



## Comparison of Agility Training Programs for Injury Prevention in Malaysian School Children

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### Abstract

*This study is conducted to determine the impact of a short-time agility intervention in four weeks period on primary school students in order to reduce the risk of injuries among school children. The subjects consist of 20 Standard 5 students that were randomly picked but must be free from any injuries, health diseases and had been allowed by their parents to participate with this study. They were divided into two groups. Group A (n = 10) will perform t-test drill and Group B (n = 10) will perform Zig-zag drill. Both groups completed agility interventions to improve agility during their physical education period in once a week for four weeks. They performed the drills three times alternately with other students according to their group. Edgren's Side Steps, an indicator of agility, were measured for both groups at the beginning and end of the intervention period. In the pre-test the test scores indicated no difference between the two groups. Post-test indicated a significant difference in the test scores that shows Zig-zag drill improved student's agility better than t-test drill,  $t(9) = 14.48$ ,  $p < 0.005$ . The results indicated that Zig-zag drill is more effective compared to t-test drill in improving students agility in order to reduce the risk of getting injured.*

**Keywords:** Agility, primary school children, zig-zag drill, t-test drill, injury, prevention.

### Introduction

According to Piaget's theory of cognitive development<sup>1</sup>, there are two stages in childhood developmental: pre-operational stage and concrete operational stage. Based on aged-related development period, newborn will be from birth to four weeks baby, infant from baby age four weeks to one year old, toddler ages from one to three years old, preschooler ages from four to six years old, school-aged child are from ages six to thirteen years old and adolescent ages from thirteen to nineteen years old.

In developmental psychology, there are four stages; toddlerhood<sup>2</sup>, early childhood, middle childhood and adolescence. The term toddler means a child from age one to three years old. At this stage the child will develop their cognitive, social and emotional state. Toddler is when the child is still learning to walk properly without any help from parents or environment. The developmental milestone of toddler can be divided into several areas; physical, fine motors, gross motor, vision, social, hearing and speech. Each toddler can be greatly different in the time taken to master each milestone. However, it is common for toddler to achieve certain skills such as walking first before they learn to jump. Early childhood human life period starts from birth to age eight years old (National Association for the Education of Young Children)<sup>3</sup>. In this stage there are also developmental stages; physical growth and development, cognitive growth and development and social-

emotional growth and development which occur simultaneously with each stage. Middle childhood is when children progress from their home to broader social environment. By this time, children learn to do things independently. Middle childhood is also characterized by various methods of further understanding and learning. This is a crucial time for them to grow conviction in all areas in life through surrounding such as family, friends, school and sports. Puberty happens through an extended process and starts with an increase in hormone production results several physical changes. Usually puberty occurred at this stage. Adolescence is the time nearly related with teenage years. At this stage, children are facing a transition from child to adulthood. According to Hogan and Aston, this transition marked with behavior such as finishing school, leaving house, starting a job, get married and have kids.

The term exercise is commonly interchangeably to have the same definition with physical activity<sup>4</sup>. Physical activity is any movement or bodily activity that improves or maintains physical fitness or overall health and wellness. The most common purpose in doing exercise is to achieve physical fitness. Exercise usually works the body at a higher intensity than usual level of daily activity. Exercise elevates the heart rate and will also work the muscles. Exercise plays an important role to ensure the body is strong enough to meet the challenges in everyday life.

There are mountain of positive effects when the person exercise regularly such as improved heart and lung regulation, improve

metabolic function, strengthen bones, joints and muscles and recent study had claimed that physical activity can increase brain function as well. Certain types of physical activity have been identified endorphin production in recent study as well. Endorphin is a type of hormone that known as natural pain killing substance found in the human brain. Regular physical activity would help in maintaining health, flexibility, strength, balance and coordination. In other words, the overall level of health and fitness can be improved through a regular exercise.

For adults exercise is a physical activity that associated with improving health and preventing from any diseases. But for children exercise means playing and having fun with their friends. There are many benefits of exercise as everyone will get benefits from regular exercise performed. The long-term health advantages of exercise are strengthen the cardiovascular system, develop stronger muscle and bone structure, have good immune system, reduce the risk of overweight and can control blood pressure and body fat. Children who are active will able to faces physical and emotional changes better and decrease the risk of developing type 2 Diabetes as it is a crucial issue in Malaysia lately. Active children will also enjoy additional health benefits as they can improve their over-all fitness through exercise, increase the blood circulation to the brain and body tissues which will transport more nutrients and oxygen. Children will feel more energized due to the increased oxygen in their body. As they exercise, there will be a lot of sweating and breathing which are among the best way to detoxify the body. Exercise improves mental health as active children have capability to concentrate more, even for an extended school day. Perhaps most significantly, physical activity prospers children ability to face challenging situations. In addition, children shall develop social skills such as communication, empathy and leadership.

Elements that consist in physical fitness are agility, balance, cardiovascular endurance, coordination, flexibility, muscular endurance, muscular strength, power and speed. Changing direction and speed, without falling, is agility and coordination. Changing speed and direction requires the muscles to shorten, immediately after lengthening. The above muscle function is called a stretch reflex, which is protective to the muscle and tendon. In order to train the muscle to react quickly enough to avoid injury neuromuscular training is essential. One example of how to train the neuromuscular system is by using coordination training. Hence, to improve the agility level in performing physical activities, children should perform coordination training programs. There are many types of coordination training programs such as cross step-over running, mirror games, multi-directional forms of running, jumping and skipping and obstacle running. Which coordination training method is the best to improve agility level is still unknown.

Agility plays an important role in everyday life. In sports performance, agility will give a good basic for motor skill function and neuromuscular control, improve overall performance in any situation and the most important is will

decrease the injury risk. The acquisition to become agile needs the occurrence of suitable movement patterns. The developments of locomotion skills in children begin at an early age as the children learn to walk without any help. If the children's movement efficiency is poor or the movement always associated with unbalanced posture, lack of coordination and timing and sometimes present of awkward hand movement, the children's agility level may not developed completely yet or maybe the children is having any disorders. Other cause of injury in school children is due to road traffic injuries and falls. The risk factors of falls are child-related factors, agent factors, environmental factors and lack of treatment and rehabilitation.

Nowadays, physical fitness among children has continued to decline. The Government of Malaysia under Ministry of Youth has developed a lot of programs in order to keep the community healthy<sup>5</sup>. As the physical fitness in pediatric population has continued to declined, this will affect the agility level in performing physical activities thus increase the rate of injuries in pediatric population. Child injuries are an extending worldwide public health problem. Millions of children suffer the effect of non-fatal injuries and thousands die each year from violence or injuries. However, there are still proven ways for each area of child injury to reduce rate of mortality and severity of injury. The awareness of the problem and method to prevent those problems from become worse in the future.

According to the World Report on Child Injury Prevention<sup>6</sup>, falls among children are the superior factor of presentation to an emergency department. Almost 47000 children and teenagers die from each year. It means that nearly 129 children die per day. For every deathly fall, there are about 690 children and teenagers who miss school. Furthermore, non-deathly falls are the major frequent factor for children to be taken to an emergency room and a superior factor of long term disability. Falls are commonly associated with agility, one of the physical fitness components that play a major role in performing active daily life especially in children. The common injuries happened to children are supracondylar humerus fracture, Panner's disease and Osgood's Schlatter. As ligaments in children are stronger than bone, they sustain fractures more rather than sprains.

Apart from that, the obesity rate has continued to increase. According to a global estimate by the World health Organization (WHO)<sup>7</sup>, there were about 1.6 billion overweight persons aged 15 years old and above and among them at least 400 million adults were obese in 2005. Malaysia has been ranked number sixth in the Asia-Pacific region for obesity and tops of the list in South-East Asia for both diabetes and obesity. Previous Deputy of Health Minister, Datuk Seri Dr Hilmi Yahaya said that there were about three million obese Malaysians and the number was growing while there were about five million individuals who distress from varying degrees of diabetes. While the president of Malaysian Society for the Study of Obesity, Prof Dr Mohd Ismail Noor said that the situation had

become more critical because there were more overweight children nowadays.

Obesity in youth will increase the risk of cardiovascular disease such as high blood pressure and high cholesterol. Obese adolescents are more likely to suffer pre-diabetes. Means that blood glucose levels show a greater risk for diabetes development. Children and adolescents who are obese are at higher risk for joints and muscles problems and sleep apnea, a type of sleep disorder distinguished by cease in breathing or instances of slight or infrequent breathing during sleep. They also will be having social and psychological problems such as poor self-esteem and stigmatization. For long-term health effects, obese children are likely to be obese too when they are adult. Therefore, there are higher chances of getting adult health problems such as type 2 diabetes, stroke, osteoarthritis, particular types of cancer including breast cancer, thyroid, colon, pancreas, kidney and as well as Hodgkin's lymphoma and multiple myeloma and the most common problem is heart disease.

Along with an unhealthy diet and tobacco use, physical inactivity has been admitted as a top-three possibility cause of Non-Communicable Diseases (NCDs), which contribute to about 60% of deaths whilst the percentage of physical inactivity students in Malaysia was 56% in male and 65% in female making Malaysia among the top ten physically inactive in Asian countries<sup>8</sup>. NCDs also called as chronic diseases cannot be transmitted from person to person (World Health Organization). In other words, NCDs are not contagious or transferable. NCDs can be divided into four main types; chronic respiratory diseases, diabetes, cancers and cardiovascular diseases. NCDs in Malaysia reported for an evaluated 67% of all mortality in 2008. The most common NCDs in Malaysia are cardiovascular diseases. It was evaluated for 32% of total deaths for all age groups in 2008. In addition, diabetes, respiratory diseases and cancers contributed 15%<sup>8</sup>.

One concern is the increasing risk of injury due to the deterioration in coordination and agility in performing daily activities among school children. This happened due to their sedentary lifestyle.

A sedentary lifestyle is a kind of lifestyle that have no or irregular exercise. Sedentary activities such as playing video games, surfing and watching television which not involved with vigorous physical activity are familiar among children nowadays. The term sedentary lifestyle usually associated with the term 'couch potato'. Couch potato means individual who did not performed any or little exercise and spent most of the time in front of television. The consequences that happened due to decrease in agility are having higher risk to get injured.

Throughout this study, we can identify which agility training program can improve student's agility in four weeks period in

order to decrease the risk of injury. In addition, the drills performed will also help in developing overall athleticism and enhancing performance.

Agility training will provide the school children with appropriate skills to be able to respond the right way when faced a situation that may potentially lead to injury. In addition, the most suitable training will be identified in improving agility among school children.

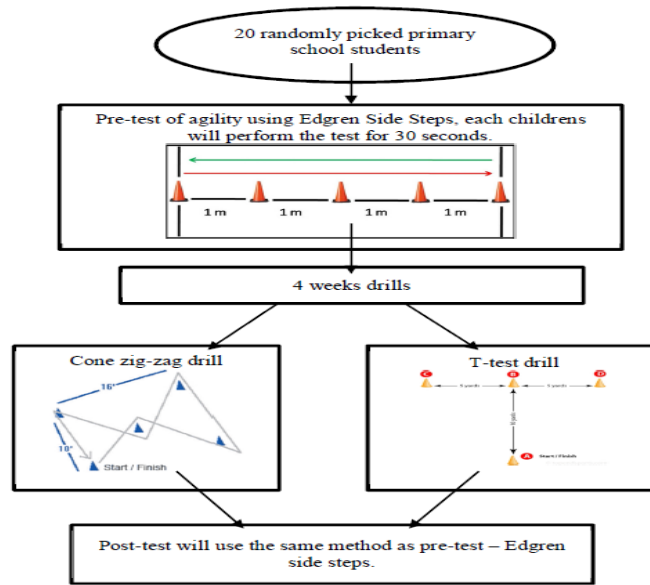
**Agility:** Agility has classically been defined as simply the ability to change direction rapidly<sup>9</sup>, and also the ability to change direction rapidly and accurately<sup>10</sup>. In more recent publications, some authors have defined agility to include whole-body change of direction as well as rapid movement and direction change of limbs<sup>11</sup>. In this study, student's agility will be measure by using repetitive side steps test

**Children:** A child means all human being that aged below eighteen years old based on The United Nations Convention on the Rights of the Child. Children are not little adults which some people thought. Children commonly have lack of rights than adults and classified as incompetent to make any important decision. Children must always be under the care of their parents or guardian.

## Methodology

**Research Framework: Procedure:** Before this study was conducted, the consent form was distributed to the students to get the permission from their parents to participate in the intervention. The consent form also to ensure students are free from any musculoskeletal problem and health diseases. If the students have asthma or not feeling well, they will automatically excluded from participating the intervention. Only students of Year 5 involved with this study as they had longer physical education period. After the consent form was submitted only 16 male and 4 female students fulfilled the qualification to participate with this study. This study started with briefly explanation to the students about this study. A warm up and cooling down activity will be held before they started the intervention for every session.

**Study Design:** This study is an experiment type which involved pre-test and post-test. The study will last for 4 weeks during a regular school day. Of the 20 subjects, 16 were male students and 4 were female students were randomly assigned. Immediately before and after the intervention, an agility test will be administered to participants. Once a week during physical education period the students will perform the interventions 3 times alternately with other students according to the group given. The study is a randomized controlled trial to determine which agility exercise program may efficient in increasing the student's agility to reduce the risk of injury.



**Figure-1**

The flow chart shows about this study research framework

**Participants:** The participant of this study was 20 primary school students from Standard 5 that consist of 14 male students and 6 female students. All of them are 11 years old. The average height and weight of the students were: 139.83cm and 36.17 kg for females and 163.5cm and 35.33 kg for males. A detailed discussion was held with the Board of Education and the headmaster of the school that related with this study and before starting this study. The headmaster gained the consent of the student’s parents. In addition, this study was carried out with the approval of the ethics of the Faculty of Sports Science and Coaching, Sultan Idris Education University.

**Venue of Study:** This study will be conducted in a primary school at Pahang, Malaysia. The school is Sekolah Kebangsaan Mela that is situated in Kuala Lipis district. It is a small school in a village area that consists of 20 teachers and 153 students. All the drills and test will be held at the school field area.



**Figure-3**

Shows the explanation given to the school children about the program



**Figure-2**

Shows Standard 5 students during the physical education period

**Instrument:** Planning and implementing drills only requires cones, stopwatch, measuring tape and open court or field. In addition, a very good instruction and organization of procedure would be enough for executing this study.

**Data Analysis:** Data collection is the process of collecting and measuring information on a logical set of features of interest, using an organized systematic fashion that enables one to answer stated research questions, test hypotheses, and evaluate outcomes. This study is using experimental design which is a type of evaluation to determine whether an intervention or program will cause an effect on the participants. Experimental study design consists of targeted groups, pre-test and post-test evaluation.

All the collected data will be analyze using SPSS version 20. One-sampled T-test will be used for further evaluation to compare the results of the Edgren’s Side Steps between the two groups at pre-test and post-test.

### Results and Discussion

Both groups consist of 10 students (table-1). So, there are 20 students altogether that participate in this study. Group A will perform T-test drill while Group B will perform Zig-zag drill. Both groups performed the interventions for 4 weeks. The mean number of pre-test for Group A is 4.80 and 5.00 at post-test. The value of standard deviation of Group A at pre-test is .632 and 1.563 at post-test.

**Table-1**

Group		N	Mean	Std. Deviation	Std. Error Mean
Group A	Pre-test	10	4.80	.632	.200
	Post-test	10	5.00	1.563	.494
Group B	Pre-test	10	4.70	.949	.300
	Post-test	10	5.20	1.135	.359

The standard error of the mean (the standard deviation of the sampling distribution of means) of Group A at pre-test is .200 and .494 at post-test. The mean number of pre-test for Group B is 4.70 and 5.20 at post-test. The value of standard deviation of Group B at pre-test is .949 and 1.135 at post-test. The standard error of the mean of Group B at pre-test is .300 and .359 at post-test.

**Table-2**

Group	t	Df	Sig. (2-tailed)	Mean Difference
Group A Pretest	24.000	9	.000	4.800
Group A Posttest	10.113	9	.000	5.000
Group B Pretest	15.667	9	.000	4.700
Group B Posttest	14.484	9	.000	5.200

The second column of the output gives the t-test value. Group A pre-test value is 24.00 and post-test value is 10.11. Group B pre-test value is 15.67 and post-test value is 14.48. The third column tells that this t test has 9 degree of freedom (N-1 = 9). The fourth column tells the two-tailed significance (the 2-tailed p value) which shows that there was a significant value from both groups which is .000.

One-sample t-test was used to compare the mean difference between Group A and Group B in pre-test and post-test. The finding shows that (M = 4.80, SD = .632), t (9) = 24.000, p < 0.005 at pre-test for Group A while at post-test the finding shows that (M = 5.00, SD = 1.563), t (9) = 10.113, p < 0.005. It shows that there was an improvement in agility after they perform the t-test drill for 4 weeks. The finding for pre-test Group B shows that (M = 4.70, SD = .949), t (9) = 15.667, p <

0.005 while for post-test the finding shows (M = 5.20, SD = 1.135), t (9) = 14.484, p < 0.005. Group B also shows an improvement after performing Zig-zag drill for 4 weeks. The minimum score between both groups were different showing that Zig-zag drill is better than t-test drill in improving agility among pediatric population.

**Discussion:** According to Draper and Lancaster<sup>11</sup>, Hastad and Lacy<sup>13</sup> and Fulton<sup>12</sup>, a lot of research about agility testing has used the word “agility” to define any vigorous sporting movement relates a change in body position. Plyometric training can develop agility<sup>14</sup>. Agility is one of the important factors of many physical activities as agility is a multidirectional performance<sup>15</sup>.

According to Sallis, Prochaska and Taylor<sup>16</sup>, about 80% of adolescents are evaluated to spend 30 minutes and above being energetic, apparently below half are energetic atleast for 60 minutes. The factors that commonly associated with adolescent’s physical activity were gender, age and ethnicity.

Nowadays, many Asian countries have encountered health-related disorders that come from overweight and obesity. Thailand has the greater number of people with obesity while India has the lowest number. These disorders recently have developed at younger age<sup>17</sup>. The ministry of Health, Malaysia and Academy of Medicine, Malaysia have established down protocols to reduce the number of overweight and obesity in children and adolescents. These include: reduction in energy intake, improving physical activity and energy expenditure, changing eating habits and activity pattern, and involvement of the family in the process of change.

The most prevalent factor of mortality in Canada and other countries is injury. Injury usually occurred in young age children due to exposure of many risks that effected by physical and cognitive-social distinctive of different phases of development. The frequent injury that happened among younger age children are head injuries as they still lack the capability to protect themselves during a fall. Contrary, in older age children injuries commonly occurred at the upper limb that related with falls from heights in order of using arms to shield the face<sup>18</sup>.

Injuries are the leading factor that causes disability, morbidity and mortality in adolescence and childhood. As childhood injuries become one of the major concerns among parents because they will not only affect their development, health and wellbeing but also devote to slightly financial and emotional load. The common body part that usually encountered injury was lower extremity, head, face, neck, chest and abdomen<sup>19</sup>.

According to World Health Organization (WHO), nearly 950,000 children die in the world due to injury each year. National Crime Records Bureau data and few independent studies reveal that nearly 15-20% of injury deaths occur among children.

Bones are the bodywork of children's growing body. Bones originate from epiphyseal plates, also known as cartilage growth plate that can be found at each end of the bone shaft. Epiphyseal plates separate the calcified shaft (diaphysis) and the calcified head of the bone (epiphysis). The bone elongates as cartilage is harden by deposition into bone. Meanwhile, cartilage will continue to originate on epiphyseal border. Thus, epiphyseal plate keep sustained the width of cartilage. Growing bones are subtle to pressure. Thus, repetitive loading must be avoided. The epiphyseal plate is vulnerable to injury. Due to that condition, a fracture to the epiphyseal plate prior to full growth may lead to a serious injury as it could distort the growth of the bone. Common growth plate injuries are Sever's disease, Salter-Harris fracture and Little Leaguer's Elbow. Other than that fracture of the bone is also common among pediatric population. Fractures can either be open fracture or closed fracture. Open fracture is more dangerous because it will breaks through the skin leading to greater chance of infection to occur compared with the closed fracture. However, both types can be severe enough if not treated properly. There are several types of fractures which are comminuted, oblique, spiral, linear, transverse and greenstick. A greenstick fracture commonly happened in children whose bones are still developing and not harden yet<sup>20</sup>. This is due to the mineral content. Injuries might also occur to musculotendinous structures and nerve tissue as well.

As the bone in childhood stage is still growing, it will make them vulnerable to get injured easily. The bone is still developing because the mineral content is not fully developed. When the body got injured, the body will quickly respond with inflammatory response. The inflammatory stage will usually last within 72 hours to a week depends on the individual differences. Inflammation is an important stage as it is a process where the body starts to promote healing. This process has the advantage and disadvantage because it can be both harmful and helpful. Prolonged inflammation will bring harm to the body. Next stage is fibroblastic stage. This stage happened when the injured tissue starts to repair that will lead to scar formation. Scar formation usually starts after the injury occurred and can last within 4 to 6 weeks. The last stage of recovery is maturation stage that also known as remodeling phase. According to Prentice<sup>20</sup> these three stages occur in sequence but still can overlap one another in a continuum.

Apart from that, muscle weight will increase until puberty. Bones and muscles will get stronger enough through physical exercises. In addition, exercises will also improve agility, one of the fitness components that play important role in injury prevention. Exercise will neither hinder nor assist growth in terms of height but it does thicken the bones by increasing mineral deposits<sup>21</sup>.

This study examined which agility intervention programs will improve the agility of school children in order to reduce the risk of getting injured. The participants were divided into two groups that performed different interventions for three times alternately with other participants once a week in a four week period. The

results proved that Zig-zag drill is more effective than t-test drill in improving student's agility to reduce the risk of getting injured.

Zig-zag drill is better due to the movements involved while performing these drill compared to t-test drill. In Zig-zag drill students need to sprint through the slalom, running around each cone as quickly and closely as possible without touching the cones. Meanwhile, in t-test drill students need to run forward and perform side steps to right and left and then run backwards as quickly as possible. Zig-zag drill used more explosive biomechanics as there is more rapid change of directions compared to t-test drill. Explosive and quicker technique is used as students need to quickly change direction. In order to rapidly change duration they need to quickly turn their hip. Thus, improving the agility more efficiently than t-test drill which did not involve with changing direction. Quicker hip turn will put knee in a superior position to apply force and avoid knee injury. Besides that, Zig-zag drill develops multidirectional speed which did not use in t-test drill. Multidirectional speed plays a vital role for children in the situation to avoid injury from happen. For an example, while they are playing rugby they need to have multidirectional speed skill and also a quick hip turn to avoid any collision with the others. Both interventions will develop control during changes in direction but Zig-zag drill will develop the control better compared with t-test drill. This is due to the pattern of running students need to perform while performing this intervention. Students must change directions rapidly in Zig-zag drill but in t-test drill less control is needed as students only need to run forward, side steps to right and left and backwards. Based on explosive biomechanics, rapid change of direction, multidirectional speed and control, Zig-zag drill is more efficient compared to t-test drill in improving agility to decrease the risk of injury.

**Recommendation:** Based on this study, teachers at school who will conduct the physical education should perform Zig-zag drill first before starting any sports activity. Through this method, hopefully the statistic of children getting injured will be decrease. What is needed for further consideration is a comparative of other agility training programs in order to know the most effective method to improve agility among school children. In addition, the intervention programs should be applied to different age to see if there is any relationship between the age and interventions.

## Conclusion

In conclusion, this study confirms that Zig-zag intervention program is more effective to improve student's agility in order to reduce injury risk. This suggest that rapid change of movements that consist in Zig-zag drill allow better improvement in the agility and only needs a short time to perform, it is suitable to practice during physical education period. This intervention allow students to participate actively although they do not enjoy sports, thus improving children's

physical fitness, health and the most important is decrease the chance of getting injured.

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