A Feasibility Study on Methods to Measure the Strain on Young Children's Bodies.

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Abstract

This paper investigates the effective methods of measuring the burden on the infant's body. Initially, the "the burden on the body and the lumbar spine burden are the same" was defined. The calculations and comparisons were carried out based on the two methods: the AnyBody Modeling System and the smartphone application Yo-bukun (a lumbar spine burden measurement application). The lumbar burden was calculated using the AnyBody Modelling System. In addition, an iPhone running the Yo-bukun lumbar burden measurement application was placed close to the heart position in order to simulate the lumbar burden. The results were compared with the respective average values and validated.

Keywords: Infants, Physical activity, Lunbar burden,

1. Introduction

In contemporary Japan, where the decline in children's physical fitness has emerged as a prominent concern [1], a comprehensive analysis of children's physical activity, particularly among young children, holds significant relevance. Various methodologies are employed to measure physical activity, encompassing continuous heart rate recording, electromyography, pedometers, calorie counters, and accelerometers [2], [3], [4]. Notably, smartwatches like the Apple Watch have gained popularity in recent years. However, the majority of these methods are tailored for adult use. Even among smartwatches, those designed for children are geared towards elementary school students and older, lacking compatibility with younger children. Accelerometers, pedometers, and behavior analysis are frequently employed for measuring physical activity in young children, yet a prevailing challenge in research utilizing these methods is their inadequacy for accommodating the needs of this demographic. Hence, there is an immediate necessity to investigate measurement methods that align with the body size of infants when assessing their physical activity.

The AnyBody Modeling System, developed at Aalborg University in Denmark, is a widely utilized musculoskeletal mechanics analysis software globally. The AnyBody Modeling System [5] employs inverse dynamics analysis to calculate forces acting on each part of the human body, including muscle activity, muscle and antagonist muscle forces, elastic energy of tendons, joint forces, and joint moments, during motion. While extensively used for simulating joint movements and analyzing motion capture data from video, research using this system has predominantly focused on adults, with limited exploration in the context of infants.

The Yo-bukun application [6], [7], a collaborative effort between the Faculty of Engineering at Miyazaki University and Densan Corporation in 2022, is an iPhone application quantifying and displaying lower back burden. This application is calibrated when the user stands upright, and calculates the amount of lumbar burden based on the tilt of the iPhone. This iPhone application facilitates the easy measurement of lower back burden and has not been previously applied to infants.

This paper investigates the effective methods of measuring the burden on the infant's body. The calculations and comparisons were carried out based on the two methods: the AnyBody Modeling System and the smartphone application Yo-bukun (a lumbar spine burden measurement application).

2. Methodology

In this paper, we will compare the results of the anybody modeling system and the "Yo-bukun" analysis application, which are set to the height and weight of infants. As a measurement system, the AnyBody

Modeling System is accurate if the movement is measured correctly. However, the AnyBody Modeling System is not realistic to accurately measure the burden of a moving infant. The “Yo-bukun” analysis application, who wears a smartphone, has fewer restrictions and can take measurements over a long period of time.

The value of the “Yo-bukun” analysis application is unclear how accurate for infants. Therefore, in order to confirm the accuracy of the “Yo-bukun” analysis application for infants, we conduct the comparative verification using the parameter settings as those for infants.

2.1. *The AnyBody Modeling System's analysis procedure*

In this paper, we use the AnyBody Modeling System to analyze the sample basic motion. Set the analysis settings in the AnyBody Modeling System to the height and weight of a typical infant, and calculate the amount of lumbar strain during movement in a pseudo manner.

2.2. *The Yo-bukun’s analysis procedure*

Set the settings in the “Yo-bukun” analysis application to the same height and weight as in Chapter 2.1. We move by hand the smartphone according to the sample basic motion. In this way, we can simulate the basic motion on our smartphone.

3. Results and Discussion

3.1. *Analysis results with the AnyBody Modeling system*

Fig. 1 shows a series of balancing movements viewed from behind. The color of the muscles used changes, indicating areas of high strain. The fact that the lower back is colored in addition to the leg on which the body weight is placed indicates that the burden is placed mainly on the lower back. The posture with the maximum burden on the lower back is considered to be posture 5, in which the subject is off-balance. In the "balance" posture, the average value was 231[N] for approximately 8 seconds, and the maximum value was 283[N] (Fig. 1).

Fig. 2 shows a series of squatting movements, viewed from behind. In this movement, too, the color of the lumbar region changes, and it can be said that the lumbar region is burdened. The posture with the maximum lumbar load is posture 5 in the standing up motion. In the crouching movement, the average value for approximately 10 seconds was 322[N], and the maximum value was 484[N].

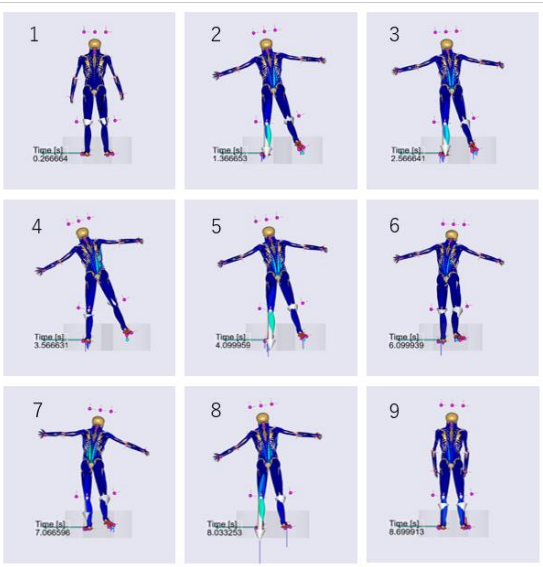

Fig. 1. Sequence of balance movements from behind with the AnyBody Modeling System analysis

Fig. 2. Sequence of squat movements from behind with the AnyBody Modeling System analysis

According to the AnyBody Modeling System analysis, two of the movements put the burden primarily on the lumbar region, thus meeting the definition of the “the burden on the body and the lumbar spine burden are the same”.

3.2. *Analysis results with the Yo-bukun*

In the context of balance movements, the approximate average load over a duration of 8 seconds was 164[N], with a maximum load reaching 204[N].

In the squatting movement, the approximate average load over a duration of 10 seconds was 228[N], with a maximum load of 320[N].

3.3. *Comparison of Analytical Results between Two Software Applications*

In the Squatting movement, the average load was 322[N] in the AnyBody Modeling System and 228[N] in the Yo-bukun, resulting in AnyBody Modeling System exhibiting a slightly higher value of approximately 90[N]. The average value for balance movements was also 231 [N] for the AnyBody Modeling System and 164[N] for Yo-bukun, with the AnyBody Modeling System being about 70[N] higher. Although there was a slight discrepancy in the average values for both "Squatting" and "Balance," the fact that similar numerical values were obtained with both software applications. The burden on the body of infants during these two movements is approximately 200[N] to 350[N]. Although we predict that the difference between the two results is due to differences in the standards of the skeletal models used.

4. Conclusion

In this paper, the physical burden on infants was measured using two different software applications. A comparison of the average values obtained from the two software applications revealed no significant differences, suggesting that the burden on infants during the two movements can be considered to range from approximately 200[N] to 350[N]. The analysis time capability of the AnyBody Modeling System is approximately ten seconds. In contrast, the Yo-bukun enables prolonged analyses. The absence of significant differences between the AnyBody Modeling System and Yo-bukun in this study suggests the potential for measuring the physical load during infant body activities using Yo-bukun. In our future work, the validations are necessary by increasing the number of infant subjects.

References

1. Japan Sports Agency, “Results of the 2022 National Physical Fitness and Exercise Capacity and Exercise Habits Survey”, https://www.mext.go.jp/sports/b_menu/toukei/kodomo/zencyo/1411922_00004.html, (Last viewed on December 15, 2023).
2. A. Sugimoto, “The Measurement of Physical Activity : A Review of Recent Progress”, The Japanese Journal of Rehabilitation Medicine, vol. 37, 2000, pp. 53-61.
3. S. Tanaka, “A Study of the Relationship between Young Children’s Motor Abilities and Physical Activities : Focusing Five Year Old Children’s Physical Activity Countsina Day, The Hoikugaku Kenkyu vol. 47, no.2, 2009, pp. 8–16.
4. R. Tsuda, M. Watanabe and K. Suzuki, “Daily physical activities of public nursery school children during winter : a case study of eight public schools in Ishikawa Prefecture”, the Japan Journal of Human Growth and Development Research, vol. 90, 2021, pp. 57-64.
5. M. Damsgaard, J. Rasmussen, S. T. Christensen, E. Surma and M. D. Zee, “Analysis of musculoskeletal systems in the AnyBody Modeling System”, Simulation Modelling Practice and Theory, vol. 14, 2006, pp. 1100-1111.
6. H. Tamura, K. Sakurai, K. Tanno, and Y. Fuse, “A Study on the Lumbar Burden Evaluation of Work using One Smartphone,” Journal of Robotics, Networking and Artificial Life, vol. 5, no. 3, pp. 173–173, Jan. 2018, doi: https://doi.org/10.2991/jrnal.2018.5.3.7.
7. H. Tamura, K. Sakurai, K. Tanno, and Y. Fuse, “A Study on the Lumbar Burden Evaluation of Work using One Smartphone,” Proceedings of International Conference on Artificial Life and Robotics, vol. 23, pp. 550–553, Feb. 2018, doi: https://doi.org/10.5954/icarob.2018.os14-1

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