Effects of 6-week agility ladder drills during recess intervention on dynamic balance performance

ROBERT S.K NG¹; CHEUNG C.W. ²; RAYMOND, K. W. SUM³

¹Physical Education Unit, the Chinese University of Hong Kong, HONG KONG, CHINA

²Po Leung Kuk Fung Ching Memorial Primary School, HONG KONG, CHINA

³Department of Sports Science and Physical Education, The Chinese University of Hong Kong, HONG KONG, CHINA

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Abstract:

The purpose of this study was to examine the effects of 6-week agility ladder drills during recess time on dynamic balance ability in school boys. Seventy-one school boys (9.82 ± 1.90 years; 1.38 ± 0.13 m; 33.28 ± 9.64 kg; BMI 17.25 ± 3.18 kg m⁻²) were assigned randomly into a control ($n = 37$) and experimental ($n = 34$) groups. The experimental group performed 3 agility ladder training sessions per week for 6 weeks. Each training session included six sets of the training program which consisted of 6 exercises in the order of side jump, in and out, hopscotch, left and right leg hop, and icky shuttle, with 30 seconds rest between each set. Both groups were assessed using Star Excursion Balance Test (SEBT) before and after 6-week recess intervention. A statistically significant increase in post-training SEBT scores from 6.1% to 19.1% was seen in all directions for the experimental group, with a score that was better than the control group for both limbs. The dynamic balance ability of the school boys was significantly enhanced in 6-week agility ladder drills training after recess intervention.

Key words: primary school children, SEBT, physical activity promotion, agility training.

Introduction

Low physical activity (PA) participation rate of youth is a global issue for all the countries (Bélanger et al., 2009). A report found that one quarter of the children in the USA did not achieve the recommended 60 minutes of moderate-to-vigorous physical activity (MVPA) participation level every day (Centers for Disease Control and Prevention, 2008). Hong Kong youth may be classified as one of the most sedentary populations in the world (Adab & Macfarlane, 1998; Lee & Tsang, 2004). Recently, the Hong Kong report card on physical activity for children and youth revealed that less than half of the children and youth met the recommended physical activity level (Huang et al., 2016). The worse situation was reflected in the results of a territory-wide community fitness survey in Hong Kong, that only 9.5% of boys and 7.0% of girls in the 7 to 12 age group were classified as physically active with an average of the recommended 60 minutes per day of MVPA (Census and Statistics Department, 2013).

Hong Kong is one of the highest population density cities in the world, the space-confined school environment limited school children to engage in PA (Johns & Ha, 1999). To address the low levels of PA, schools can provide a significant source of PA for the children by: allotting more Physical Education (PE) periods; increasing amount of MVPA in PE lessons; providing PA during recess time; integrating PA throughout the school day; and providing PA opportunities before and after school (Cox et al., 2011; Institute of Medicine of the National Academies, 2004; Kriemler et al., 2011; Ng et al., 2016; Pate et al., 2006).

Among all the possible strategies, the intervention conducted during recess period is more suitable to Hong Kong situation. It not only can promote the PA level of school-aged children (Escalante et al., 2014; Parrish, Okely, Stanley & Ridgers, 2013; Ridgers, Stratton & Fairclough, 2006; Ridgers et al., 2012), but also minimizes the disturbance of the tight schedule of the children before and after school periods. Moreover, safety concern is guaranteed as the activities were conducted under the supervision of teachers (Ng, 2002; Sum, 2016).

The modification of playground setting such as added equipment or materials, playground markings and playground zones is the most common approaches among all the designs and implementations of the recess intervention (Parrish, Okely, Stanley & Ridgers, 2013). Studies were mainly focused on the assessment of the adhesive of the PA level during and after the recess intervention. Only few studies addressed other outcome measures such as the changes of sedentary time and energy expenditure (Ickes, Erwin & Beighle, 2013). Dynamic balance is the ability to maintain a stable base of support while completing a functional task without compromising one's base of support (Winter, Patla & Frank, 1990). It involves a complexity demand of proprioception, range of motion (ROM), and strength (Ricotti, 2011). Agility ladder is a popular piece of

equipment for training speed, coordination, balance, and agility of people with different age group, sports and gender (Brown & Ferrigno, 2014; Ricotti, 2011; Sheppard & Young, 2006; White, 2007). There is no study to explore the training effects of agility ladder drills on Star Excursion Balance Test (SEBT) in the elementary school boys during recess intervention. We hypothesized that the dynamic balance ability of the children would be increased after 6-week agility ladder drills during recess period. Therefore, the purpose of this study was to examine the effects of 6-week agility ladder drills during recess time on dynamic balance ability in school boys.

Methods

Participants

Seventy-one out of 356 school boys aged 6-13 years old, were recruited from a subsidized Catholic boy's primary school in Western District of Hong Kong during the period of April-June 2016. According to their self-reported health record, none of the children had musculoskeletal, cardiovascular, vestibular, visual, neurologic disorder, surgery or underwent balance training or feet muscle strengthening within 6 months at the time of recruitment. They were assigned randomly into a control ($n = 37$) and experimental ($n = 34$) groups. Their body height (measured with a measuring tape) and body weight (BF-531, Tanita, Japan) were collected before the commencement of the intervention. Their dynamic balance ability on both legs of all the participants was evaluated prior to and after the 6-week intervention period. The children volunteered to participate were given a consent form to be signed by the guardians. The ethical approval was received for the university research and ethics committee.

Procedures

Protocol

The procedure of SEBT described by Plisky and his colleagues (2006) was used to examine dynamic balance of participants. The three reach directions (anterior, posteromedial, and posterolateral) of the SEBT were located by adhering 120 cm measuring tapes to the floor at anterior and two aligned at an angle of 135 degree to this in the posteromedial and posterolateral directions. The test was conducted during PE lessons. The investigator provided each participant a verbal instruction and visual demonstration of the testing procedure. Participants conducted the test with bared foot and kept their hands on their hips. No encouragement was given to the participants during testing. Six practice trials on each limb for each of the 3 reach directions were performed to reduce any potential learning effect prior to official testing (Hertel, Miller & Denegar, 2000). Following a rest break, participants completed 3 trials in randomized order of leg tested and order of reach direction with a 10-second break between trials and 20 seconds between directions. The trial was completed when the participant returned to the starting position by placing the reaching leg within 5 in. (12.7 cm) of the stance leg. The reach distance was taken to the nearest millimeter. The maximum of 2 mis-trials was allowed if 1) the reach leg rested on the floor; 2) the stance's leg moved from the starting position; 3) the reach leg could not return to the starting position (Hardy, Huxel, Brucker & Nesser, 2008). Only the best of three measurements was recorded for each directional reach for statistical analysis. Their leg length on both legs was determined with a tape measure, from the anterior superior iliac spine to the medial malleolus of the same leg (Gribble & Hertel, 2003). The measurement in the nearest centimeter was recorded while the participants lay supine on the floor. The average of the sum of both left and right leg lengths was used to normalize excursion distances by dividing the distance reached by leg length and then multiplying by 100 (Gribble, Kelly, Refshauge & Hiller, 2013; Hardy, Huxel, Brucker & Nesser, 2008) so that effects of training could be compared among participants.

Training

The experimental group underwent a total of 18 agility ladder drills training sessions of 15-minute duration on 25-minute recess period, administered in 6 weeks with the frequency of three sessions per week, whereas the control group adhered to their normal daily activities during recess time. All participants were also instructed to avoid any exercises aside from activities of daily living. Each training session consisted of a standardised 3-minute dynamic warm up and static stretches follow by a 10-minute agility ladder drills and a 2-minute cool down that include static and dynamic stretches. They put on their PE attires and completed six sets of the training program which consisted of 6 exercises in the order of side jump, in and out, hopscotch, left and right leg hop, and icky shuttle, with 30 seconds rest between each set. The training protocol was designed by the first author who is a certified fitness trainer. Both the 6-week training session and SEBT was administered by the same investigator who is a certificated PE teacher. The outline of the ladder was affixed using 2 cm width tape to the floor with the dimensions of 10.0 meter long, 0.5 meter width and 0.3 meter between rung. This can avoid the interruption of the training and the risk of injury by preventing the ladder from being misplaced by participants during training. Finally, all the participants completed the SEBT, and those in the experimental group attended all the training sessions.

Statistical analysis

Descriptive statistics (Mean $\pm$ SD) were derived for all variables. The demographic data, pre- and post-test values for the dependent variables were first analysed to determine whether the distributions were normal

using Shapiro Wilk Test. Independent sample t-test and Levene test was then employed to test for equality of variance between control and experimental groups. Data was analysed using SPSS (Version 20.0, IBM Corporation, Somers, NY).

The independent variables in this study were group (control and experimental) and time (pre-test and post-test). The dependent variable (normalized distances) was each determined for main effects and interactions with a 2 (group) x 2 (time) analysis of variance (ANOVA) with repeated measures on the individual NSEBT scores, for the mean of the sum of three normalised reach distances (anterior, posteromedial, and posterolateral) of right limb score (3R-NSEBT) and left limbs score (3L-NSEBT) as well as for the mean of the sum of six normalized reach distances of both right and left limbs score (6RL-NSEBT), between the control and experimental groups. Pairwise comparisons were performed if significance was evident. Statistical significance was set at $p < 0.05$.

Results

The SEBT had been found to have good intra-tester reliability with Intraclass correlation coefficients (ICC) of 0.80 to 0.85 with a standard error of measurement (SEM) ranging from 3.1 to 4.2 cm for the 3 reach directions (Shaffer et al., 2013). In the present study, intra-tester reliability across the 3 repetitions for each direction resulted in ICC, six values ranging from 0.97 to 0.99, with the SEM value between 1.1 and 2.0 cm and minimum difference (MD) ranged from 3.1 to 5.6 cm. The data suggest excellent reliability across all directions of left and right limbs among the three measurements.

The result of Shapiro-Wilk test ($P > 0.05$) (Razali & Wah, 2011; Shapiro & Wilk, 1965) showed that the age was approximately normally distributed for both groups, with a skewness of -0.256 (SE = 0.434) and a kurtosis of -0.789 (SE = 0.845) for the control group and a skewness of 0.046 (SE = 0.414) and a kurtosis of -0.892 (SE = 0.809) for the experimental group (Doane & Seward, 2011).

Independent sample t-test and Levene's test results verified that the demographic and anthropometrical variables such as age, weight, leg length and pre-test leg reach distances of the two groups were approximately the same ($P > 0.05$) and was accepted for comparison (Martin & Bridgmon, 2012) (Table 1).

Results of paired sample t-test showed that participants in the experimental group improved performance of the individual NSEBT scores and composite scores on both limbs after 6-week of training, while no significant improvement of posteromedial of right limb (0.7 ± 15.3 cm), posterolateral of left limb (0.9 ± 19.4 cm) and the 3R-NSEBT (6.2 ± 11.4 cm) was observed in the control group. Comparison of NSEBT score pre- and post-training in each group showed a higher mean score after 6-week intervention period. A statistically significant increase in post-training NSEBT scores from 6.1% to 19.1% was obtained in all directions for the experimental group, with a score that was better than the control group for both limbs (Table 2).

Repeated measure ANOVA revealed a significant main effect for time was observed on the 3L-NSEBT, $F(1, 69) = 2.054$, $p = .000$; partial $\eta^2 = .305$; 3R-NSEBT, $F(1, 69) = 2.054$, $p = .000$; partial $\eta^2 = .313$; and 6RL-NSEBT, $F(1, 69) = 2.054$, $p = .000$; partial $\eta^2 = .305$.

There was no statistically significant interaction effect between group (control and experimental) and time (pre-test and post-test) on 3L-NSEBT, $F(1, 69) = 2.054$, $p = .156$; partial $\eta^2 = .029$; 3R-NSEBT, $F(1, 69) = 1.825$, $p = .181$; partial $\eta^2 = .026$; and 6RL-NSEBT, $F(1, 69) = 2.054$, $p = .000$; partial $\eta^2 = .305$.

Table 1: Demographic and anthropometrical variables of control and experimental groups

Variables		All (n = 71)	Control group (n = 37)	Experimental group (n = 34)	P value
Age (years)		9.82±1.90	10.19±1.88	9.41±1.96	0.093
Height (meter)		1.38±0.13	1.41±0.11	1.34±0.13	0.033*
Weight (kg)		33.28±9.64	33.99±8.46	32.51±10.86	0.529
Body Mass Index (kg m ⁻²)		17.25±3.18	16.99±2.84	17.53±3.53	0.478
Average leg length (cm)		72.62±7.79	74.59±7.09	70.47±8.05	0.065
Pre-training normalized SEBT scores					
Anterior (cm)	Right limb	76.68±10.22	78.27±10.85	74.95±9.35	0.173
	Left limb	75.87±11.03	74.81±9.45	77.02±12.57	0.405
Posteromedial (cm)	Right limb	94.97±11.28	95.34±11.35	94.59±11.35	0.780
	Left limb	94.60±12.25	95.68±13.51	93.42±10.88	0.441
Posterolateral (cm)	Right limb	75.66±15.11	75.77±15.80	75.54±14.57	0.951
	Left limb	74.72±13.79	78.44±13.83	70.67±12.73	0.016*

* Independent sample t-test $p < 0.05$

Table 2: Mean $\pm$ Standard Deviation NSEBT scores and scores difference of control and experimental groups.

Direction of movement		Control Group n = 37		Scores difference	Experimental Group n = 34		Scores difference
Test		Pre-test (cm)	Post-test (cm)	(cm) (%)	Pre-test (cm)	Post-test (cm)	(cm) (%)
Anterior	Right limb	78.3 $\pm$ 10.9	84.1 $\pm$ 15.2	5.8 $\pm$ 13.5** 7.4%	74.9 $\pm$ 9.3	88.4 $\pm$ 11.9	13.5 $\pm$ 16.0** 18.0%
	Left limb	74.8 $\pm$ 9.4	83.5 $\pm$ 13.1	8.7 $\pm$ 15.3** 11.6%	77.0 $\pm$ 12.6	90.2 $\pm$ 16.3	13.2 $\pm$ 18.8** 17.1%
Posteromedial	Right limb	95.3 $\pm$ 11.4	96.0 $\pm$ 10.0	0.7 $\pm$ 15.3 0.7%	94.6 $\pm$ 11.3	100.4 $\pm$ 11.7	5.8 $\pm$ 14.1* 6.1%
	Left limb	95.7 $\pm$ 13.5	96.6 $\pm$ 12.2	0.9 $\pm$ 19.4 0.9%	93.4 $\pm$ 10.8	99.9 $\pm$ 11.6	6.5 $\pm$ 15.8* 7.0%
Posterolateral	Right limb	75.8 $\pm$ 15.8	86.5 $\pm$ 12.3	10.7 $\pm$ 18.0** 14.1%	75.5 $\pm$ 14.6	86.2 $\pm$ 12.9	10.7 $\pm$ 15.7** 14.2%
	Left limb	78.4 $\pm$ 9.4	88.4 $\pm$ 11.9	10.9 $\pm$ 16.2** 12.8%	70.7 $\pm$ 12.7	84.1 $\pm$ 15.2	13.4 $\pm$ 17.8** 19.1%
Composite scores ¹	Right limb (3R-NSEBT)	83.1 $\pm$ 9.8	89.3 $\pm$ 8.1	6.2 $\pm$ 11.4 7.5%	81.7 $\pm$ 8.7	89.3 $\pm$ 8.1	7.6 $\pm$ 12.8** 9.3%
	Left limb (3L-NSEBT)	83.0 $\pm$ 9.9	89.5 $\pm$ 9.5	6.5 $\pm$ 13.4** 7.8%	80.4 $\pm$ 8.1	91.4 $\pm$ 10.2	11.0 $\pm$ 13.5** 13.7%
Composite scores ²	Right and left limbs (6RL-NSEBT)	83.1 $\pm$ 9.5	89.4 $\pm$ 8.3	6.3 $\pm$ 11.6** 7.6%	81.0 $\pm$ 7.7	91.6 $\pm$ 9.6	10.6 $\pm$ 12.6** 13.1%

* P < 0.05; **P < 0.01 paired samples test

Composite scores¹ = the mean of the sum of 3 normalized scores

Composite scores² = the mean of the sum of 6 normalized scores

Independent samples t-test revealed no significant difference in pre-test NSEBT measurements between control and experimental groups.

Discussion

The aim of the present recess intervention is not only to provide an opportunity for school boys to be active during recess time, but also to explore whether their dynamic balance ability can be enhanced in 6-week agility ladder drills training after recess intervention.

Prior to the intervention, both groups of school boys showed similar reach distances on the NSEBT in all directions. After the intervention, the NSEBT reported that the maximum reach scores increased from pre to post test in both groups. The NSEBT performance of both limbs in all directions was significantly improved in the experimental group compared to the control group. In contrast with the work of Meng and Lee (2014), who reported no significant improvement in NSEBT reach scores of nine school boys following 2 sets of 12 agility ladder exercises after school, three times a week for 4 weeks. The observation of the non-significant results may be due to the employment of the small sample size and short intervention period in their study. In the present study, 18 sessions of 15-minute agility ladder training in 6 weeks during recess period significantly improved reaching distance in all directions of both legs. Further research could also explore the effect of agility ladder training on dynamic balance in school girls and make comparison of the training effect between genders.

Despite the fact that there were significant improvements in composite scores and individual reaches scores, it is pertinent to note some disparity in the percent change from pre- to post-score in the experimental group. Comparing with the largest improvement of 19.1% was noted in posterolateral direction of left limb, the slight improvement of 6.1% was recorded in the posteromedial side of right limb. The explanation for the differences was not apparent which reflected that some elements in the training program were missing or incomplete. The refinement of the training program is an area for further investigation.

Studies found that limb dominance and side-to side imbalance in lower extremity measures have been found to be a risk factor for anterior cruciate ligament injury (Filipa, Byrnes, Paterno, Myer & Hewett, 2010; Ford, Myer & Hewett, 2003). In the present study, there was no significant difference between the NSEBT composite scores of both legs in the experimental group which indicated that the agility ladder training had equal training effect on each limb.

A significant limitation to our study is the lack of ROM, agility and strength data. This study also did not assess their lower extremity flexibility, although Gribble and Hertel (2003) reported that no statistically significant relations were found between ROM measurements and excursion distances with the SEBT in 30 recreationally active participants. Besides, exercise outside of the intervention of both groups were not closely monitored, with some students might involve in any combinations of balance, strength and conditioning, and agility training during their PE lessons. Moreover, comparing with the traditional agility ladder, the ladder

employed in the present study was adhered on the floor. Despite of the mentioned limitations, the improvements observed in NSEBT reach scores after 6-week recess intervention has practical implications.

School children spend a half day in school. The school environment plays a vital role in providing opportunities for children to be physically active (Centers for Disease Control and Prevention, 2011; Kriemler et al., 2011). School recess offers an ideal opportunity for children to be active on a daily basis in many countries around the world (Parrish, Okely, Stanley & Ridgers, 2013). It has the potential to contribute up to 40% towards PA recommendations (Ridgers, Stratton & Fairclough, 2006). In Hong Kong, the school environments characterize with small space (Johns & Ha, 1999). The development of sedentary behavior of school children during recess time may be due to the safety reason that they are strictly prohibited to run or chase with each other in the playground. The school playground environments with limited space can be altered by providing ladder-shaped marks on the ground like hopscotch. It is an area to explore whether this arrangement can promote their spontaneity PA participation, although the findings of previous studies provided contrary results (Cardon, Labarque, Smits, & De Bourdeaudhuij, 2009; Parrish, Okely, Stanley, & Ridgers 2013; Verstraete, Cardon, De Clercq, & De Bourdeaudhuij, 2006).

Conclusions

The dynamic balance ability of the school boys was significantly enhanced in 6-week agility ladder drills after recess intervention. In a long run, the advancement of their dynamic balance ability not only promotes their participation in a variety of physical activities that involve body movement, but also increase injury prevention (Claxton, Troy & Dupree, 2006).

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