ผลของรูปแบบการเคลื่อนไหวต่อระยะทางการเอื้อมมือทิศทางด้านหน้า และด้านหลังในเด็กปกติ

Effects of Various Movement Strategies on Forward and Backward Reach Distance in Typical Children

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บทคัดย่อ

การทดสอบด้วยการเอื้อมมือ เป็นหนึ่งในกระบวนการทดสอบทางคลินิก ที่ใช้ในการทดสอบความสามารถการทรงตัวขณะเคลื่อนไหวในเด็ก ซึ่งค่ามาตรฐานของระยะทางการเอื้อมมือในประเทศต่างๆ มีค่าคะแนนที่มีความหลากหลาย หนึ่งในปัจจัยที่มีส่วนเกี่ยวข้องในความแตกต่างของระยะทางการเอื้อมมือคือ รูปแบบที่ถูกนำมาใช้ในการเคลื่อนไหวขณะทดสอบ วัตถุประสงค์ของการศึกษานี้คือ เพื่อศึกษาค่าระยะทางการเอื้อมมือในทิศทางด้านหน้า และด้านหลังด้วยรูปแบบเคลื่อนไหวที่มีความแตกต่างกัน และศึกษาค่าระยะทางการเอื้อมมือทั้งสองทิศทางในกลุ่มวัยเด็กตอนกลาง ในการศึกษานี้เด็กพัฒนาการสมวัย จำนวน 60 คน ที่มีอายุระหว่าง 7-12 ปี ถูกแบ่งออกเป็น 2 กลุ่มตามช่วงอายุ (7-9 ปี และ 10-12 ปี) เด็กทุกคนจะถูกทดสอบการเอื้อมมือทิศทางด้านหน้า และด้านหลังด้วยรูปแบบการเคลื่อนไหวแบบปกติ จากนั้นจะได้รับการทดสอบด้วยการเคลื่อนไหวรูปแบบข้อเท้าในลำดับต่อไป ผลการวิจัยพบว่าค่าระยะทางการเอื้อมมือทั้ง 2 ทิศทางในกลุ่มอายุ 10-12 ปี มีค่าสูงกว่ากลุ่มอายุ 7-9 ปีอย่างมีนัยสำคัญ (p-value<0.05) แสดงให้เห็นว่า ค่าระยะทางการเอื้อมมือพัฒนาขึ้นตามอายุ นอกจากนี้ค่าระยะทางการเอื้อมมือมีความแตกต่างอย่างมีนัยสำคัญระหว่างรูปแบบการเคลื่อนไหวแบบปกติและรูปแบบข้อเท้า โดยค่าระยะทางการเอื้อมมือรูปแบบปกติมีค่าสูงกว่ารูปแบบข้อเท้าในทั้งสองทิศทาง (p-value<0.05) ผลของการวิจัยแสดงให้เห็นว่ารูปแบบการเคลื่อนไหวมีผลต่อระยะทางการเอื้อมมือทั้งทิศทางด้านหน้า และด้านหลัง ดังนั้นการทดสอบการเอื้อมมือในเด็กควรจะตระหนักถึงความหลากหลายของรูปแบบการเคลื่อนไหว และออกแบบการวิจัยภายใต้วิธีการทดสอบที่เป็นมาตรฐาน

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Abstract

The reach test is a one of clinical tools that is used to measure dynamic balance ability in children. Normative reach distances conducted in different countries showed variation in these scores. One of the factors that could be of particular relevance in the different reach distance is the movement strategies which were asked to perform. The objectives of this study were to investigate forward and backward reach distances in various strategies and to establish reach scores both of the directions in middle-aged children. In this study, sixty children with typical development, aged 7-12, were divided into two age groups (7-9 and 10-12 age groups). The forward and backward reach tests were administered to all the children with their common strategy. Then, they were asked to perform an ankle strategy. The result showed that the reach distances both of the directions in the 10-12 age group were significantly higher than the 7-9 age group (p-value<0.05). That is the reach distances were significantly improved in relation to an increase in age. Moreover, reach distances between the common strategy and the ankle strategy were significantly different. The reach distance in the common strategy was higher than the ankle strategy in both directions (p-value<0. 05) . In conclusion, Movement strategies could affect the reach distances in forward and backward directions. Therefore, various movement strategies and the design of the study under a standardized protocol should be considered when the reach test is conducted in children.

Keywords: *Reach test, Movement strategy, Typical children*

1. Introduction

Reach test is a performance-based test to assess an individual's boundary of stability. A greater reach distance represents a larger boundary of stability and also indicates better dynamic balance ability (Duncan, Weiner, Chandler, & Studenski, 1990). The reach test is simple to understand and perform, cost-effective and required only a yardstick or ruler to measure the distance. It has been shown to be valid and reliable when used in children (Bartlett & Birmingham, 2003; Donahoe, Turner, & Worrell, 1994) . The normative reach distances in children were conducted in different countries such as Turkey (Yuksel, Ozcan Kahraman, Nalbant, Kocak, & Unver, 2016), Indian (Deshmukh, Ganesan, & Tedla, 2011), and the U.S. (Donahoe et al., 1994; Norris, Wilder, & Norton, 2008). It was found that values showed differences in each study. There could be several explanations such as race, life-style difference, or variation in the growth spurt. However, one of the factors that could be of particular relevance in the different reach distance is the procedures or movement strategies which the children were allowed to perform.

The procedures from literature about reach test in the children were varied not only the instruction but also the movement strategy that was allowed to perform. In some previous studies of reach test in children, the participants were allowed to reach with any movement strategies. However, some studies the participants were controlled to use only a given strategy (Bartlett & Birmingham, 2003; Deshmukh et al., 2011; Donahoe et al., 1994; Norris et al., 2008; Volkman, Stergiou, Stuberg, Blanke, & Stoner, 2007, 2009; Yuksel et al., 2016). Chien-Fen Liao

and Sang-I Lin (2008) investigated effects of different movement strategies on forward reach distance in healthy young adults. It was found that differences of instructions (control, yardstick and target conditions) were given to induce different strategies (hip, ankle and mixed strategies) during reaching. Comparison of the reach distances between the strategies showed that the reach distance of hip strategy was significantly higher than ankle strategy (33.2 ± 2.1, 26.3 ± 5.4 cm, respectively) (Liao & Lin, 2008). However, the effects of forward direction, not all different movement strategies, were only studied to find out compensatory movements or movement strategies while the children were asked to perform. In addition, the evidence of the backward reach test in children is not available. The purposes of this study, therefore, were to investigate the forward and backward reach distances in various strategies based on standardized instruction and to establish the forward and backward reach distances in middle-aged children. These results would provide the information for better understanding and correct interpretation of reach test results.

2. Objectives

1. To investigate the forward and backward reach distances in different strategies
2. To establish the forward and backward reach scores in middle-aged children.

3. Materials and methods

The study protocol has been approved by the Ethic Review Committee for Research Involving Human Research Subjects, Health Science Group, Chulalongkorn University, Thailand. The consent to participation was obtained from all children and their parents prior to participation.

3.1 Participants

A cross-sectional study was performed using convenience sampling method. Children, aged between 7 to 12, with typical development were recruited from 2 schools in Bangkok metropolitan region. 60 children were divided into 2 age groups: 7-9 and 10-12 years of age. Each group comprised 30 children (15 males and 15 females). A parent questionnaire was used to screen the children, requesting each child's demographic information (birthday and gender) and current health conditions. The children were selected based on inclusion and exclusion criteria. Children aged 7 to 12 with typical development , appropriate height and weight based on age range (Department of health, 1999) and an ability to follow instructions were included in the study. Children whose health history affected the balance ability, such as those with a musculoskeletal problem, neurological deficit, a visual problem unable to be resolved by wearing eyeglasses, or those receiving the medication with sedative effects within 24 hours prior to the testing were excluded.

3.2 Procedures

Measurements of anthropometric characteristics included height in centimeters and weight in kilograms using a measuring tape and a portable digital scale, respectively.

The reach test procedure was demonstrated to children prior testing. Each child was asked to stand barefoot on a piece of paper adhered to the floor using tapes. Stance width was set at an approximate shoulder's width apart, and the feet position was traced on the paper to ensure that the base of support during their reaching remained equal in forward and backward directions. The block randomization was used to random the directions of reach test. Prior to the testing, a ruler affixed to an adjustable rail cloth was set at the level of the child's acromion process. The children were instructed to raise their right arms at 90 degrees of shoulder flexion remaining their elbows extended, forearms pronated, wrists in neutral, and fingers extended (Figure 1). This position was set as the starting position in both forward and backward reach tests. The children were asked to perform, first of all, a common strategy controlled by the standardized instruction as follows: " reach as far (direction given) as possible without losing balance and do not to touch the ruler" (Figure 2A, 2B). For the backward direction, the participants were instructed to "lean backward as far as possible". In case of showing no primary movements at the ankle joint, a child was asked to perform again with an ankle strategy. The ankle strategy was controlled by the standardized instruction as Chien-Fen Liao and Sang-I Lin (2008) in yardstick condition. The reach score from the distance between middle fingertip at starting and ending positions was recorded, and an average score of three trials correctly performed was used for analysis.

3.3 Statistical Analysis

The statistical analysis was performed by SPSS statistics (version 17.0) software. The descriptive statistic was used to describe demographic and anthropometric characteristics data. The Kolmogorov-Smirnov test was used to assess the normality of data distribution. A two-way mixed analysis of variance was used to examine main effects and interactive effects of independent factors on the strategy (common and ankle) x age group (7-9 and 10-12 years of age) , and post hoc pairwise comparison was carried out using Bonferroni method. For all comparison, the significant level was considered at a p-value of less than 0.05.

Figure 1 Starting position: a child was instructed to raise her right arm at 90 degrees of shoulder flexion with the elbow extended, forearm pronated, wrist in neutral, and finger extended; and the level of the ruler was set at the child's acromion process.

(A) **(B)**

Figure 2 Forward (A) and backward (B) reach tests, a child was asked to reach with standardized instruction "reach as far (direction given) as possible without losing balance and not to touch the ruler" and performed again with an ankle strategy. The ankle strategy was controlled by instruction as common strategy "reach as far (direction given) as possible without losing balance, keep the arm at the same level and not to touch the ruler".

4. Results

Prior to data collection, the intrarater reliability of the forward and backward reach test in both strategies in healthy young adults was studied. This result showed excellent reliability in both common and ankle strategies ($ICC_{(3, 3)} = 0.94$ and $ICC_{(3, 3)} = 0.90$, respectively).

Sixty children with typical development that were divided into 7-9 and 10-12 age groups participated in the study. The demographic and anthropometric characteristics data of participants are presented in Table 1.

Homogeneous distribution was found in the data. Therefore, the data were explained through parametric statistics. Means and standard deviations of forward reach distances in both age groups and difference between the strategies were shown in Table 2. The two-way mixed analysis of variance showed that there were no significant interaction effects between strategies and age groups. However, the group effect ($F_{(1, 58)} = 6.64$, $p < 0.05$) and the strategy effect ($F_{(1, 58)} = 18.23$, $p < 0.001$) were found. The reach distance in 7-9 aged group was significantly lower

than 10-12 aged group (Mean difference between age group = -1.64 cm, $p < 0.05$). For the strategy effect, the reach distance in common strategy was significantly higher than the ankle strategy (Mean difference between strategy = 1.70 cm, $p < 0.001$).

Table 1 Demographic and anthropometric characteristic data of participants, mean (SD).

Characteristics	Age 7-9	Age 10-12
N (Male/Female)	30 (15/15)	30 (15/15)
Age, years	8 (0.83)	11 (0.83)
Height, cm	128.10 (6.51)	142.65 (6.27)
Weight, kg	26.36 (3.70)	36.70 (5.00)

cm = Centimeters, kg = Kilograms

In backward direction, means and standard deviations of reach distances were presented in Table 3. The results were found to be the same as the forward direction. There were significant difference both in the group effect ($F_{(1, 58)} = 17.61$, $p < 0.001$) and in the strategy effect ($F_{(1, 58)} = 10.49$, $p < 0.05$). The reach distances in 7-9 age group was significantly shorter than 10-12 age group (Mean difference between age group = -2.18 cm, $p < 0.001$). For the strategy effect, the reach distance in common strategy showed significantly higher than the ankle strategy (Mean difference between strategy = 0.53 cm, $p < 0.05$).

Table 2 Forward reach distances in different strategy, means (SD).

Age group	Strategy		Mean difference between strategy (95% CI)	Mean difference between age (95% CI)
	Common	Ankle		
7 - 9	11.99 (3.15)	10.79 (2.63)	1.70	-1.64
10 - 12	14.12 (3.58)	11.94 (2.03)	(0.90, 2.49) [1]	(-2.91, -0.37) [2]

SD = Standard deviation, CI = Confidence interval

[1] Significant difference between common and ankle strategy ($p < 0.001$)

[2] Significant difference between 7-9 and 10-12 age group ($p < 0.05$)

Table 3 Backward reach distances in different strategy, means (SD).

Age group	Strategy		Mean difference between strategy (95% CI)	Mean difference between age (95% CI)
	Common	Ankle		
7 - 9	7.32 (2.01)	6.64 (1.57)	0.53	-2.18
10 - 12	9.35 (2.33)	8.97 (2.42)	(0.20, 0.86) [1]	(-3.22, -1.14) [2]

SD = Standard deviation, CI = Confidence interval

[1] Significant difference between common and ankle strategy ($p < 0.05$)

[2] Significant difference between 7-9 and 10-12 age group ($p < 0.001$)

5. Discussion

Balance ability is achieved by the interaction of multiple body systems, including the musculoskeletal function, development of sensory, somatosensory, and vestibular systems involving a number of neuromuscular processes (Horak, Henry, & Shumway-Cook, 1997; Shumway-Cook & Woollacott, 2012; Westcott, Lowes, & Richardson, 1997). Children rely most heavily on their vision to maintain their balance and postural control; then, this ability was improved following developmental level and converted to multi-sensory like adults. This transition period begins to occur around the age of 7-8 (Shumway-Cook & Woollacott, 2012), thus any balance measurements in children should be performed with vision unobstructed (Yuksel et al., 2016) such as the reach test.

The results of this study showed that mean reach distances increased based on age, similar to the results of previous studies (Deshmukh et al., 2011; Donahoe et al., 1994; Norris et al., 2008; Yuksel et al., 2016). The late middle-aged children (10-12 years old) had a significantly higher reach distance than early middle aged ones (7-9 years old) in both of the directions, at mean differences between age groups of 1.64 cm (95% CI 0.37, 2.91) in forward direction and 2.18 cm (95%CI 1.14, 3.22) in backward direction. Increasing age of children does not only improve the level maturity of multiple body systems, but also covers all the anthropometric characteristics, especially height. Previous studies on effects of anthropometric characteristics factors on the reach distance showed that height was a significant predictor. It is implied that taller children may perform the reach test with higher values (Habib & Westcott, 1998; Yuksel et al., 2016).

Compared between strategies, the distance values of the common strategy was significantly higher than an ankle strategy in both of the directions. The mean differences between strategy were 1.70 cm (95%CI 0.90, 2.49) in forward direction, and 0.53 cm (95% CI 0.20, 0.86) in backward direction. The movement strategies in this study followed the study of Chien-Fen Liao and Sang-I Lin (2008). A common strategy was any strategy that the children preferred to perform the task, and children adopt various strategies when learning the same instruction. An ankle strategy was defined as the movements tended to occur primarily at the ankle joint (Liao & Lin, 2008). However, comparison with movement strategies used for reaching distances in the ankle strategy were significantly shorter than the common strategy, consistent with the reports in healthy young adults (Liao & Lin, 2008). This finding demonstrated that reach distances were affected by different movement strategies. The common strategy involved greater hip and trunk movements resulting in a greater reach distance than the ankle strategy. Therefore, further studies should concern about what strategy to be used during testing because different strategies could affect a reach distance.

6. Conclusion

The forward and backward reach tests were used to measure an individual's boundary of stabilities in anteroposterior direction. The results of this study demonstrated that the reach distances were significantly improved

following their increasing age. The forward and backward reach distances in the 10-12 aged group were significantly greater than the 7-9 aged group. Moreover, these values were affected by individuals' different movement strategies. Significantly higher forward and backward reach distances were found in a common strategy compared to an ankle strategy. It is suggested that researchers should design their studies under a standardized protocol to perform a reach test.

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