THE CHARACTERISTICS OF BACKWARD WALKING AND BACKWARD RUNNING IN PRIMARY SCHOOL CHILDREN

Saki Sodeyama, Masayuki Horie, Ikuko Shohji,Yumi Yoshida and Hiroh Yamamoto
Biomechanics Lab., Fac. of Educ., Kanazawa Univ., Japan.

The purpose of this study is to identify the characteristics of both backward walking (BW) and backward running (BR) and show the differences between two kinds of movements according to age. One hundred and four primary school children and varsity 20 students participated in this study. The subjects were divided into four groups. 15-meters-long lane was used in this experiment. All video pictures were manually digitized on Sony Motion Analyzer (SMC-70G). Cycles of motion in BW &BR were analyzed. The walking velocity didn't increase so with age in BW-test, but the results of BR-test revealed that running velocity increased with age. Step length was increased with age in each test. Step frequency of BR didn't increase with age. Step frequency in BW didn't increase with age. We categorized the form using examples from Miyamaru's procedure. BW was categorized to 5 patterns, and BR divided to 6 patterns.

KEY WORDS: backward walking, backward running, flight phase, step frequency, step length

INTRODUCTION: "Walking" is one of important exercises in our daily life, and we can't live freely without walking. And also "Running" is one of locomotions as a physical exertion that we can move faster. These movements were learned in connection with growth. We tend to take "Walking" and "Running" "Forward" movements, but we can do "Backward" walking and running. We often use backward walking and running (BW and BR) in sport. Whereas there are many studies about walking and/or running forwards (FR & FW), there are few about BR & BW. It is not clear how they appear and develop. The purpose of this study was to investigate the characteristics of these movements and show the difference of movements owing to age using biomechanical methods.

METHODS: Eighty-four primary school children and 20 students in a university participated in this study. The subjects were categorized into four groups. (Group 1: 6~7 year-old [NS = 32], Group 2: 8~9 year-old [NS = 32], Group 3: 10~11 year-old [NS = 20], Group 4: 19~22 year-old [NS = 20]) 15-meters-long lane was used in this experiment. In BW-test, we didn't specify their steps. We tell them to run not at full speed but at speed that they don't fall down in BR-test. Number of steps and duration at 0~10 m was measured, and calculated step length, step frequency, and running velocity. Eight reflective markers were placed on the subjects left-hand-side. Videotaping was carried out with VHS video camera (National AG-400) operating 60 fields per second. The camera recorder was located on the left of the lane at a distance of 10 m, and the BW&BR movements of 7-10 m phase were videotaped. All video pictures were manually digitized on Sony Motion Analyzer (SMC-70G). Cycles of motion in BW &BR were analyzed. Analysis was carried out every two flames. Subjects wore hardhat for safety's sake.

RESULTS AND DISCUSSION: In BW-test, less of increase of walking velocity according to age was shown. On the other hand, the results of BR-test revealed that running velocity increased with age. (Table 1) These data emphasis that we can do BW as fast as grown-ups at the age of group1, but the velocity of BR in primary school children is inferior to grown-ups. It was reported that FW appears before FR does because FR requires waist-down power and balance. This may be also the case for BW and BR. Step length was increased with age in each test.(Table2A and Table2B) The increase of step length in BW owe to growing stature. In BR, waist-down power and balance contributed to increase of step length. Step frequency in BW didn't increase with age. It is reported that the step frequency of FW decrease with age. However, we couldn't find out this tendency from BW-test. Step

frequency of BR didn't increase with age. It was said that the transformation of step frequency in FR was unapparent through 2~20 years old. This result follows the report.

Table1   Means and standard deviations of velocity in backward running related to age and sex.

		Group I	Group II	Group III	Group IV
Velocity	male	1.22±0.435	1.46±0.205	1.65±0.278	1.91±0.212
(m/sec)	female	1.07±0.229	1.15±0.221	1.48±0.175	1.91±0.211
sex difference t value		1.1753	4.0181*	1.6252	0.0239

* :significant at $p<0.05$

Table2A   Means and standard deviations of step length in backward walking related to age and sex.

		Group I	Group II	Group III	Group IV
step length	male	0.39±0.056	0.48±0.054	0.50±0.063	0.54±0.046
(m)	female	0.35±0.091	0.42±0.048	0.47±0.029	0.51±0.041
sex difference t value		1.2654	3.2522*	1.6744	1.5424

* :significant at $p<0.05$

Table2B   Means and standard deviations of step length in backward running related to age and sex.

		Group I	Group II	Group III	Group IV
step length	male	0.41±0.077	0.48±0.079	0.52±0.072	0.63±0.071
(m)	female	0.36±0.074	0.44±0.053	0.51±0.064	0.63±0.035
sex difference t value		1.3884	1.7126	0.4104	0.2148

* :significant at $p<0.05$

In BW-test, each group had 65% of stance phase and 35% of swing phase in a stride. Each group showed about 40% of stance phase and 60% of swing phase in the BR-test. On the other hand, the test showed a difference of flight phase. Flight phase of female subjects who belong to group 1 and group 2 (about 6%) was shorter than other groups (about 25%). It can be considered that the reason why female subjects who belong to group 1 and group 2 is shorter than other groups is born from the lack of waist-down power and balance at landing and at flight phase. We categorized the form using examples from Miyamaru's procedure, which have an interest in arms swinging. BW was categorized to 5 patterns, and BR divided to 6 patterns.

<BW>
A- Type: Shoulders and arms were swung little. The swing appears irregularly to keep balance of upper extremity.
B- Type: This type shows little swing of upper extremity.
C- Type: In this type, negative swings of arms are shown with the arms flexed.
D- Type: Shoulders and arms are relaxed and swung, but it is small swing.
E- Type: Shoulders and arms are relaxed and swung positively.
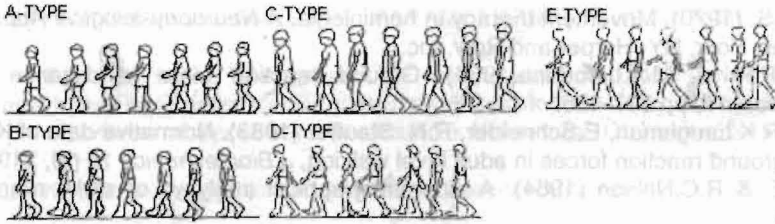
Figure 1A BW form of each group.

A- Type: Shoulders and arms were swung little. The swing appears irregularly to keep balance of upper extremity.
B- Type: This type shows little swing of upper extremity. The arms are extended.
C- Type: This type shows little swing of upper extremity. The arms are flexed.
D- Type: In this type, negative swings of arms are shown with the arms extended.
E- Type: In this type, negative swings of arms are shown with the arms flexed.
F- Type: Shoulders and arms are relaxed and swung positively. The flexion of arms is well maintained.
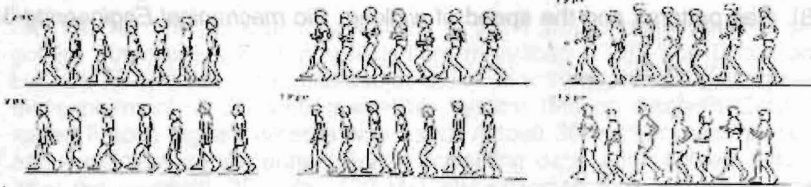

Figure 1B BR form of each group.

In BW-test, more than half of subjects who belong to group 1 were categorized to A-Type or B- type. A lot of male subjects were categorized to B-Type or C-Type, and female subjects to B-Type. There were more than half of male subjects who were classified into D-Type and were classified into B-Type in group 3. All of the subjects who belong to group 4 were categorized to E-Type. In BR-test, there were great differences between individual. However, all of the subjects who belong to group 4 were categorized to F-Type. Group 4 showed the perfect form of BW and BR. It suggests that BW and BR may develop over 11-year-old. It was reported that FW was learned at 3 years old, and FR learned at 7 years old. Comparing with this report, BW and BR complete late. This is owing to the fact that BW and BR is not the movement in daily life. It can be considered that the reason why male subjects were able to develop the form faster than female subjects has a lot of things to do with their less anxiety of moving their body backward.

CONCLUSION: It is reported that the form is near completion at 3 years old in FW, and at 7 years old in FR. On the other hand, the form of BW and BR may be developing at 11 years old. In BW-test, stance time and swing time of primary children were similar to grown-up. By contrast, the flight time of female subjects of group 1and group 2 was shorter than the other groups. The step frequency was same through all groups, and it had no difference between different age groups.

REFERENCES:
Bassey, E.J., P.H.Fentem, I.C.MacDonald & P.M.Scriven (1976). Self-paced waliking as a method for exercise testing in elderly and young men. *Clin.Sci. Mole.Med.* 51,609-612.
Beak,R. J, T.P.Andriacchi, K.N.Kuo, R.W.Fermier & J.O.Galante (1981). Changes in the Gait Patterns of Growing Children. *J. Bone and Joint Surgery.* 63-A (9).
Bobath, B. Adult Hemiplegia, Evaluation and Treatment. pp 59-62.

Brunnstrom, S. (1970). Movement therapy in hemiplegia. *A Neurophysiclogical Approach. 1st Ed*, p128. New York, NY: Harper and Row, Inc.

Cavanagh, P.R. & M.A.Lafortune(1980). Ground reaction force in distance running. *J.Biomechanics. 13*, pp 397-406.

Chao, E.Y., R.K.Laughman, E.Schneider, R.N. Stauffer (1983). Normative data of Knee joint motion and ground reaction forces in adult level walking, *J.Biomechanics 16 (3)*, 219-233.

Deshon, D.E. & R.C.Nelson (1964). A cinematographical analysys of sprint running Res. *Quart.* 35 (4).

Devita. P., J. Stribling (1991). Lower extremity joint kinetics and energetic during backward running. Med. Sci. *Sports and Exercise,* 23 (5), 602-610.

Dillman, C.J. (1975). Kinematics analyses of running. In: *Exercise and Sports Science Reviews.* Vol.3, pp 193-218. J.H.Wilmore and J.E.Keogh, New York: Academic Press.

Fenn, W.O. (1929). Mechanical energy expenditure in sprint running as measured by moving pictures. *Am.J.Physiol.* 90: 343-344.

Finley, F.R., K.A.Cody & R.V.Finizie. (1970). Locomotive characteristics of urban Pedestrians., *Arch. Phys. Med.* 51: 423-426.

Flynn, T.W., S.M.Connery, M.A.Smvtok, R,J.Zeballos & I.M.Weisman (1994). Comparison of cardiopulmonary response to forward and backward walking and running. M*ed. Sci. Sports Exerc.,* 26 (1) 88-94.

Grieve, D.W (1968). Gait patterns and the speed of walking, *Bio mechanical Engineering* 3: 119-122.