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Bottom-up and top-down estimation of L5/S1 moments during lifting in childcare from video data

Diana Pardo Ramos

Univ Eiffel, Univ Lyon 1, LBMC UMR T_ 9406, F-69622 Lyon, France.

Conseil Départemental du Val de Marne, Direction des Crèches, 94000 Créteil, France

Adriana Savescu

Conception Equipements de protection Interfaces homme-machine, INRS, Nancy, France.

Lauren Henry

Univ Eiffel, Univ Lyon 1, LBMC UMR T_ 9406, F-69622 Lyon, France.

Arnaud Baziere

Conseil Départemental du Val de Marne, Direction des Crèches, 94000 Créteil, France

Raphaël Dumas

Univ Eiffel, Univ Lyon 1, LBMC UMR T_ 9406, F-69622 Lyon, France.

Antoine Muller*

Univ Eiffel, Univ Lyon 1, LBMC UMR T_ 9406, F-69622 Lyon, France.

*Corresponding author. Email: antoine.muller@univ-lyon1.fr

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1. Introduction

Lifting a child is the most repeated handling activities in nurseries. Few studies in the literature have been focused in quantifying the risks associated to lifting a child, especially at the workplace.

Quantitative measurements of work activities in a nursery are hardly feasible with the conventional motion analysis systems. Nevertheless, the majority of the reported accidents during childcare occurs at the workplace.

Markerless systems based on video data are nowadays used to estimate kinematic and dynamic parameters in ecological conditions, giving promising results compared to the marker-based system (Chaumeil et al., 2024).

The estimation of intersegmental moments requires, among others, information about the external forces

acting into the body. They usually include external loads (e.g. during manual material handling) and the ground reaction forces measured with force platforms and applied to the feet. Inverse dynamics computation is done introducing these forces in the recursive computation of the intersegmental moments (bottom-up, BU).

Alternatively, some authors have estimated intersegmental moments in a descending way (top-down, TD) from the extremities (the hands) (Muller et al., 2020). This approach has been tested during classic manual handling. However, the postures, the work environment and the handled “loads” during childcare (typically a child) have not been considered in the existing literature.

The objective of this study is to compare intersegmental moments at L5/S1 estimated from video-data using BU and TD approaches while lifting a baby dummy.

2. Methods

2.1 Experimental protocol

One male and four females (BMI 24.9 ± 4.9 kg/m², age 28 ± 7 years) participated to the experimental protocol.

The task consisted into lifting a baby dummy placed at the ground level from the armpits, to bring it straight towards the chest, to keep the posture some seconds and to descend de baby dummy to the initial position. Participants adopted three initial postures typically observed during childcare: standing, kneeling and squatting. Two baby dummies (2.7 kg and 10 kg weight) were used to represent a newborn and a one-year old child respectively, for a total of six posture-load trials. One lifting were recorded by each trial.

2.2 Data acquisition

Video data was acquired using ten Qualisys Miquis Video cameras ($F_s = 50$ Hz). Ground reaction forces for each limb were obtained using two force platforms ($F_s = 2000$ Hz).

2.3 Kinematics and dynamics estimation

Kinematics was computed using Theia3D (Theia Markerless v2023.1) from video data. Intersegmental moments at L5/S1 were obtained using the biorbd biomechanical toolbox (Michaud & Begon, 2021).

L5/S1 moments were estimated using the BU approach following the biomechanical chain from the torso to the feet and using ground reactions forces applied at the right and left feet. For the TD approach, L5/S1 moments were estimated following the biomechanical chain from the pelvis to the hands, assuming that the weight of the baby dummy was equally distributed between the right and the left hands. Body segment

inertial parameters (BSIPs) for each participant were calculated according to Dumas & Wojtusich (2018). L5/S1 moments were post-processed using a fourth order Butterworth low pass filter ($F_c = 6$ Hz).

2.4 Bottom-up and top-down comparison

The Root Mean Square Difference (RMSD) was used to compare both approaches. Only the phase in which the participant carried the baby dummy (from the beginning of the lifting until the end of the deposing) was analysed.

3. Results and discussion

Intersegmental moments obtained using BU and TD approaches were similar in magnitude for all the postures and level of charge (Figure 1). Maximal joint moments magnitude (2.7 kg/10 kg dummy) were around 150/200 Nm for standing, 80/100 Nm for kneeling and 100/140 for squatting, respectively.

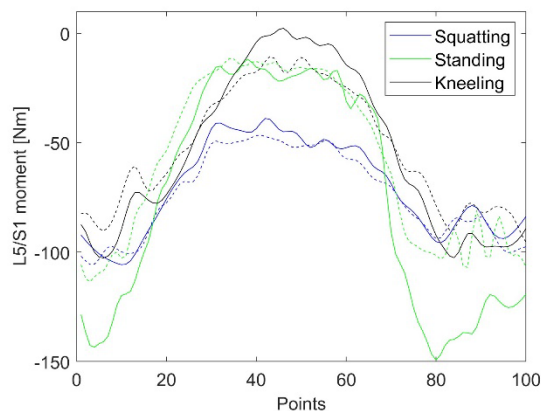


Figure 1. L5/S1 moments with the 2.7 kg baby dummy estimated using BU (filled lines) and TD (dashed lines) approaches for one subject.

RMSD between the two approaches for all the participants were around 25 Nm for most of the tasks (Table 1). These differences are similar to the ones reported in the literature (19.9 Nm and from 12 to 23.1) during lifting a 9 kg box (Delisle et al., 2015) and during a balance retrieval movement (Robert et al., 2007).

Table 1. RMSD between BU and TD approaches

Trial	Squatting		Standing		Kneeling	
	2.7	10	2.7	10	2.7	10
RMSD(Nm)	13.0	22.9	24.5	20.2	28.6	46.2

Differences between the two approaches can be associated to the estimation of the external forces (dummy-mass contributions) and the kinematic input (upper and lower limb kinematics).

Finally, the magnitudes of the moments estimated are coherent in the two approaches concerning the task and

the weights lifted. This is a first step toward a quantitative measurement in nurseries from video-data only, i.e. using the TD approach.

4. Conclusions

Using marker-less motion analysis, estimated L5/S1 moments while lifting a baby dummy are comparable using BU and TD approaches. Differences between the two approaches were in the range of the literature using marker-based motion analysis.

5. Conflict of interests

There is no conflict of interests between the authors.

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