

A Study on Methodology of Measurement for the Physical Burden on Preschool Children

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Abstract

Measuring the burden placed on the body of a preschool child is difficult and has rarely been measured using motion capture. In this paper, the AnyBody Modelling System was used to verify whether it is possible to calculate the burden on the preschool child's body using motion capture. The lumbar burden value for preschool children was calculated, defining the burden on the lumbar region as the burden on the body as a whole. Few measurements have been made on young children with the AnyBody Modelling System. Therefore, the validity of the pre-school child figure was verified by comparing the lumbar burden with that of adult male. In addition, by setting the adult male data based on the preschool child's height and weight and comparing the calculated values with the preschool child's actual values, the possibility of simulating children's body burden in various movements using adult body models in the future was examined.

Keywords: Preschool child, Physical activity, Lumbar burden,

1. Introduction

In contemporary Japan, where the decline in children's physical fitness [1] is an issue, it is very meaningful to analyze the physical activity of children, especially preschool children, by various methods.

Methods for measuring physical activity include continuous heart rate recording, electromyography, pedometers, calorie counters and accelerometers [2],[3],[4]. However, analysis with motion capture data is less common in pre-school children. Possible reasons for this include the inability to accurately read body movements due to their small size, and the fact that children often move differently from adults and cannot respond to these movements.

In this paper, we have examined whether it is possible to calculate the burden on the body of pre-school children using motion capture, using the AnyBody Modelling System [5], a musculoskeletal mechanics analysis software that is widely used worldwide. The lumbar burden values for pre-school children were calculated based on the definition that 'the burden on the lumbar region is the burden on the body'. Few measurements have been made on pre-school children using the 'AnyBody Modelling System'. Therefore, the lumbar burden values of adult males were compared to those of preschool children to verify the validity of the preschool children's values. In addition, the adult male data was set to the height and weight of a girl, and the calculated values were compared and examined with those of a preschool child to verify whether it would be possible to

simulate the burden on a child's body in various movements with an adult's body in the future.

2. Methodology

The subjects were one 5-year-old girl and one adult male. Their respective heights and weights are shown in Table 1. To verify whether it is possible to calculate the burden on the infant's body using motion capture, videos of 'balancing' and 'squatting' (Fig. 1) were taken and the burden on the lower back was calculated using the AnyBody Modelling System. To verify whether the values were valid, videos of the two movements were also taken of adult males and compared with the calculated values. In addition, the adult male data was analyzed with the height and weight of a 5-year-old girl set and compared and examined with the actual values for a 5-year-old girl to verify whether simulation of the movements by an adult would be possible in the future.

Table 1. Adult male squatting

	Preschool Child	Adult Male
Height (cm)	100	180
Weight (kg)	17	78



Fig. 1. Adult male squatting

The AnyBody Modeling System's analysis procedure

After the video was recorded, the video was converted to mp4, the part to be analyzed was cut out for about 10 seconds, and motion capture data (hereinafter referred to as BVH) was created. The lumbar burden was calculated as the burden on the most painful lumbar vertebrae L4L5.

3. Results and Discussion

3.1. Relevance of the definition

For the purposes of this paper, we define “the burden on the hips is the burden on the body. Fig. 2 shows a 5-year-old girl performing a series of balancing movements from behind. The color of the muscles used is changed to indicate the areas of high burden. The color of the lower back in addition to the color of one leg, which is weight-bearing, indicates that the burden is placed mainly on the lower back. Fig. 3 shows a series of crouching movements viewed from behind. The fact that the two movements are mainly burdened on the lower back shows that they meet the definition of “the burden on the lower back is the burden on the body”.

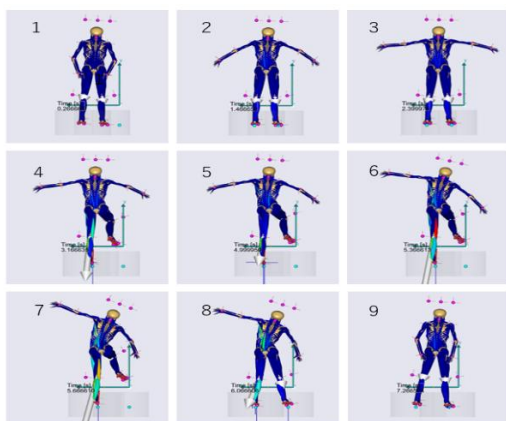


Fig. 2. Sequence of balance movements from behind



Fig. 3. Sequence of squat movements from behind

3.2. Comparison of Values between a 5-year-old girl and an adult male

The burden on the body, based on the standing posture, is approximately 100 [N] for a weight of 10 kg. Therefore, a 5-year-old girl weighs 17 kg, so the burden on her body in the standing posture is approximately 170 [N]. An adult male weighs 78 kg, so the standard is approximately 780 N. The burden increases when the body is carrying a load in its hands or when the body axis is tilted.

The average and maximum values of the burden value of the lower back in the balancing movement were 257.866[N] and 425.870[N], respectively, for a 5-year-old girl (Fig. 4). A 5-year-old girl's maximum value posture is posture 8 in Fig. 2, in which the body is tilted due to loss of balance. The mean and maximum lumbar strain values for the balancing movements of adult males were 1012.574 [N] and 1939.441 [N], respectively (Fig. 5). The posture with the maximum value for the adult male was the same as that of the 5-year-old girl, in which he was off-balance, and his body was tilted.

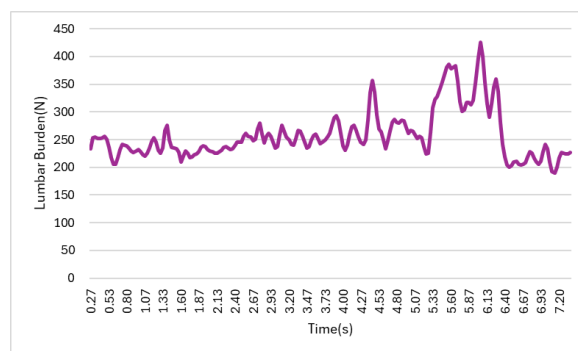


Fig. 4. Graph of lumbar burden values for Balance in a preschool child

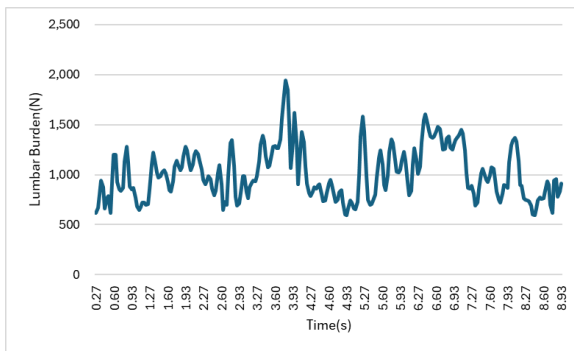


Fig. 5. Graph of lumbar burden values for Balance in an adult male

The mean and maximum values of the squatting burden were 310.173[N] and 556.171[N], respectively, for the 5-year-old girl (Fig. 6). The mean and maximum lumbar strain values for the squatting motion for adult males were 1101.497[N] and 2456.474[N], respectively (Fig. 7). The posture with the maximum value is the most squatting posture.

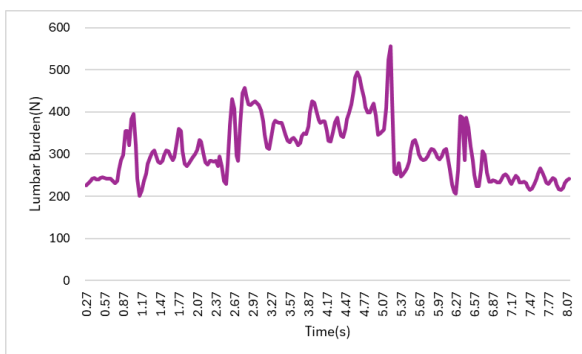


Fig. 6. Graph of lumbar burden values for Squat in a preschool child

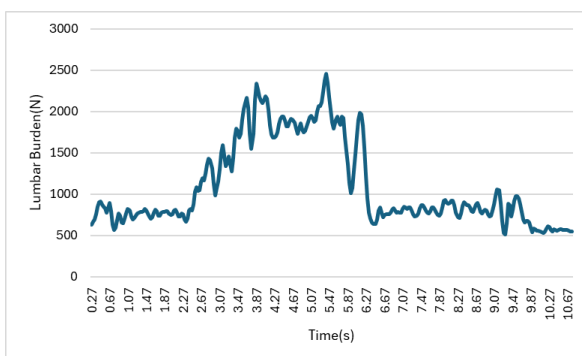


Fig. 7. Graph of lumbar burden values for Squat in an adult male

The difference between the criterion for 5-year-old girls and the mean value of the balance movement was about 88 [N], and the difference between the criterion and the mean value of the squatting movement was about 140 [N]. The difference between the mean values of balance and

squatting movements was about 232[N] and 321[N], respectively, from the standard for adult males. Considering the body leaning and squatting movements, we believe that both values are reasonable. In addition, when comparing the average values between the 5-year-old girl and the adult male, the difference in balance movement was about 755[N] and the difference in squatting movement was about 791[N], which we consider to be a reasonable difference since the difference is thought to be caused by differences in height and weight.

3.3. Analysis of adult male data in the setting of a 5-year-old girl

Using the adult male BVH and analyzing in the setting of a 5-year-old girl's height and weight, the mean and maximum values for the balance movement were 290.559 [N] and 418.476 [N], respectively. (Fig. 8) The mean value for squatting movements was 342.096 [N] and the maximum value was 560.767 [N]. (Fig. 9) Compared to the figures for 5-year-old girls, the difference in mean values for balance movements was about 33 [N] and for squatting movements about 32 [N], a small difference for both balance and squatting movements, Simulation of children's movements with motion capture data is considered to be possible for adults.

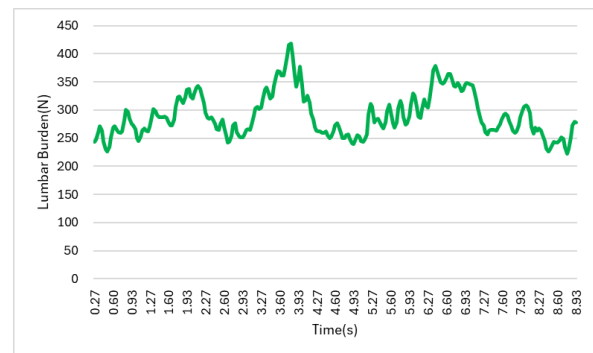


Fig. 8. Graph of lumbar burden values for Balance in an adult male

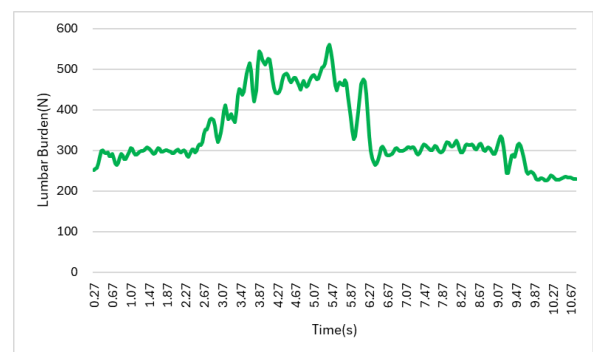


Fig. 9. Graph of lumbar burden values for Squat in an adult male

4. Conclusion

The figures calculated in this paper are shown in Table 2. Reasonable results were obtained in all comparisons of the values of the two movements with the 5-year-old girl's standards, with the adult male's standards and with the values of the two movements, and with the values of the 5-year-old girl and the adult male. In addition, values analyzed using the adult male BVH with the height and weight of a five-year-old girl were calculated to be almost identical to the actual values of a five-year-old girl. This suggests that it is possible to simulate children's movements in adults with an awareness of the amount of physical activity in children's movements. In the future, many movements should be analyzed.

Table 2. Figures calculated in this paper

		Adult Male	Preschool Child	Adult for Child's Setting
Balance	Average[N]	1012.574	257.866	290.559
	Max[N]	1939.441	425.870	418.476
Squat	Average[N]	1101.497	310.173	342.096
	Max[N]	2456.474	556.171	560.767

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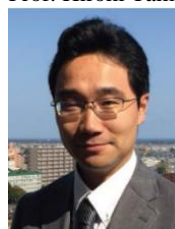
Authors Introduction

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She received her M.S. from Nakamura Gakuen University, Graduate School of Human Development in 2015. Currently enrolled in the doctoral program at the Graduate School of Agriculture and Engineering, University of Miyazaki. Assistant Professor, Department of Early Childhood Education, Higashikyushu Junior College, 2010. Lecturer, Faculty of Education, Miyazaki International University, since 2019. Her main research interest is the development of motor skills in young children.

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