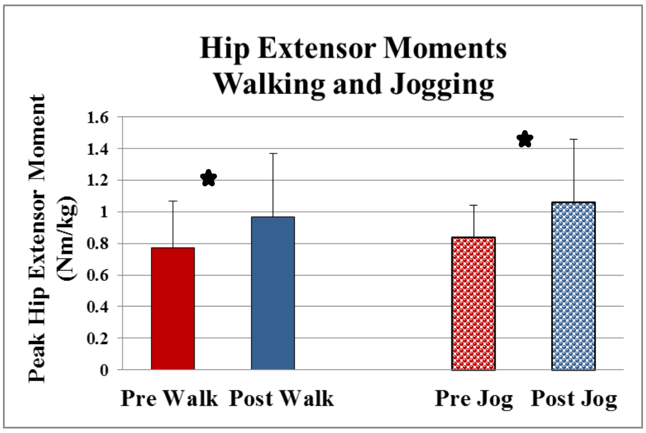

Figure 3: Mean and standard deviation for peak hip extensor moments for walking and jogging trials. For jogging trials, only hip extensor moments showed an increase (*) after the PACER (p-value 0.008). The change in adduction and extensor moments did not show any relationship to fitness levels.

Studies investigating running and drop-landing types of activities in adults have reported that muscular fatigue leads to an increase of ground impact forces [4]. Thus, an increase of peak hip and knee extensor moment during the weight acceptance phase of gait in a fatigued state, suggests increased biomechanical stresses which can have long term effects on musculoskeletal system.

CONCLUSIONS

The results show a weak to moderate inverse relationship between cardiorespiratory fitness and gait biomechanics, as measured by hip and knee moments. This has demonstrated associations between level of fitness and adiposity and biomechanical loads, which may have implications for participation in activities and long-term effects on the musculoskeletal system. Furthermore, the hip and knee extensor and knee adduction moments show a significant increase after fatigue. This might have implications in the clinics, where gait patterns may not be present when obese children are briefly examined during an unfatigued state. This study provides information on how the level of fitness and fatigue might affect the response during clinical evaluations in overweight and obese children.

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Table 1: Represents the mean and standard deviation of peak knee and hip moments pre and post PACER protocol

	WALKING				**JOGGING**			
MOMENTS	**Hip Add**	**Hip Ex**	**Knee Add**	**Knee Ex**	**Hip Add**	**Hip Ex**	**Knee Add**	**Knee Ex**
Pre Pacer	0.59 (0.2)	0.77 (0.3)	0.35 (0.2)	0.57 (0.2)	0.98 (0.3)	0.84 (0.2)	0.39 (0.2)	1.24 (0.3)
Post Pacer	0.64 (0.3)	0.97 (0.4)	0.43 (0.2)	0.66 (0.2)	0.93 (0.4)	1.06 (0.4)	0.44 (0.2)	1.27 (0.4)