

Age and Gender Differences of Motor Skills of the Overarm Throw in Children and Adolescents

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Abstract

Objective: To systematically analyze the age and gender differences in the development of overarm throw from children to adolescents from both quantitative and qualitative perspectives, from the aspects of throwing ball speed, distance, accuracy and the development sequence of overarm throwing action components. **Methods:** Using the method of literature data and logical analysis, the literature on overarm throw on WOS and CNKI was sorted and analyzed, and the development characteristics of overarm throw were summarized. **Results:** There were significant age and gender differences in the overarm throw from children and adolescents, and males consistently outperformed women in quantitative and qualitative overarm throw performance. Age had an effect on all motor components of the overarm throw, while gender had a significant effect only on footsteps and trunk movements. With age, both males and females continue to develop, and practice can narrow the gender gap, but it cannot eliminate it. **Conclusion:** overarm throw are highly complex, produced with considerable speed and force, rooted in human evolution, and characterized by distinct gender differences. Overall, with regard to overarm throws, overall gender differences were observed in favour of males, with females being inherently disadvantaged in overarm throw development. Throwing ability in childhood helps predict throwing ability in adolescence.

Keywords

Overarm throw, motor development, age difference, gender difference

1. Introduction

In recent years, the physical health of children and adolescents has been highly valued by the state and society. Strengthening the physical fitness of adolescents and promoting their all-round development is the main goal of Physical Education of school. The national student physical health monitoring shows that the physical health of students is not optimistic, and the promotion of student physical health still has a long way to go. However, getting children to engage in vigorous physical activity on a regular basis presents complex challenges for schools, parents and society. Not only are time, space, and budget issues limiting physical education, but factors such as minority status, socioeconomic status, school enrollment, and location also affect access to physical activity (Beaulieu & Butterfield, 2009). The nature of the problem is that the development of Fundamental Motor Skills (FMS) in children and adolescents is an important factor affecting their participation in physical activity.

Motor developments are essential to support physical activity throughout the lifespan, and the mastery of FMS is a prerequisite for the development of more specific motor and physical activity-related skills (Thomas, 1997). Existing studies have shown that children with strong object control skills are more likely to become healthy adolescents, and the development of FMS in childhood may be an important part of promoting long-term health interventions (Barnett, Van

Beurden, & Morgan, 2008). More importantly, the development of motor skills, in addition to being important for children's physical, mental and social development (Lubans, Morgan, Cliff, Barnett, & Okely, 2010) and the acquisition of academic abilities such as reading and mathematics (Westendorp, Hartman, Houwen, Smith, & Visscher, 2011), also contributes to the acquisition of language (Iverson, 2010). However, in the process of motor development, there are many influencing factors, among which age and gender are the most prominent reasons. Among FMS, the greatest gender difference is overarm throw (Thomas & French, 1985). Overarm throw is a basic and complex motor skill, and its acquisition requires the coordination of the whole body (Hamilton & Tate, 2002), and there are significant age and gender differences in the development of this motor.

Therefore, understanding the developmental characteristics and gender differences of children and adolescents in the overarm throw will help physical education teachers to provide more effective and targeted guidance and teaching, and it will also be more conducive to the development and maturity of students' movements, laying a solid foundation for lifelong participation in sports activities. This paper focuses on the age and gender differences in the development of overarm throw, and explains the behavior of children and adolescents' overarm throw from the quantitative performance of throwing speed, distance and accuracy, as well as the process-oriented analysis of movement components to explain the developmental characteristics of children and adolescents' overarm throw, which provides theoretical guidance for determining how to intervene to improve proficiency in overarm throw motor skills.

2. Age and gender differences in quantitative performance of overarm throw

Throwing speed distance and accuracy are commonly used to study differences in quantitative performance of overarm throws. Studies consistently show that men have better quantitative performance in overarm throwing (Keogh, 1969; Thomas & French, 1985; Vogt, 1978; van den Tillaar & Ettema, 2004; Ahnert & Schneider, 2007; Rousanoglou, Noutsos, Bayios, & Boudolos, 2015).

2.1 Throwing speed

Age and gender are the main factors that affect throwing speed. In all age groups, men outperformed women by nearly two standard deviations in ball speed. A meta-analysis found that sex differences in throwing accuracy and speed were present as early as age 3 years, with boys' throwing speed exceeding girls' throwing speed by 1.5 standard deviation units as early as 4 to 7 years of age. This disparity widened rapidly, and by age 12 boys were 3.5 standard deviation units worse than girls (Thomas & French, 1985). This conclusion is consistent with current throwing research in childhood and adolescence (Halverson, Robertson, & Langendorfer, 1982; Ehl, Langendorfer, & Robertson, 2005; Runion, Robertson, & Langendorfer, 2003).

Gender differences in throwing speed were also significant, with gender differences in throwing speed appearing in preschool years, with males throwing faster than females on average across all age groups. The gender gap in throwing speed between boys and girls continues to widen from childhood to adolescence. Differences in throwing appear to begin with biological differences, with practice increasing women's throwing speed, but gender differences persist compared to men with similar throwing experience. By the age of 12, the girls with the fastest throws were on par with the boys with the slowest throws (Thomas & French, 1985). Robertson and Konczak (2001) identified gender differences in throwing speed from 6-13 years, with boys outperforming girls of the same age. In addition, they found growing differences in throwing performance. At a certain level of development, only boys improve their skills, while girls stagnate at their level, or get worse.

2.2 Throwing distance

Throwing distance is highly dependent on the throwing speed and follows a similar pattern (Anthamatten, 2014; Axe, Snyder-Mackler, Konin, & Strube, 1996; Zhu, Dapena, & Bingham, 2009). Gender differences are greater than any other motor skills in the development of throwing distance and manifest early. Boys outnumbered girls by 1.5 standard deviation units as early as age 2 to 4, boys at age 6 threw farther than girls at age 9 (Rippee, Pangrazi, Corbin, Borsdorf, Petersen, & Pangrazi, 1990), and at age 17 only the best girls throw as far as the least skilled boys. The gender difference in throwing distance did not accelerate rapidly, but was more than 2 standard deviation units at age 12 and more than 3 standard deviation units after age 16. This increase was linear from puberty to age 17 when men outperformed women by 3 standard deviation units.

2.3 Throwing accuracy

The most powerful example of the difference between males and females is that males exhibit better throwing accu-

racy (Geng Peixin, 2008; Zeng & Chiu, 2008), which reflects male superiority in aiming ability. Some argue that this gender difference has been around since early humans, when men went out hunting and women stayed with their children while gathering food or doing manual labor. Regardless of its origin, sex differences in throwing accuracy manifest early, even in children, and persist throughout life, suggesting that gender effects are independent of age (Ozkaya et al., 2017). Vogt's (1978) study showed that boys aged 5-6 performed significantly better in throwing accuracy. Similar results were provided by Morris et al. (1982), who examined the effects of age and gender on performance of seven FMS, two of which (tennis throw distance and softball throw distance) were related to throw. In terms of throwing speed and throwing accuracy, boys aged 3-6 are better than girls of the same age. Overall, 75% of men outperformed the average woman in throwing accuracy.

As boys have more opportunities to practice, the effect on throwing accuracy is also large, and practice is a possible sex-difference factor in throwing accuracy, which persists considering the influence of sport history (Li Jia Bin, 2015). Therefore, the differences may also have some biological basis. It is likely that males and females have different methods of visual movement when throwing, and this difference leads to different throwing accuracy.

3. Age and gender differences in qualitative performance of overarm throw

3.1 The developmental sequence of overarm throw

Regarding the qualitative performance of overarm throw, there are significant differences between men and women (Robertson & Konczak, 2001; Hamilton & Tate, 2002; Langendorfer & Robertson, 2002b; Barrett & Burton, 2002; Ehl, Langendorfer, & Robertson, 2005; Goodway & Lorson, 2008). Existing studies have analyzed gender differences in component levels within each age group. Qualitative evaluation of overarm throwing is usually based on the action component analysis of Halverson and Robertson (1984) and the component analysis method is the most widely used and used analysis of overarm throw. The partial sequence method of overarm throw believes that the development of overarm throw should be determined according to the development of the action in each part of the body. The overarm throw can be decomposed into five action parts: foot action (SA), back pull action (BA), trunk action (TA), humerus action (HA) and forearm action (FA), each action part includes 3- 4 stages of development (Halverson et al., 1977).

Overall, the majority of men and women in each age group exhibited an immature (grade 3 or 4) developmental stage, trunk block rotation (grade2-3), and humerus aligned but independent (grade 2- Grade 3), forearm lag (Grade 2-3). This motor feature (S3-T2-H2-F2) is considered to be the most common combination of motor components in early adolescent throwing movements (Barrett & Burton, 2002). With the footstep, trunk, and forearm movement patterns described by Langendorfer and Robertson (2002), most members after puberty are able to demonstrate moderately proficient overarm throw.

3.2 Age differences of different action components

Age had a significant effect on qualitative performance in overarm throw. Both males and females show the greatest development between childhood and adolescence, but males do not develop trunk movements; females do not develop footsteps and humeral action. Regarding development between puberty and adolescence, the findings suggest that males have lower levels of development because males have reached high levels during puberty. Except for trunk movements, the differences between puberty and adolescence were not significant; in contrast to men, women develop overarm throw in all but forearm movements, and forearm and humerus movements have shown high levels of development.

Age differences in overarm throw components were not prevalent among women. The only significant age difference was found in the humerus movement, where younger women outperformed adolescent and adult women, and there were no differences in other moving parts, probably because fewer women showed a mature level of throwing motor skill at any age (Halverson, Robertson, & Langendorfer, 1982; Barrett & Burton, 2002). Differences in humeral motion across age groups show a developmental trajectory similar to that of males at the level of most motor components (growing from adolescence to peaking in early adulthood and then regressing to adulthood). Compared with men of all age groups, women generally did not achieve the most mature throwing motion and had lower ball speeds. These findings are consistent with historically lower levels of throwing development in females than in males (Thomas & French, 1985; Halverson, Robertson, & Langendorfer, 1982).

Overall, the data in these cross-sectional studies support the hypothesis of a lifelong developmental trajectory from the onset of overarm throw development, peaking at young age, and then regressing between motor component levels throughout life. Evidence for this hypothetical trajectory was stronger in men, for whom all exercise components showed a regression between youth and middle age. For females, only humerus movements follow this pattern, with footstep, trunk, and forearm movements consistent throughout adulthood, mainly because even young women only

reach a moderate level of maturity in throwing movements. These data support Williams and colleagues' (1998) data that older adults use throwing patterns similar to children.

3.3 Gender differences in different action components

Most of the previous research results show that there are age and gender differences in overarm throw in the analysis of specific movement components, and the reported studies have consistently emphasized the better performance of men (Vogt, 1978; Robertson & Konczak, 2001; Ozkaya et al., 2017; Thomas & French, 1985). In terms of throwing motion components, males and females showed similar movement patterns in humerus and forearm movements, but differed in trunk, stepping, and backswing actions. Nelson et al. (1991), in a 3-year longitudinal study, found that the quality of trunk and foot movements favored boys; Lorson and Goodway (2008) recognized that children aged 6-8 years had a qualitative They found significant gender differences in steps, torso, and forearm components (Langendorfer & Robertson, 2002b). Kevin M. Lorson et al. (2013) found age and gender differences in the development of overarm throwing movements in adolescents, young adults, and adults, and also the regression phenomenon of throwing action was found.

In qualitative performance of throwing, gender differences were only seen in specific components: trunk, footsteps, and backswing movements, and at certain developmental levels, males and females exhibited similar movement patterns in humerus and forearm movements. Trunk and footwork are the major deficits in the development of female throwing sports. Trunk movement is a major defect in men. Among adolescents, there were significant gender differences in the level of development of footstep, trunk, and forearm movements, with males developing better than females, and no gender differences in humerus movements. Meinel and Schnabel (1998) pointed out that during adolescence, male throwing performance has a high growth rate in both qualitative and quantitative performance, while females show only small jumps in development. Women's performance levels stagnate during adolescence, and it is not until the development of women during adolescence that these differences can be compensated. This is also in line with Lorson et al. (2013) who found significant gender differences in humeral motion only in adults, and also talked about a narrowing gender gap at the component level.

From 6-16 years of age, women showed the same motor pattern in trunk movements, they displayed a blocky rotation and did not show the development of this motor pattern. Males show a moderate level of motion in trunk movements. During puberty, males are able to throw with a more differentiated torso rotation that fades from bottom to top, while females still exhibit blocky rotation. Regarding trunk movements, the present results may suggest that women may have difficulty achieving well-coordinated movement patterns in trunk movements.

During childhood and adolescence, male and female foot movements are different. Males show a higher level of sophistication in footwork. Females mostly showed ipsilateral strides and contralateral long strides. Males exhibit predominantly contralateral strides.

Males and females exhibit different developmental processes in humeral motion (Wagner, Pfusterschmied, Klous, van Duvillard, & Müller, 2012). During childhood, males develop markedly, while females stagnate during childhood. During puberty, gender differences are compensated, and both sexes develop humeral motion in the same way. During puberty to adolescence, females improved their throwing patterns only in humeral motion, while males stagnated in puberty.

From the age of 12-16, the continuous development of men and women can be seen. This results in correct forearm lag, with humerus action exceeding shoulder height, a finding that can be demonstrated in studies by Nelson et al. (1991), Menzel (1999), and Goodway and Lorson (2008). The movement of the forearm and the humerus forms the forearm whip. The forearm whip is one of the most important nodes in the overarm throw, the main functional stage and the most important component of the overarm throwing movement. From a functional standpoint, it is important to see that the forearm whip is not affected by age-specific sex differences. The current results show that only footstep, trunk and upper arm movements are affected.

4. Conclusion and significance

Overarm throw is highly complex, produced with considerable speed and force, is rooted in human evolution, and is characterized by distinct gender differences. The ability to improve throwing distance, speed and accuracy was a watershed event in human evolution. Gender and age are different factors affecting the development of children's overarm throw, and gender may be a direct factor affecting children's athletic ability. Quantitative and qualitative performance of overarm throws improved in both men and women throughout childhood and early adolescence, but not everyone reached a mature level of throwing performance. The study found that a greater proportion of boys showed patterns of maturity in each skill. The most striking difference was in throwing, with two-thirds of boys showing a pattern of ma-

turity and slightly more than two-thirds of girls showing no pattern of maturity. Males outperformed females in throwing at all ages on a number of metrics including motion composition, throwing speed, distance, and accuracy. Overall, overall gender differences were observed in favor of males, and females were inherently disadvantaged in the development of overarm throwing movements. Interestingly, no historical changes in age or gender differences were observed in developmental level or ball velocity measurements over the past 40 years.

Gender differences in overarm throw become more pronounced with age. However, fundamental motor skills are independent of age and do not develop naturally. The fact that this relatively large gender difference continues to increase during childhood and adolescence is likely the result of the interaction of biological and environmental factors. According to constraint model theory, task individual and environment play important roles in the performance of motor skills. Motor skill proficiency can be achieved through adequate practice, instruction, and learning opportunities. Different development may affect the results obtained in different age and exercise tests for each sex. In general, boys are encouraged and supported more in sports than girls, so girls will have more limited opportunities to improve their motor skills, widening the gender gap (Hills & Croston, 2012). Gender differences and exercise preferences between girls and boys also help explain these gender differences (Barnett et al., 2016). Therefore, a possible explanation for these findings is that children, adolescents, and young adults are not given enough practice, instruction, or learning opportunities to improve their FMS competencies. Because of these results, it is important for PE teachers to incorporate FMS practices as proposed by Carley (2010). We encourage physical education teachers, coaches and sports professionals not to underestimate girls and women just because of their gender, but to try to encourage them to practice all FMS and stay physically active. In addition, being outcome-oriented, we encourage all sports professionals to take the time to teach FMS to all age groups and not to assume that just because they are not children, they can perform FMS proficiently.

Throwing ability in childhood can help predict throwing ability in adolescence, and understanding the initial characteristics of the development of overarm throw by age and gender can help to provide physical education teachers with specific knowledge to help them improve their intervention programs. Physical education and subsequent physical activity behavior have important effects. All low-skilled children in primary school need intervention in motor development so that they are not low-skilled during adolescence (Barnett et al., 2010). Although boys outperformed girls, gender did not affect the relationship between child and adolescent proficiency, so developing overarm throw skills in childhood may be equally important for adolescent boys and girls. Physical educators should monitor very carefully the development of object control skills in all children, especially overarm throw.

At the same time, it should be noted that there are individual differences in the development process of young children, because some children can reach a higher development stage at the age of 3, while some children still stay at a lower development stage when they are 5 years old (Wen Ruixiang, Jiang Guiping, Ji Zhongqiu, ZhaoPanchao, Jiao Xibian, 2018). This provides further evidence that the developmental changes in throwing movements are not necessarily age-based. A quantitative study of overarm throw in children aged 5-10 years pointed out that children of the same age do not necessarily reach the same developmental level in overarm throw (Grimpampi et al., 2016). As Menzel (1999) pointed out, theory and practice should refer to the individual developmental levels of children and adolescents to guide individualized instruction. Therefore, before puberty, boys and girls should be carefully grouped according to skill level if throwing is an important sport and skill training for boys and girls together.

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