Multi-age-grouping paradigm for young swimmers

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(Accepted 10 November 2011)

Abstract
The purpose of this study was to examine the adequacy of “multi-age” classification systems in youth sports with a specific focus on the unisex multi-age-groupings used by USA Swimming. In addition, we offer an analytical rationale for the multi-age-groupings and potential alternatives. We examined the top 100 US swim performances for three years (2005, 2006, and 2007) for girls and boys in 15 age-groups (7 to 20 years and a singular group of 21 years and older). Data for each age and sex were pooled over the three years and means were calculated for each of seven competitive swim events. Swim times differed among each age up to the 14-year age-group in girls (F14,30885 = 183.9, P < 0.01, Cohen's d = 1.19–3.72, large effect) and 16-year age-group in boys (F14,30885 = 308.7, P < 0.01, Cohen's d = 0.81–3.64, large effect) for all events. Age-related differences in swim times continued later in boys than girls likely due to differences between the sexes in timing of growth and maturation. Because of the differences in swim performance in contemporary multi-age-groups, stratifying swimmers by a single age is the best means to ensure competitive fairness and equality, although there is no rationale for swimmers under the age of 8 years to compete in separate unisex competitive groups.

Keywords: Age-group swimming, classification, fair competition, youth sports

Introduction
Matching youth athletes to encourage competition and make it fair and safe is an important goal of sports federations (Baxter-Jones, 1995; Malina & Beunen, 1996). In youth (also called age-group) swimming, “fairness” has been administered by creating separate girls' and boys' competitions and then further classifying competitors into groups based on chronological age that is presumably a general indicator of developmental status. There is no universal classification system for children in youth sports other than chronological age because maturity assessments are neither theoretically simple nor logistically possible. Worldwide, there is no current consensus on the most appropriate and fair competitive classification system for children. Many swimming federations commonly combine more than two chronological ages into competition groups (Kojima & Stager, 2010). In the United States, four distinct multi-age-groups are typically used for state-level championships. Each competition group comprises multiple chronological ages: children aged 10 years old and younger, 11–12 years, 13–14 years, and 15 years and older. We could not find any historically relevant or factually documented rationale to support these classifications.

The considerable differences in maturity status among young swimmers result in marked differences in the size and strength of competitors in multi-age-groups. Competitive outcomes are frequently influenced by maturity-based performance advantages rather than by skill or training-induced improvements. For example, in the 11–12 years group, 12-year-old swimmers are more likely to be taller and stronger and, consequently, faster than their 11-year-old counterparts. In support of this, age-related differences in swim performance have been reported in non-skilled students aged 11–17 years (Pelayo, Wille, Sidney, Berthoin, & Lavoie, 1997). Age-related improvements as well as sex-based differences in swim performance were claimed to be a function of maximal exercise capability that arises from age-related increases in properties of muscle, which was particularly evident in the boys. Therefore, younger or late-maturing swimmers in multi-age-groups are disadvantaged and tend to experience less competitive success, more competitive failure, or
frustration because of the multi-age classification system and inherent age bias in competition. Because they are physically “behind” their older or precocious peers who compete in the same competitive age-group, combining growing adolescent swimmers of different ages into multi-age-groups could discourage some from continuing in competitive swimming.

Whether or not the classification system that combines multiple ages into competitive groups equalizes competition by minimizing the influence of maturational differences is the central question of the present study. To examine the adequacy of the multi-age classification in youth sports, swim performances in the USA were evaluated and compared to provide an analytical rationale for the multi-age-grouping system and potential alternatives. In light of the well-documented maturational differences among children of similar chronological ages (Malina, Bouchard, & Bar-Or, 2004), it was hypothesized that there is a difference in swim performance in the current multi-age-competition groups as well as across chronological ages.

Methods

All data (ages and competitive performances) were acquired through the open-access website of USA Swimming (http://www.usaswimming.org). The data are available indefinitely at the website or upon request without compromising the children’s privacy. The main variables used to test the hypothesis included:

(a) swim times of the top 100 US girls and boys for the years 2005 to 2007;
(b) seven swim events: 45.7-m, 91.4-m, and 182.9-m freestyle (50-, 100-, and 200-yard, respectively), 91.4-m backstroke, butterfly, and breaststroke, and 182.9-m individual medley; and
(c) fourteen chronological ages from 7 to 20 years old as well as an age-group of 21 years and over, resulting in a total of 15 competitive age-groups for each sex.

Because there were no differences in mean swim times across all chronological ages among the calendar years 2005, 2006, and 2007 for any event (Table I), competition results were pooled over the three years and means were calculated for each sex, chronological age, and swim event. If any events lacked complete times for the top 100 girls or boys for that event, they were excluded from further data analysis for that chronological age. The sample size for each event is shown in Table I.

Descriptive statistics (means ± standard deviations) were used to characterize performances at each age. A $15 \times 2 \times 7$ (age × sex × event) factorial analysis of variance (ANOVA) with Tukey’s post-hoc test was used to compare groups. Statistical significance was set at $P < 0.01$. All calculations and analyses were performed using the Statistical Package for the Social Sciences (SPSS v.16.0 for Windows; SPSS Inc., Chicago, IL). Cohen’s $d$ was used to estimate effect sizes (Cohen, 1992). Boundaries of 0.20–0.49 were considered a “small” effect, 0.50–0.79 a “medium” effect, and 0.80 to infinity a “large” effect.

Results

Tables II and III present the mean times of the top 100 US swimmers for 15 age-groups in girls and boys, respectively. In the girls (Table II), swim times differed among each age up to 15 years for all events ($P < 0.01$, Cohen’s $d = 0.54–3.72$) with the exception of individual medley ($P = 0.02$ between ages of 14 and 15 years). In the 182.9-m individual medley, times differed among each age up to the 14-year age group ($F_{13,4186} = 9282.3$, $P < 0.01$, $d = 1.35–3.41$). The 21 and over group was faster than all other ages in all events ($P < 0.01$, $d = 0.46–0.88$) except the 182.9-m events. There was no difference among 19-year, 20-year, and 21 and over age-groups in 182.9-m freestyle ($P = 0.03$), or between 18-year and 21 and over age groups in the 182.9-m individual medley ($P = 0.05$).

In the boys (Table III), there were age-related differences in times up to 17 years of age for all events ($P < 0.01$, $d = 0.81–3.64$), with the exception of 45.7-m freestyle and 182.9-m individual medley. There were differences across all ages in 45.7-m freestyle ($F_{14,4485} = 21228.2$, $P < 0.01$, $d = 0.55–3.51$) and up to 16 years of age in 182.9-m individual medley ($F_{13,4186} = 14082.0$, $P < 0.01$, $d = 1.18–3.27$). Similar to that observed for the girl swimmers, all 91.4-m events had the same pattern of age-related differences in performance. Differences among each age occurred up to 17 years in boys in all 91.4-m events (15 years in girls). Swim times for the 21 and over boys were faster than all other ages in all events ($P < 0.01$, $d = 0.83–1.22$). Therefore, for patterns of age-related differences in swim times between the sexes, there was approximately a 2-year lag for the boys compared with the girls when swim times across ages became similar (Tables II and III).

Mean swim times in boys were faster than those in girls in all swim events ($P < 0.01$; Figure 1). As noted in the Methods, no difference in swim time was identified among years 2005, 2006, and 2007 for any event or either sex (e.g. the mean times in 45.7-m freestyle of the top 100 eleven-year-old girls were
26.28 ± 0.40, 26.31 ± 0.47, and 26.29 ± 0.40 s, respectively. The sex-based differences in swim times were 1.3 s (4.6%) in 45.7-m freestyle, 3.0 s (5.0%) in 91.4-m freestyle, 5.9 s (4.8%) in 182.9-m freestyle, 3.3 s (5.1%) in 91.4-m backstroke, 3.6 s (4.9%) in 91.4-m breaststroke, 3.8 s (6.1%) in 91.4-m butterfly, and 7.3 s (5.2%) in 182.9-m individual medley. Figure 2 illustrates the sex-based differences in swim performance across ages for each event, and correspondingly, Table IV presents the statistical significance of the differences across ages for all events. Differences in swim times between the sexes increased with age and the distance of swim performances after the age of 11 in all events (Figure 2). There were sex-based differences in the 8-year-olds and older ages in most events, and boys were always faster than girls ($P < 0.01$, $d = 0.23–0.76$), with the exception of the breaststroke at ages 10 and 11 years ($P < 0.01$, $d = 0.39$ and 0.31, respectively). There were no such differences, however, in swimmers under the age of 8 in freestyle and backstroke events (Table IV). In the breaststroke and butterfly, there were no sex-based differences in 8- and 9-year-olds and in 8-year-olds, respectively.

**Discussion**

The notable finding of the present study is that swim performance differed among consecutive chronological ages up to age 14 years in girls and age 16 years.
Table III. Swim times (s) of the top 100 US boy swimmers for 15 age-groups in seven events (mean ± s).

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>45.7-m Fr</th>
<th>91.4-m Fr</th>
<th>182.9-m Fr</th>
<th>91.4-m Ba</th>
<th>91.4-m Br</th>
<th>91.4-m Fly</th>
<th>182.9-m IM</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>35.14 ± 1.1</td>
<td>80.30 ± 3.3</td>
<td>188.32 ± 12.4</td>
<td>97.78 ± 5.5</td>
<td>113.04 ± 6.8</td>
<td>177.23 ± 6.8</td>
<td>158.80 ± 4.2</td>
</tr>
<tr>
<td>8</td>
<td>31.55 ± 0.9♀</td>
<td>85.02 ± 2.1♀</td>
<td>156.15 ± 6.4♀</td>
<td>81.87 ± 3.1♀</td>
<td>95.13 ± 3.5♀</td>
<td>86.27 ± 5.5</td>
<td>147.85 ± 3.0♀</td>
</tr>
<tr>
<td>9</td>
<td>29.20 ± 0.6♀</td>
<td>64.41 ± 1.6♀</td>
<td>139.62 ± 3.6♀</td>
<td>73.80 ± 2.2♀</td>
<td>84.62 ± 2.5♀</td>
<td>73.97 ± 2.7♀</td>
<td>139.90 ± 3.1♀</td>
</tr>
<tr>
<td>10</td>
<td>27.42 ± 0.5♀</td>
<td>59.89 ± 1.2♀</td>
<td>130.16 ± 2.5♀</td>
<td>68.41 ± 1.5♀</td>
<td>78.35 ± 2.1♀</td>
<td>67.70 ± 1.7♀</td>
<td>124.66 ± 2.3♀</td>
</tr>
<tr>
<td>11</td>
<td>25.99 ± 0.6♀</td>
<td>56.78 ± 1.2♀</td>
<td>123.28 ± 2.6♀</td>
<td>64.51 ± 1.6♀</td>
<td>73.53 ± 1.9♀</td>
<td>63.71 ± 1.7♀</td>
<td>119.60 ± 1.8♀</td>
</tr>
<tr>
<td>12</td>
<td>24.33 ± 0.5♀</td>
<td>53.13 ± 1.0♀</td>
<td>115.95 ± 2.0♀</td>
<td>60.23 ± 1.4♀</td>
<td>67.97 ± 1.6♀</td>
<td>59.25 ± 1.3♀</td>
<td>113.19 ± 1.7♀</td>
</tr>
<tr>
<td>13</td>
<td>23.32 ± 0.4♀</td>
<td>50.72 ± 0.8♀</td>
<td>110.45 ± 1.9♀</td>
<td>57.12 ± 1.1♀</td>
<td>64.45 ± 1.4♀</td>
<td>56.32 ± 1.1♀</td>
<td>110.80 ± 1.8♀</td>
</tr>
<tr>
<td>14</td>
<td>22.41 ± 0.3♀</td>
<td>48.81 ± 0.7♀</td>
<td>106.00 ± 1.6♀</td>
<td>54.55 ± 1.0♀</td>
<td>61.67 ± 1.2♀</td>
<td>53.75 ± 0.9♀</td>
<td>104.78 ± 1.6♀</td>
</tr>
<tr>
<td>15</td>
<td>21.95 ± 0.3♀</td>
<td>47.80 ± 0.7♀</td>
<td>103.81 ± 1.3♀</td>
<td>53.16 ± 1.0♀</td>
<td>60.19 ± 1.1♀</td>
<td>52.36 ± 0.8♀</td>
<td>101.26 ± 2.1♀</td>
</tr>
<tr>
<td>16</td>
<td>21.49 ± 0.3♀</td>
<td>46.89 ± 0.6♀</td>
<td>102.02 ± 1.3♀</td>
<td>52.20 ± 1.0♀</td>
<td>59.23 ± 1.3♀</td>
<td>51.17 ± 0.8♀</td>
<td>99.60 ± 1.8♀</td>
</tr>
<tr>
<td>17</td>
<td>21.13 ± 0.3♀</td>
<td>46.20 ± 0.5♀</td>
<td>100.74 ± 1.3♀</td>
<td>51.38 ± 1.0♀</td>
<td>58.15 ± 0.9♀</td>
<td>50.43 ± 0.8♀</td>
<td>97.11 ± 1.7♀</td>
</tr>
<tr>
<td>18</td>
<td>20.95 ± 0.3♀</td>
<td>45.85 ± 0.7</td>
<td>100.19 ± 1.5</td>
<td>51.13 ± 1.1</td>
<td>57.71 ± 1.2</td>
<td>50.02 ± 1.0</td>
<td>95.28 ± 1.2</td>
</tr>
<tr>
<td>19</td>
<td>20.75 ± 0.4♀</td>
<td>45.51 ± 0.9</td>
<td>99.83 ± 1.8</td>
<td>50.63 ± 1.4♀</td>
<td>57.57 ± 1.6</td>
<td>49.73 ± 1.1</td>
<td>92.85 ± 2.5♀</td>
</tr>
<tr>
<td>20</td>
<td>20.52 ± 0.4♀</td>
<td>45.02 ± 0.9♀</td>
<td>99.13 ± 1.9</td>
<td>50.38 ± 1.7</td>
<td>56.89 ± 1.5♀</td>
<td>49.35 ± 1.2</td>
<td>91.20 ± 2.6♀</td>
</tr>
<tr>
<td>21 &amp; over</td>
<td>20.04 ± 0.4♀</td>
<td>44.10 ± 0.8♀</td>
<td>97.41 ± 1.8♀</td>
<td>49.14 ± 1.3♀</td>
<td>55.23 ± 1.3♀</td>
<td>48.19 ± 1.0♀</td>
<td>109.05 ± 2.4♀</td>
</tr>
</tbody>
</table>

♀Significant difference from one-year younger age (P < 0.01) based on ANOVA with Tukey’s post-hoc tests.

Note: Fr = freestyle; Ba = backstroke; Br = breaststroke; Fly = butterfly; IM = individual medley.

Figure 1. Comparison of mean swim times between girls and boys in seven competitive swim events. Numbers on the x-axis show distance in metres. Fr = freestyle; Ba = backstroke; Br = breaststroke; Fly = butterfly; IM = individual medley. *Significant difference between girls and boys (P < 0.01).

Figure 2. Differences between the sexes in swim times (s) across ages for seven events.

A sex-based difference was calculated by subtracting the mean swim time of boys from that of girls, and thus positive values indicate that boys are faster than girls. Fr = freestyle; Ba = backstroke; Br = breaststroke; Fly = butterfly; IM = individual medley.

in boys for all seven competitive swim events (Tables II and III). These results demonstrate that (1) younger athletes cannot successfully compete with their older peers, and (2) there is an inadequacy of the multi-age-groupings commonly employed by most youth sport governing organizations. The results also show that the manner in which athletes are grouped dictates the competitive outcomes at least in age-group swimming. Thus, the practice of merging multiple ages of youth swimmers into competitive groups does not optimally guarantee fairness and equality in competition as it is presumably supposed to do. We use the word “presumably” because we were unable to find a rationale for the paradigm most commonly employed. It is possible that the objective is simply one based upon convenience rather than any specific rationale.

Previous research supports our contention that athletes of each age should compete separately until mid- to late adolescence (age 14–18 years). Using lower-body impulse calculated from vertical jump height, body mass, and gravity, Anderson and Ward (2002) concluded that girls aged 14 years and older should be able to compete together in one group because of similar abilities to generate impulse. Up until age 14 years, continual physical growth and improvements in impulse occurred in the girls such that combined competitive groupings based only on age were inappropriate. Using similar reasoning, they concluded that for boys, combined competitive groups based on age alone were inappropriate for those younger than age 18 years. After examining the age-related differences in swimming speed among 2058 non-skilled students aged 11–17 years, Pelayo et al. (1997) reported that boys require single-age-groups to compete, whereas girls could be
classified into the following multi-age-groupings: (1) ages 11–12, 13–14, 15–16, and 17 years; (2) ages 11–12, 13–15, and 16–17 years; (3) 11, 12–13, 14–15, and 16–17 years; or (4) 11, 12–13, 14–16, and 17 years. Proposed groupings were based on the similarity in swimming speed among the various ages. Furthermore, Saavedra and colleagues (Saavedra, Escalante, & Rodriguez, 2010) concluded that young swimmers who range in age between 11 and 12 years for girls and 13 and 14 years for boys should be classified into competitive groups based upon the year of their birth, that is, by a single age rather than a single combined group. The multivariate model they developed (which analysed more than 50 anthropometric fitness and training variables) resulted in age ($R^2 = 0.59$ for boys and 0.55 for girls) being the best predictor of swim performance in this age range for boys and third best for girls. Finally, Kojima and Stager (2010) demonstrated that older swimmers in each multi-age-group represented a disproportionately high number of qualifying participants as well as finalists for all swim events at the FINA World Youth Swimming Championships (age 14–17 years for girls, age 15–18 years for boys). The consensus from this research is that single-year competition groupings are better than multi-age groupings.

That younger athletes cannot successfully compete with their older peers is well supported by studies of physiological characteristics and growth and development of adolescents. Overall improvements in sport performance that accompany chronological age have been attributed, in part, to increases in: (1) muscular quantity and quality, (2) anaerobic and aerobic capabilities, (3) physical size, and (4) motor skill and sensory perception (Bar-Or, 1983; Bar-Or, Unnithan, & Illescas, 1994; Malina et al., 2004). Many of these traits seem to be limited in terms of their ability to improve prior to puberty. Thus, the physical advantages that accompany age or precocity contribute to and magnify the difference in sports performance outcomes particularly among adolescent athletes.

It has been documented that successful adolescent athletes including swimmers are often early maturers, possessing increased physical size and muscular quantity and quality (Åstrand et al., 1963; Kanitz & Bar-Or, 1974; Malina et al., 2004). Given that the top 100 performing swimmers in the USA during the adolescent ages were included in the present analysis, it is likely that these elite swimmers are early maturers compared with the other thousands of swimmers of adolescent age. Furthermore, as a group, the top 100 swimmers are probably maturation-homogeneous children. With this supposition and the age-related differences in swim performance reported in the previous and present studies, the multi-age classification system is inadequate for adolescent swimmers regardless of skill or maturity status. Thus, the use of single-age classification systems is recommended as a means to minimize the influence of maturational and physical-size differences among young swimmers particularly if the goal is to ensure fairness and equity in competition.

In addition to age, athletes in competition are commonly separated by sex. This seems to be because of physiological and morphological differences between the sexes (Malina et al., 2004) and the published results of sports competitions demonstrated in adults. In the present study, the sex-based differences in swim performance were more pronounced with increasing age. There were differences between the sexes in swim performance ($P < 0.01$) in 8-year-olds and older ages in most events and 12-year-olds and older ages in all events, whereas there were no sex-based differences in swimmers under the age of 8 (Table IV and Figure 2). Similarly, the only available data for the top 100 five- and six-year-old swimmers (45.7-m and 91.4-m freestyle) showed no differences between the sexes in swim performance (Table IV). Effect sizes of the sex-based differences ($P < 0.01$) in swimmers aged 11 years and younger were small to medium (Cohen’s $d = 0.23–0.61$), whereas those for 12 year-olds and older were large.

### Table IV. Summary of statistical significance of sex-based differences in swim times.

<table>
<thead>
<tr>
<th>Stroke</th>
<th>Distance (m)</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
<th>20</th>
<th>21&amp;O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freestyle</td>
<td>45.7</td>
<td>n.s.</td>
<td>n.s.</td>
<td>n.s.</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
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<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Freestyle</td>
<td>91.4</td>
<td>n.s.</td>
<td>n.s.</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
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<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Freestyle</td>
<td>182.9</td>
<td>n.s.</td>
<td>n.s.</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
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<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Backstroke</td>
<td>91.4</td>
<td>n.s.</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
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<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Breaststroke</td>
<td>91.4</td>
<td>n.s.</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
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<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Butterfly</td>
<td>91.4</td>
<td>n.s.</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
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<td>+</td>
<td>+</td>
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<td>+</td>
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</tr>
<tr>
<td>Ind. medley</td>
<td>182.9</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
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<td>+</td>
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</tr>
</tbody>
</table>

*Significant difference between girls and boys ($P < 0.01$). n.s. = not significant ($P > 0.01$). 21&O = 21 years and over.*
(Cohen’s $d = 0.90–8.76$). Thus, swimmers younger than age 11 years demonstrate limited sex-based differences in performance, while age 12 years appears to be the onset of increasing sex-based differences in performance.

The sex-based differences in swim performance are related to differences in physical growth patterns and perhaps muscular quantity and quality. Several investigations have reported correlates of performance in young swimmers (Geladas, Nassis, & Pavlicevic, 2005; Jürimäe et al., 2007; Kunski, Jegier, Maslankiewicz, & Rakus, 1988; Saavedra et al., 2010). After age, stature and fat-free mass are consistently highly related to swim performance in young swimmers aged from 9 to 14 years. Sex-based differences in the accrual of fat-free mass in untrained and trained children that occur after the age of 12 have been well documented (Baxter-Jones, Eisenmann, Mirwald, Faulkner, & Bailey, 2008). Fat-free mass is often considered a surrogate for skeletal muscle mass because of the difficulty of quantifying the latter. Baxter-Jones et al. (2008) showed that fat-free mass accrual between girls and boys was comparable at age 11 but increased more in trained boys than in trained girls. In addition, maximal exercise capability, muscular strength and endurance, and skeletal muscle mass for women have been reported to be 60–70% of men’s values (Abe, Kears, & Fukunaga, 2003; Heyward, Johanner-Ellis, & Romer, 1986; Holloway & Baechle, 1990; Karlsson & Jacobs, 1980; Shephard, 2000). There is a link between growth reference data (McDowell, Fryar, Ogden, & Flegal, 2008) and the present swim performance data (Figure 3). Differences in stature and mid-arm circumference between the sexes escalate from the age of the boys’ growth spurt (at a time when swim performance of the boys also accelerates more than that of the girls). This is supported by cross-sectional studies that have shown that stature and muscle mass are important predictors of success in swimming (Geladas et al., 2005; Jürimäe et al., 2007; Kunski et al., 1988; Saavedra et al., 2010). The three distance curves of the relative sex-based differences in swim performance in Figure 3 show that the physical and muscular advantages of boys over girls after the boys’ growth spurt are pronounced at short distances.

Although sex-based differences in physiological variables that influence sports performance are magnified during/after boys’ adolescent growth spurt, they are generally small before puberty (Malina et al., 2004; see also Figure 3). Puberty tends to begin at age 8–10 years in girls and 10–12 years in boys (Ankarberg-Lindgren & Norjavaara, 2004; Malina et al., 2004; Marshall & Tanner, 1986). This maturational sequence of sex-based differences in sports performance is well documented and is proposed to be associated with a limited activation of the endocrine system in prepubescents and an increased availability of androgens and growth hormone during puberty (Ankarberg-Lindgren & Norjavaara, 2004; Falkner & Tanner 1986; Raivio & Dunkel, 2002; Veldhuis et al., 2005). Also, lower proteolysis and protein oxidation of pubescents than prepubescents have been demonstrated (Arslanian & Kalhan, 1996). Our data showed that the sex-based differences in growth and muscular development clearly contribute to differences in swim performance in older swimmers, but not in pubescent swimmers (Figure 3). In view of the present findings and literature on maturational and endocrinological characteristics of pubescents, it is proposed that girl and boy swimmers under the age of 8 years can reasonably be classified into a sex-independent single group and compete together.

![Figure 3](https://example.com/figure3.png)

**Figure 3.** Relative differences between the sexes (%) in 45.7-m, 91.4-m, and 182.9-m freestyle (Fr) and growth (stature and mid-arm girth) across ages. Positive numbers indicate boys are faster, taller or larger than girls. Growth reference data (cross-sectional) were obtained from McDowell et al. (2008).

<table>
<thead>
<tr>
<th>G1</th>
<th>G2</th>
<th>G3</th>
<th>G4</th>
<th>G5</th>
<th>G6</th>
<th>G7</th>
<th>G8</th>
<th>G9</th>
<th>G10</th>
<th>G11</th>
<th>G12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Girls 7&amp;U</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
<td>12</td>
<td>13</td>
<td>14</td>
<td>15–16</td>
<td>17–18</td>
<td>19&amp;O</td>
<td></td>
</tr>
<tr>
<td>Boys 8</td>
<td>9</td>
<td>10</td>
<td>11</td>
<td>12</td>
<td>13</td>
<td>14</td>
<td>15</td>
<td>16</td>
<td>17–18</td>
<td>19&amp;O</td>
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</tbody>
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Note: G = group; 7&U = 7 years and under; 19&O = 19 years and over.
Therefore, there are three distinct phases in respect of a scheme of age-grouping children. The first phase (prepubertal phase) terminates at around age 8 years, and such aged children can be grouped into a sex-independent single category. The second phase (pubertal phase), from age 8 to 14 years in girls and from age 8 to 16 years in boys, requires sex-specific, single-age-grouping paradigms. The third, postpubertal phase (young adulthood), can use multi-age competition groups based on competition purposes.

During the second phase (pubertal phase), similarities in swim performance among adjacent ages occurred later in boys than girls (Tables II and III), i.e. two years earlier in girls (at age 14–15) than boys (at age 16–17). This, once again, conforms well to maturational characteristics (timing of maturational events) in girls and boys. The onset of puberty and the adolescent growth spurt in girls tend to occur two years earlier than in boys (Malina et al., 2004; Marshall & Tanner, 1986). Consequently, physical qualities in girls develop at earlier ages and they become similar to adults’ status earlier than boys. Therefore, girls of different ages (15 years and older) could compete against each other fairly at a younger age than boys (17 years and older), and we suggest that there is a need for distinct sex-specific age-groupings, instead of a unisex age classification, for children between ages 8 years and 16 years or during puberty.

On the basis of patterns of age- and sex-related differences in swim performance in the present study, we propose the alternative age-grouping paradigms illustrated in Table V. The important aspects of the alternatives are: (1) a single unisex multi-age-group for girls and boys aged 7 years and under; (2) sex-dependent-grouping patterns beyond age 7 years; and (3) the use of single-age-groups at least up to age 14 years in girls and 16 years in boys. These proposals might not fully address all inherent issues of grouping adolescent swimmers by chronological age, but we contend that they would improve fairness and reduce inequalities in competition over current age-grouping paradigms in use today.

In conclusion, there were systematic age-related differences in swim performance among the top 100 US swimmers in both sexes. The age-grouping system that combines multiple ages into groups unfairly influences and biases competition outcomes. Youth sports organizations need to consider the purpose of the use of a multi-age-grouping paradigm and address whether or not such use limits or even eliminates participants from competition or acts to classify participants for fair competition. To ensure fairness and equity in competition and reduce maturational influence among youth sports athletes, the use of single-age classification along the lines of the alternative age-groups proposed in the present study (Table V) is an improvement. The findings of the present study support further development and prosperity of age-group swimming and youth sports in general, and should encourage competitive age-group swimmers who might be inclined to drop out as a result of the current classification systems.

References


