Feasibility and Reliability of a Repeated Sprint Test in Children Age 6 to 8 Years

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This study investigated the feasibility and reliability of a 12 × 25-m repeated sprint test with sprints starting every 25-s in children aged 6–8 years (36 boys, 41 girls). In all subjects, total sprint time (TST) demonstrated high test-retest reliability (ICC: \( r = .98 \); CV: 0.7% (95% CI: 0.6–0.9)). While sprint time varied over the 12 sprints in all subjects (\( p < .001 \)) with a significant increase in time for the third effort onwards compared with the first sprint (\( p < .001 \)), there was no difference in performance between genders. In all subjects, TST decreased with age (\( p < .001 \)) and was accompanied by an increase in estimated anaerobic power (\( p < .001 \)) but also in sprint time decrement percentage (\( p < .001 \)). Gender did not effect these changes. The present study demonstrates the practicability and reliability of a repeated sprint test with respect to age and gender in young children.

During the last two decades much attention has been devoted to the health and fitness of children and adolescents and the use of field-based testing to assess physical fitness in these populations (7,9). Data on physical performance are important markers of health and can subsequently be used to advise childhood health promotion programs that specifically target increases in physical fitness. In addition, talent identification and recruitment policies in team sports such as soccer frequently use data obtained from the field-testing of athletic performance and can often commence as early as 7-years and upward (35). Accurate measures of youth fitness based on valid and reliable tests of performance are therefore essential before the results of youth fitness tests can be used by researchers and practitioners to make sound decisions.
Despite the development and validation of numerous field test batteries for testing fitness, the application of anaerobic performance assessment as part of contemporary fitness measurement has generally received little attention especially in young children. Indeed, a recent review of the literature only highlighted the use of field tests of running performance to assess cardio respiratory fitness via estimates of oxygen uptake (8). This lack of information is quite surprising especially in regard to the type of physical activities performed by young pediatric populations. In general, children are more attracted to brief, spontaneous exercise than continuous activity (36,37). Indeed, repeated short-duration high-intensity exercise involving multiple sprint bursts over brief time periods is performed regularly in daily tasks, games or sporting events in early childhood. Therefore, information from field-based tests of fitness to evaluate anaerobic performance using protocols that mimic the specific sports activity patterns of children is warranted.

The necessity to perform repeated short-duration sprints over a brief period of time defined as “repeated sprint ability”, has been suggested to be an important fitness component especially in team sports (7). Tests of repeated sprint ability have therefore been designed to replicate the demands of an intense period of play during multiple-sprint sports and require participants to complete a set number of sprints with limited recovery (active or passive) between bouts. The reliability of tests of repeated sprint ability has generally been shown to be high (14) especially when performance data are presented as the total sprint time (TST) (34). These tests are also shown to differentiate between athletes of different competitive levels (2) and display sufficient sensitivity to detect changes in fitness induced by training interventions (4,15). Indeed, Buchheit et al. (5) reported that a repeated sprint test might be used as a single measure for evaluating seasonal changes in an athlete’s overall fitness and performance. Unfortunately, studies on the reliability of repeated-sprint activity tests have been limited to adolescent school boys (23, 28,38), adolescent soccer players (19,21,24–26) and adult team sport players (5,6,32,33). No information on the reliability of repeated sprint ability test protocols performed in young children (e.g., under-10 years of age) is available.

Finally, there is limited information on the longitudinal evolution of repeated sprint performance across age groups and differences across genders. The majority of studies have compared performance in adults and children (<10 years of age) and demonstrated a greater ability of children to resist fatigue in protocols that incorporate repeated bouts of sprint exercise (27). To our knowledge, only one longitudinal study has been conducted and showed that while performance (total sprint time) in elite academy soccer players improved progressively from 11 to 15 age groups, percent sprint decrements did not deteriorate with age (19). Similarly, no studies have attempted to determine gender-related differences in the capacity of young children to perform repeated sprint exercise. Therefore, this paucity of research suggests a need for studies on the effects of gender on repeated sprint performance and age-related changes in young populations in whom short-term high-intensity activities characterize spontaneous physical activity (28).

Therefore, the purposes of this study were to: 1) assess the reliability of a repeated sprint test in young school children (boys and girls) aged 6–8 years; and,
2) to characterize running velocity, anaerobic power (AnP) and fatigue index (FI) in this population and assess the influence of age and gender.

**Methods**

**Experimental Approach to the Problem**

Information on the reliability of tests of repeated sprint ability and subsequent data on running performance are scarce in younger populations. Children aged 6–8 years performed 12 × 25-m repeated sprint test with sprints starting every 25-s. Three testing sessions were organized: first, a practice trial was performed four times over one month to familiarize subjects and second, two trials separated by one week were completed to assess performance in each subject and to examine the reliability of this test in children. The test was performed in a random order by girls or boys to minimize the diurnal effect on performance across genders. On the day before each session, only low-intensity exercise was permitted. The children were asked to maintain their normal diet throughout the study and were instructed to restrict fluid intake to water only and not to ingest any food 1h before the test.

**Subjects**

Altogether, seventy seven children (36 boys and 41 girls) aged 6–8 years participated in the current study. For males and female children, respective values for age, mass and height were: 86.8 ± 5.3 vs 89.7 ± 5.7 months, 28.8± 3.1 vs 29.4± 3.7 kg and 124 ± 6 vs 126 ± 5 cm. All experimental procedures were carried out in full agreement with the school establishment and respected the Helsinki Declaration of 1975. Written consent from parents or guardians was obtained after they were thoroughly informed of the purpose and potential risks of the study. In addition, each child gave his/her verbal consent before participation.

**The 12 × 25-m Repeated-Sprint Test**

To ensure familiarization and reduce variability between test trials, children completed multiple trials once per week over one month before the first test (10,17). A 12 × 25-m repeated sprint test with sprints starting every 25-s was performed in a school sports hall after a 10-min warm-up period of active running at low intensity followed by dynamic stretching exercises. Each subject completed two sprints from a standing start over a 25-m marked distance. All subjects had a 5-min passive recovery period before the test. On completion of each 25-m sprint, each subject was required to decelerate to walking pace and then had a passive recovery period before the next sprint. Ten seconds before the verbal “go” command (at the start position) was given, the subject took a ready position 1m from the start gate and waited for a verbal command (steady, go). A standardized body position at the start of each sprint was used to minimize any variation across subjects in sprint start technique. On ‘go’, the subject broke the light beam of the electronic timing gates (Swift Speed Light, Australia) and the time over 25-m was recorded for each sprint. The test was repeated one week later by the same subjects in the same sports hall and at a similar time (between 8.30 and 10.00 a.m.). During both test sessions, four instructors were present and performed the
same tasks on each occasion: one conducted the warm-up session, two looked after the start procedure, and the latter collected data on sprint times.

The sprint distances used here were mainly due to space constraints within the testing area and which are commonly encountered in schools in France. The test design was similar to that employed in studies by Wadley and Le Rossignol (39), and Meckel et al. (18) both of which used a 12 × 20-m protocol with 20-s recovery period between efforts. The present authors feel that the present sprint test design was challenging enough for evaluating fatigue in children while allowing maximal performance to be maintained. The current number of efforts and rest period would provide an opportunity to test the individual’s ability to use their available ATP-CP stores as well as their aerobic system to produce a greater degree of ATP-CP replenishment between efforts (18). In addition, work by Glaister et al. (12) has demonstrated the absence of any learning effects from a similar protocol consisting of 12 × 30-m sprints repeated at 35-s intervals. Finally, previous studies have shown that an active recovery between sprint bouts may have potential suboptimal effects on repeated sprint ability performance (33,32). As one of the aims of this test was to provide age-related repeated sprint ability data in a group of young children, a passive recovery between sprint bouts approximately 18-s observed during the period of the test familiarization was used in an attempt to provide information on optimal repeated-sprint performance.

For each subject, performance in the repeated-sprint ability test was determined by calculating: total sprint time (TST), sprint time decrement performance (STDP), anaerobic power (AnP) and fatigue index (FI) for the latter parameter (7). The TST was determined using the sum of all twelve sprint times calculated in seconds. The ideal time was the best time (usually that of the first sprint). The STDP (%) was calculated as 100 [(TST / (ideal time × multiplied by twelve)]. For each sprint and for each subject, AnP for each sprint was calculated using the formula: AnP = (body mass) × (distance = 25m)²/(sprint time)³ (40). Maximal AnP and minimum AnP were used to determine the FI during the test. Thus, FI was calculated as follows: FI = (maximal AnP—minimal AnP)/TST.

Statistics
The STATVIEW software (StatView SE-Graphics, Abacus Concepts, Berkely, CA) was used for all statistical analyses. To examine the reliability of the present repeated sprint test, the intraclass correlation coefficient (ICC) and the mean values of the TST were compared for the test-retest in all subjects. The typical error of performance measures was presented as a percentage of the mean coefficient of variation (CV). Mean CV values with 95% confidence intervals (95% CI) were calculated from the log-transformed raw data. A two-way ANOVA with repeated measures with gender as the between-subject effect and sprint number as the within-subject effect was used to identify any effect of gender, sprint time and gender-time interaction. Follow-up univariate analyses using Bonferroni-corrected pairwise comparisons were employed where appropriate. To compare mean values obtained for fatigue index and performance decrement between across test trials and genders, a t test was employed. Simple regression analyses tested the relationship between TST, AnP, and STDP from the mean of the first and second trial combined and age in girls and boys. Significance was accepted when \( p < .05 \).
Results

Performance in this repeated sprint test demonstrated high reliability in children when presented as the TST. No difference was observed between the first and the second repeated sprint performance (75.9 ± 4.2 vs 75.3 ± 5.1 s, \( p = .108 \)) for the TST in all subjects. The test-retest measures yielded an ICC of \( r = .98 \) for the TST and the CV between the two trials was 0.7% (95% CI 0.6–0.9). For the entire population, high reliability between trials was obtained for both the FI (ICC, \( r = .99, p = .729 \)) and STDP (ICC, \( r = .99, p = .223 \)). The CVs for the STDP and FI were 0.7% (95% CI 0.6–0.8) and 5.7% (95% CI 5.0–6.6) respectively.

For all subjects combined, the time for the first sprint increased significantly from 6.09 ± 0.39–6.51 ± 0.36 s for the 12th sprint with a significant difference between each pair of subsequent sprints (\( p < .05 \)). No significant difference was obtained in sprint time across all sprints between genders (\( p = .304 \)) and performance was similar in each sprint. A significant main effect was observed for changes in sprint time in all subjects (\( p < .001 \)). In contrast, no significant interaction (\( p = .129 \)) was observed between gender and changes in sprint time (Figure 1). The STDP (3.3 ± 1.5 vs 3.4 ± 1.7%; \( p = .064 \)) and FI (0.32 ± 0.17 vs 0.28 ± 0.12; \( p = .205 \)) were similar in boys and girls.

Regression analyses showed that the TST decreased significantly in all participants with increasing age (\( p < .001 \)). No significant difference was observed between boys and girls (Figure 2). The STDP increased significantly (\( p < .001 \)) in girls and boys in relation to the increase in age, again, with no difference between genders (Figure 3).

Figure 1 — Changes in sprint time in girls and boys during a 12 × 25-m repeated sprint test with sprints starting every 25 s. *\( p < .05 \); difference between subsequent sprint times in boys or in girls.
Figure 2 — The relationship between total sprint time and age in boys and girls during a 12 × 25-m repeated sprint test with sprints starting every 25 s.

Figure 3 — The relationships between sprint time decrement percentage and age in boys and girls during a 12 × 25-m repeated sprint test with sprints starting every 25 s.
Across all subjects, AnP in watts (W) increased significantly from 555W to 1341W (\( p < .001 \)) with age. This increase in AnP was also accompanied by an increase in STDP but with no significant difference between genders (Figure 4).

**Figure 4** — The relationships between power and age in boys and girls during a 12 × 25-m repeated sprint test with sprints starting every 25 s.

**Discussion**

The present study assessed the reliability of a repeated sprint test: 12 × 25-m repeated sprint test with sprints starting every 25-s in young children aged 6–8 years. Performance in this population was characterized using measures of running speed, anaerobic power and resistance to fatigue. In all subjects, test-retest comparisons showed high reliability for repeated sprint performance when presented as TST and STDP. A significant increase in sprint time was observed from the third efforts onwards compared with the first sprint. For each sprint bout, the time to cover the distance was similar in girls and boys. A significant reduction in TST accompanied by a significant increase in AnP but also in STDP was observed in relation to the increase in age but these differences did not vary across genders.

There is a scarcity of data on the reliability of tests of repeated sprint ability in young children. To the best of our knowledge, the present test is the first to provide such information in children aged 6–8. The reliability of the present repeated sprint test years examined by test-retest measures demonstrated a high intraclass correlation coefficient and a low coefficient of variation for the TST and STDP. These indices have previously been described as reliable measures in tests of repeated sprint performance in other populations (1,18). Therefore, the present findings
also lend support to the choice of scores of TST (33) and STDP (11) as indices of performance in young children. In contrast, the coefficient of variation value for the FI was less reliable (5.7%). While this result partly agrees with previous research that FI scores should be viewed with caution (11) the present CV in young children demonstrates higher reliability than previously reported CVs in a range of populations (values between 11 and 50%) (23). The familiarization trials may partly explain the ability of the children to achieve similar sprinting performance during test-retest trials. This result may also be linked to a population-specific effect as younger children are limited in how much fatigue they can experience (29) and may therefore have less potential than adult populations for producing large variations in performance.

Tests of repeated sprint ability provide useful information on the ability of individuals to resist fatigue and maintain performance during multiple sprint exercise. In the present population, sprint times decreased significantly from the third to the final effort. This result is in line with the progressively impaired performance during multiple sprint work commonly reported in studies in subjects aged over 10 years of age (5,10,11,19,27). However, the STDP observed in this nonelite sporting population of young children (?3%) was slightly lower than that reported in highly trained elite male youth soccer players aged 11–18 (19), years and elite male adult hockey (34) and male professional soccer players (15) (all >4%). This finding may be linked to the generally higher resistance to fatigue during repeated bouts of high-intensity exercise in young children and even in those that are not sporting experts. Indeed, preadolescents benefit from a higher percentage contribution of oxidative metabolism and accumulate lower lactate concentrations in their blood than adults during high intensity exercise and generally recover faster than adults following short-term intense exercise (13,27).

In general, the ability to perform anaerobic work increases progressively during maturation until reaching that of adults after the teenage years (30). However, little information is available on differences in repeated sprint ability across younger age groups. In the present population, a decrease in total sprint time in older children was observed suggesting that sprint performance in repeated high intensity exercise improves with age. This finding is in part agreement with research recently conducted in elite highly trained Spanish youth soccer players (19). The authors observed a significant decrease in the total time in a repeated-sprint ability test with increasing age (from 11 to 14 years) in players. This improvement in repeated sprint velocity across age groups may be linked to increases in body mass, height and greater glycolytic capacity (35). In addition, AnP values (calculated using body mass and sprint times) were presently shown to increase substantially with age as performance was generally superior in older children. Although not measured in this study, greater muscle mass and changes in morphology, energy metabolism and neuromuscular activation are suggested to be responsible for greater anaerobic power with increasing age (27,29,36). Interestingly though, a plateau in total sprint time in the aforementioned elite Spanish youth soccer players occurred during maturation (from 15 to 18 years of age). Future longitudinal research would be useful to verify the potential existence in young nonspecialist populations of a performance plateau and from what age onwards this occurs.

The sprint time decrement percentage is used as a means for quantifying resistance to fatigue in tests of multiple-sprint performance (11,20). In the present population, lower sprint time decrement percentages were observed in the youngest
children suggesting that age plays an important part in the ability to recover during sprint exercise. While both velocity of sprints and total time to complete a repeated test protocol will improve with age, sprint decrement scores are likely to worsen as children in general, recover faster from sprint exercise than adult counterparts (22). This greater ability to recover between sprint bouts may be linked to a higher reliance on oxidative metabolism, faster phosphocreatine resynthesis, reduced glycolytic potential resulting in lower lactate accumulation and/or a greater ability to exchange and to remove lactate and hydrogen ions within muscles (18,27,36). In addition, the higher resistance to fatigue in children may be due to lower muscle mass. At the same relative work rate, smaller active muscle mass generates a lower absolute work rate and has a lesser effect on muscle fatigue (27). In contrast, Mujika et al. (19), observed no significant change with age in the sprint time decrement percentage during repeated sprints in elite youth academy soccer players belonging to age categories ranging from 11 to 18 years despite changes in body mass. Further investigation of the decreased resistance to fatigue during repeated sprinting protocols and its relationship with muscle mass is warranted in younger children.

In studies in young children, measures of aerobic and anaerobic fitness have shown that performance may differ between boys and girls (3) and that results from tests of repeated sprint ability are likely to be representative of gender (4). Therefore, it has been suggested that the type of protocol used to determine repeated sprint ability should be adapted to the gender of the subject (18). However, no differences in TST or STDP were observed between male and female children in the current study. This finding could be explained by the fact that the current population of boys and girls generally had similar anthropometric characteristics (body mass and body mass index) (31). Research on the ability to perform anaerobic work with data corrected for body mass has also demonstrated similar performance in 8 years old boys and girls (16). However, as variations according to gender in anaerobic performance and body mass occur throughout adolescence (35) we again suggest that further longitudinal research is required for the systematic collection and comparison of repeated sprint ability performance measures in boys and girls from childhood through adolescence to maturation.

In conclusion, the present test of repeated sprint ability: 12 × 25-m repeated sprint test with sprints starting every 25 s can be used as a reliable means to test repeated sprint performance in young children (6–8 years of age). The test is also relatively easy to perform, requires simple equipment and limited space. The results obtained provide useful information on repeated sprint ability and resistance to fatigue in young children and notably show that with age, a decrease in total sprint time during repeated short sprinting occurs and is accompanied by an increase in power output but also by a greater decrement in sprint time percentage. Furthermore, performance was notably similar across genders in these age groups. These findings could also play a role in helping coaches and trainers to assess the anaerobic qualities of young athletic talent, diagnose specific weaknesses, and provide information on changes in performance with age and gender.

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References


