INTRODUCTION
Sit-to-stand (STS) motion is one of the most frequently executed motions of daily life with a major importance for the subsequent mobility. School students carry heavy backpacks (e.g. on the average 22% of their body weight, Negrini et al. 1999) and regularly execute STS motion with such back loading. However, the effects of back loading on the biomechanics of STS motion of children are not studied. The goal of this study was to determine in healthy children the effects of back loading on the temporal, kinematic and kinetic parameters of STS motion.

METHODS
Fifteen elementary school children with no neuromuscular disorders participated in the study. A motion analysis system (Eltei Elicinic, BTS, Milan, Italy) with 6 infrared cameras and 2 force plates (Kistler Instrumente AG, Winterthur, Switzerland) was used. Reflective markers were placed according to Helen Hayes Marker Placement Protocol (Davis 1991) with the addition of a marker on C7 and two shoulder markers.

The subjects were seated on a backless seat with a fixed height of 43 cm, representing the height of a standard primary school bench. They wore both strands of the backpack and crossed their arms on their chests. The anteroposterior feet position was fixed on separate force plates. The subjects were instructed to meet a standard seating position i.e., neither at the front nor at the back edge of the seat. They were tested under three conditions: (1) With no back load (unloaded case), (2) With a backpack containing a load of 10% of the subjects’ body weight (10% load case), (3) With a backpack containing a load of 20% of the subjects’ body weight (20% load case).

The phases of the STS motion were defined via 4 critical points: (1) initial point (marker C7 starts to move forward), (2) the point at which buttocks are lifted (the hip joint center starts to move in vertical direction), (3) the point of maximal ankle dorsiflexion and (4) the point at which hip rise is finalized (the hip joint center ceases to move upward in vertical direction). Three phases were defined: flexion-momentum phase, momentum-transfer phase and extension phase. Temporal variables as well as initial, maximal and final values of the kinematic and kinetic data were tested with ANOVA with repeated measures. Differences were considered significant at $P < 0.05$.

RESULTS AND DISCUSSION
Temporal parameters. The total duration of STS motion is independent of back loading however, the durations of the individual phases are altered: (1) the flexion-momentum phase shortens (significantly for 10% load case), (2) the momentum-transfer phase duration remains unaffected and (3) the extension phase duration increases (significantly for both 10% and 20% load cases with respect to the unloaded case).

Therefore, despite the altered mechanical conditions due to added back load, healthy children may control the total duration of STS motion by employing different strategies during different parts of the STS motion. Kinematic parameters. Except for the final angle, ankle dorsiflexion increases: (1) 20% load causes a significant increase in the initial angle of dorsiflexion with respect to both 10% load and unloaded cases, (2) 10% load increases the maximal dorsiflexion significantly and 20% load causes a further significant increase. Subjects with back load are conceivable to have an increased need to propel forward the center of mass which is in a statically unstable position immediately after seat-off, in order to avoid a fall. The increase in ankle dorsiflexion in the first two phases yielding a greater joint range of motion in the extension phase can be explained with this strategy. Effects on the knee angle are limited however; the final knee angle is affected significantly: 10% load decreases the knee flexion significantly and 20% load causes a further significant decrease such that the knee attains full extension. This indicates that with higher back loads the knee can be even hyperextended.

Both 10% and 20% load causes a significant increase in initial and maximal hip angles with respect to unloaded case but no change in final hip angle. Both load cases cause a significant increase in maximal and final trunk flexion with respect to unloaded case. Therefore, a trunk flexion strategy is employed by the subjects with back loading starting from the flexion-momentum phase till the end of STS motion. Kinetic parameters. The maximal ankle plantar flexor moment is significantly higher for the 20% load case compared to the unloaded case. The maximal knee extensor moment is significantly higher in the 10% and 20% load cases compared to the unloaded case. The maximal hip extensor moment was unaffected by back loading.

When compared to the findings of Fosang and Baker (2006), the present maximal ankle plantar flexion, knee extension and hip extension moment is 26%, 29% and 44% respectively of what the children are capable of. However, the present maximal knee and hip moments are much greater than that those obtained analyzing the unloaded gait of children.

CONCLUSIONS
The effects of back loading on the biomechanics of STS motion are substantial even for the lower back load tested. The clinical relevance may be important and needs to be tested.

REFERENCES