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THE MOMENT OF THE HIP AND KNEE IN OBESE AND NON-OBESE INDIVIDUALS DURING STAIR ASCENT AND DESCENT

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The purpose of this study was to examine whether there is a difference in the knee and hip joint moment between obese and normal weight subjects during stair climbing. One normal weight female participant and one overweight female participant were recruited to perform a series of stair ascent and descent. The 3-D kinetic data were collected using 9 infrared cameras and 4 force plates. Both the overweight and normal weight participants had similar peak hip extensor moments during ascent. Their peak hip flexor moment, however, was significantly different in the obese subjects (0.19 (Nm/kg)/m) than in the normal weight subjects (0.18 (Nm/kg)/m) during descent. Furthermore, the obese subjects had a higher adduction moment than the normal weight subject during ascent (obese: -0.26 (Nm/kg)/m, normal: -0.38 (Nm/kg)/m).

KEYWORDS: stair ascent, stair descent, joint moment, obesity

INTRODUCTION: Obesity is a growing epidemic not only in United States, but also in other developed countries such as Canada. According to Statistic Canada, 2 out of every 3 adults in Canada are overweight or obese (Statistics Canada, 2006). Individuals with a high BMI may be at risk of developing osteoarthritis due to joint loading, which accelerate the 'wear and tear' of the joints (Griffin & Guilak, 2005). Little, however, is known about the effects that obesity has on the musculoskeletal system during walking and stair-climbing (Wearing et al., 2006; Hills et al., 2002). To the author's knowledge, only one study (Strutzenberger et al., 2000) has examined the joint loading pattern of children during stair ascent and descent. The aged population, on the other hand, has a higher risk in developing joint degeneration compared to other subgroups in the normal population. Hence, the purpose of this study was to determine whether there is a difference in the knee and hip joint moment between the obese and normal weight subjects during stair ascent and descent. Based on (Strutzenberger et al., 2000) study, it is hypothesized that the knee extension and hip adduction joint moment for the obese subjects will be higher than the non-obese subjects when ascending stairs.

METHOD: One female participant with a normal BMI, 21.9, and one female participant with a high BMI, 31.7, were recruited to perform a series stair ascent and descent. The staircase is comprised of three steps 17.8 cm high and 28 cm deep, with the first and second steps built with portable force plates (Model 9286AA, Kistler Instruments Corp, Winterhur, and Swtz). The participants were free from neuromuscular disorders, musculoskeletal injuries, cardiorespiratory problems, and weight fluctuations. The participants in the study were asked to ascend and descend the staircase for 5 trials. A motion capturing system (Vicon MX-13, Oxford Metrics, Oxford, UK) was used to record the subject's movement at 200 Hz as they performed each trial. There were 9 infrared cameras that captured the 3D trajectories of 43 reflective markers that were placed on the subject's body based on the University of Ottawa Motion Analysis Model (UOMAN). The anatomical landmark for the markers include: the heel, the lateral and medial side of the ankle, the tibia, the lateral and medial side of the knee, the thigh, the anterior iliac spine, the posterior iliac spine, C7 and T10 vertebras, the wrist, the second metacarpal of the hand, the radius, the elbow, upper arm, shoulder, the posterior side of the head, and the anterior side of the head. Student t-tests was used to determine if the hip and knee joint moments were significantly different (α=0.05).

Four Kisler force plates, two were built in the stair case and two were built on the ground, were used to record the ground reaction force. The knee and hip joint moments were computed using Polygon and normalized. The stride period were normalized by gait cycle (%). The joint moment for the right hip and knee were based on the sagittal plane (x-direction) and frontal plane (y-direction). The ensemble averages of the moment were calculated over a total of 5 trials, and normalized by body mass (kg) and height (m). Hence, the unit for the normalized joint moment would be (Nm/kg)/m.

RESULTS: Table 1 provides the subjects' physical characteristics information and the peak values of the hip and knee joint moment during stair climbing. Both the overweight and normal weight participants had similar peak hip extensor moment (table 1). During descent, the hip produced a flexion moment rather than an extension moment. The maximum flexion moment was significantly different for both the normal weight subject and for the obese subject ($t(1) = 4.3314$, $p = 0.000035$) (table 1).

Table 1
Physical characteristics of the participants and peak values (mean) of hip and knee joint moment ((Nm/kg)/m)

Subject	Age	BM (kg)	BH (cm)	BMI	Hip Flex/Ext		Knee Flex/Ext		Hip Add/Ab		Knee Val/Var	
					Up	Down	Up	Down	Up	Down	Up	Down
1	52	56.1	160.0	21.9	-0.36	0.18*	-0.50	-0.34	-0.38*	-0.38	-0.15	-0.05
2	55	76.1	155	31.7	-0.38	0.19*	-0.69	-0.86	-0.26*	-0.24	-0.14	-0.09

BM, body mass; BH, body height
*p< 0.05 significantly different

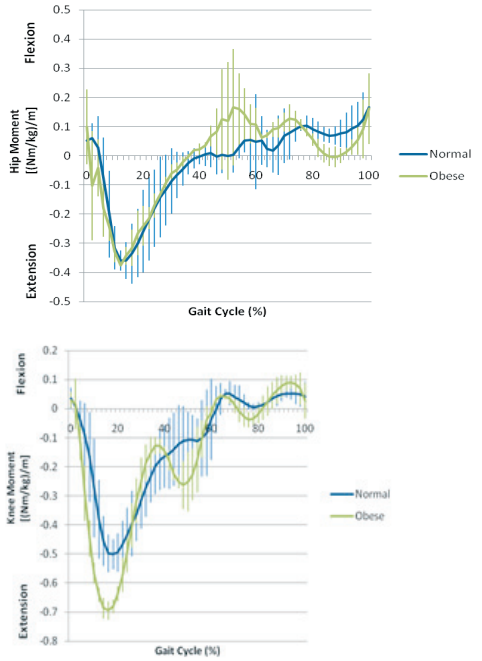

Figure 1: Hip and knee flexion/extension moment in obese vs. normal weight during ascent.

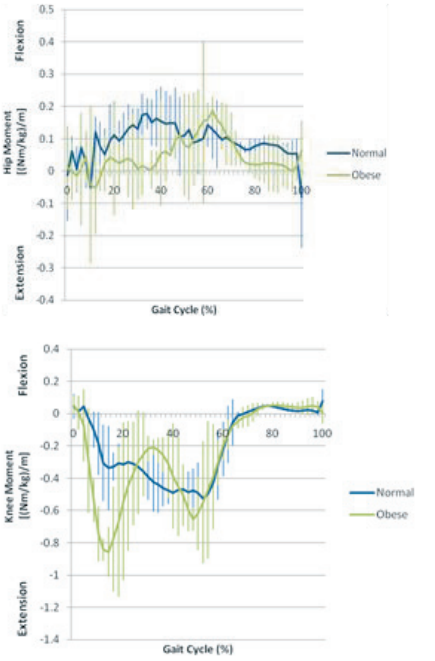

Figure 2: Hip and knee flexion/extension moment in obese vs. normal weight during descent.

During stair ascent, the knee extensor moment in both the participants tended to get smaller as it approached the end of swing phase (figure 2). There was no significant difference that was noted between the two subjects when ascending and descending the stairs (table 1).
Throughout most of stance phase (0-60%), the adductor moments were required at both the hip and the knee joints. The hip adduction moment was significantly larger in the obese subject ($t(1) = 7.3554$, $p < 0.0001$) than in the normal weight subject during ascent (Table 1).

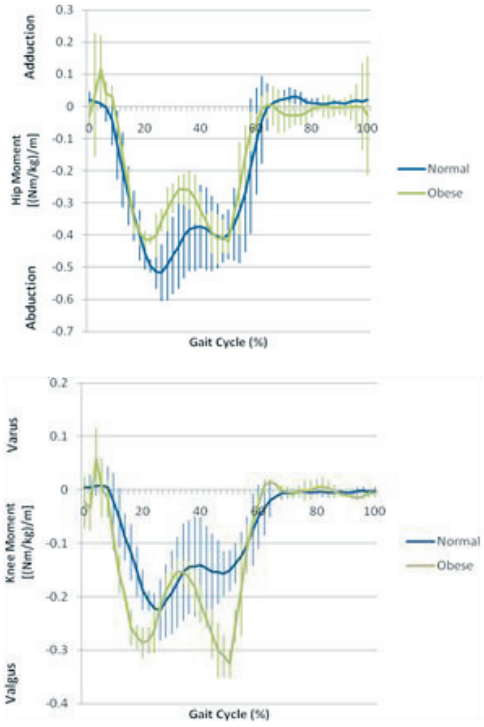

Figure 3: Hip adduction/adduction moment and knee varus/valgus in obese vs. normal weight during ascent.

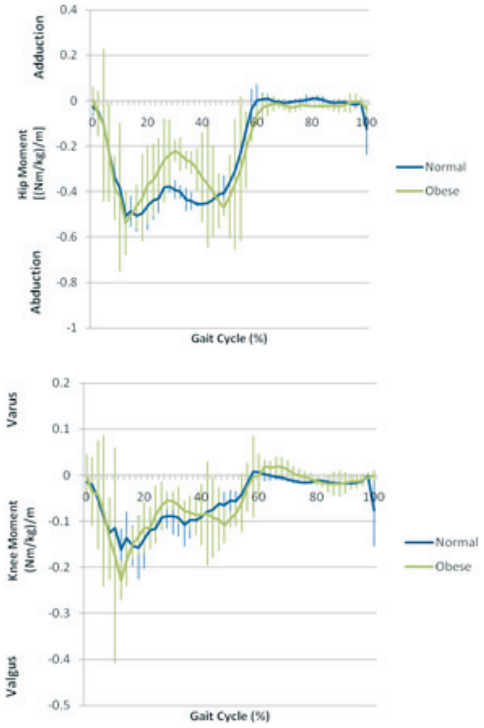

Figure 4: Hip adduction/adduction moment and knee varus/valgus in obese vs. normal weight during descent.

DISCUSSION: The hip joint moments during stair climbing for this study were consistent with the results from past studies. As seen in studies with normal weight individuals by Riener et al., (2002) and Lin et al., (2002), the hip produced an extension moment during most of stance phase in order to lift the body during stair ascent, which later changed to flexor moment during the rest of swing phase. Contrary to this, the hip produced a flexion moment during descent rather than an extension moment, which is similar to findings by Riener et al., (2002). Both the overweight and normal weight participants in this study had similar peak hip extensor moments during ascent, but their hip flexor moments were significantly different during descent.
Like the hip joint moments, the knee joint moments for this study were also consistent with the results from past studies by Riener et al., (2002) and Lin et al., (2002). During ascent, the knee extension moment gradually became smaller towards the end of swing phase. The joint moment curves for the knee, however, differed when it came to stair descent because there was a second peak that helped extend the knee. In terms of the difference between the curves for obese vs. normal weight participants, the results from the study *did not support* the initial hypothesis. There was no significant difference that noted between the participants

knee moments during stair ascent and descent as shown in table 2. This finding was not consistent with the study by Strutzenberger et al, (2002) who found a greater knee extension moment during stair ascent and descent in obese children.
During ascent and descent, the abductor/adductor moments were required at both the hip and the knee for most of stance phase. Similar to Lin et al., (2002), there were two peak abductor moment in the knee during stair ascent and descent. The knee abduction moment did not vary much between the obese and normal weight participant for both stair ascent and descent. The hip adduction moment, however, did *support* the initial hypothesis. Based on the results from the study, the peak hip adduction was significantly different during stair ascent. As seen in (table 1), the hip adductor moment was significantly larger in the obese subject than in the normal weight subject during ascent (obese: up: -0.26 (Nm/kg)/m; normal: up: -0.38 (Nm/kg)/m). This finding was once again consistent with the findings by Strutzenberger et al., (2002) who also found a greater hip adduction moment among the obese children.

CONCLUSION: This study was a preliminary study for a research thesis. The knee and hip joint moment curves were consistent with the curves from past studies that examined the joint moments of normal weight individuals during stair ascent and descent. In terms of the difference between the joint moment curves for obese vs. normal weight participants, the curves for this study were also consistent with the ones found in children. In the future, the results from the study may be generalized if a larger sample size were to be used.

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