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Research Article

Comparison of Cardiac Response and Performance in Children Aged 10-13 Years Old in 300 m and 25 m x 12 Races

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ABSTRACT

Background: Young people devote themselves to various types of physical activities among which the races chases. These last are characterized by multiple bursts of sprints over short distances with low recovery periods.

Objective: The study compared the effects of repeated sprints and continuous race on cardiac responses and performance in children.

Materials and Methods: 142 boys and 135 girls aged between 10-13 years in Cameroon college participated in two randomized tests separated by at least one week [25 m x 12 with sprints (S) starting every 25 seconds, and 300 m race (E)]. The durations of each sprint and E (at each 25 m) were collected. Cardiac responses were collected in continuous.

Results: The race time increased with the distance during both tests with significant differences ($p<0.001$) between each pair of 25 m. Total time obtained during S was significantly smaller ($p<0.001$) than that of E. Power decrement percentages were similar in both tests, maximal and minimal anaerobic power and the fatigue index were significantly higher ($p<0.001$) during S compared to E.

Conclusion: If the performance in terms of race duration was better for S compared to E, cardiac response remained similar in both tests.

Keywords: Children, Continuous Race, Heart Rate, Physical Performance, Repeated Sprints

Introduction

The practice of physical activity among young students is not limited to Physical and Sport Education (PSE) sessions. For example, during recreational breaks and weekends, young people devote themselves to various types of physical activities among which the races chases. These last are characterized by multiple bursts of sprints over short distances with low recovery periods.[1] Yet the continuous race, which takes often long-term, remains the main type of activity proposed to students in school during the PSE sessions to increase their endurance capacity. And that is surprising in comparison with the spontaneous activity of children and adolescents.[2] Moreover, short races series with short recovery periods would be more attractive because they characterize the best type of physical activity performed by children[3], contrary to continuous races which are monotonous and less attractive. Study of anaerobic function during growth has not received the same attention as aerobic function.[4] Information on the reliability of tests of repeated sprints ability and subsequent data on running performance are scarce in younger populations.[5] Many studies have assessed the repeated sprints ability of children, adolescents or adults.[5-9] Some of them have even assessed the influence of gender and age.[5,7] Feasibility and reliability to achieve a 25 m x 12 with sprints starting every 25 seconds, so that to characterize running velocity, anaerobic power and resistance to fatigue was already showed.[5] To have more information on physical performances in children during continuous race and repeated sprints races on a same distance, it was interesting to associate anthropometric characteristics and performances with cardiac responses.

Materials and Methods

Two hundred seventy-seven children (142 boys and 135 girls) aged 10–13 years participated in the current study. For boys and girls, respective values for age, mass, height and body mass index (BMI) were: 11.8 ± 1.1 vs. 11.6 ± 1.1 years; 37.7 ± 5.5 vs. 42.0 ± 8.3 kg; 146.4 ± 6.4 vs 149.1 ± 9.1 cm and 17.0 ± 2.5 vs. 18.7 ± 2.2 kg/m^2. Children, parents or tutors were thoroughly informed about the purpose and potential risks of the study. Written consent from parents or tutors has been obtained. In addition, each child gave his verbal consent before participation. The study was approved by the University of Douala Institutional Ethic committee for Human Research and was conducted in accordance with the Helsinki Declaration as amended in Fortaleza, in October 2013.

In the present cross-sectional study, two randomized races [25 m x 12 with sprints starting every 25 seconds (S) and the endurance race as 300m race (E)], separated by a week were made by children. The chronological age of the participants was used to compare them and to bring us closer to what is done during physical education and sport. They participated in S and E on the same playground in school establishment in the same period (between 8.00-11.00 a.m.) for the evaluation of their physical and physiological performance.

This track (Figure 1) was chosen because physical activity of children is characterized by multiple bursts of sprints over short distances and to overcome the constraints of space frequently encountered in schools and high schools in Cameroon. The design of the sprint test (straight line of 25 m) was identical to that used in the study by Temfemo A et al.[5] These authors used a protocol of 25 m × 12 every 25 seconds. Likewise, the test design was similar to that employed in studies of Wadley G and Le Rossignol P[10] and Meckel Y et al.[11] which used a 20 m × 12 protocol with 20 seconds recovery period between efforts. Moreover, the oval track gives the advantage to work over relatively long distances but in a reduced space. Preliminary practice trial sessions were conducted at least four times over one month before testing. That was to familiarize children with the protocols and reduce variability between test trials.[12,13]

Both tests were performed in a random order by girls or boys to minimize the order effect on performance across gender or test. 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 one hour before the test. Children should respect the instructions to give oneself up during repeated sprints and from the beginning to the end of endurance race. Each child was encouraged by the instructors and even the other participants: “go - go, go ahead - go ahead, forward run! - forward run!”

The measures of anthropometric characteristics were realized before the first test. For each session each child wore the heart rate monitor and started with a rest period of five minutes in a sitting position for the measurement of resting heart. After that the child passed to 10 minutes warm-up period of active running at low intensity followed by dynamic stretching exercises. Then the child continued with five minutes of passive recovery period before the start of each test. S was performed on a straight line of 25 m and E was on an oval trail traced (Figure 1). During S, we placed two photos electric cells in front of departure and arrival lines. The system went off at the passage of the child. It allowed us to have the right time performed at every sprint. Each child began every sprint by a standing start. Between sprints, each child observed at first an active recovery period by walking to return at the starting line. Then the subject observed a passive recovery period. Here the child was upright steady at one meter behind the starting line before next sprint. Before the start of the next sprint, the signal “at the start position” was given to each child, inviting the child to take a ready position at one meter from the starting line. Then, the subject expected steady standing about the verbal “go” command. At the beginning of each sprint, a standardized body position at the start of each sprint was used to minimize any variation across subjects in sprint start technique. After the “go” signal, the subject ran as quickly as possible through the distance to reach the finish line.

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The duration of each sprint on 25 m was recorded through contacts with the light beams of the electronic timing gates (Swift Light Speed, Australia) at the start and finish. During E, the subject was standing on the start line, and began to run after the "go!" signal. Durations were collected at the same time by two photoelectric cells and two experimenters placed at two different positions: at the start line and at a distance of 25 m. Thus, the duration performances were recorded every 25 seconds by the experimenters and the photoelectric cells.

During S and E, the duration effected by each child were collected at every 25 m. Then Anaerobic Power (AP) was determined by calculation according to the speed and weight of each child. Also, the Total Time (TT), the Percentage of Decrement Performance (PDP), the Anaerobic Power (AP) and the Fatigue Index (FI) were calculated. The TT was determined in seconds by the sum of all the durations on 25 m for S and taking the total duration E. The ideal time was the best time (generally the time of the first sprint). The PDP (%) was calculated as follows: 100 x [TT/ (ideal time multiplied by twelve)]. For each race and for each child, AP was calculated using the following formula: [AP = (body mass) x (distance = 25 m)^2/ (sprint time)^3].[14] We used the time of the first 25 m to calculate the maximal value of AP, and for its minimal value we used the time of the last 25 m. Maximal and minimal (AP_{max} and AP_{min}) were used to determine FI during the test. Thus, the expression used to calculate the FI was: FI = (AP_{max} - AP_{min})/ TT.[5]

Cardiac responses were recorded using the heart rate monitor (Polar RS800CX, Kempele, Finland) continuously from rest until the end of each test. During the S, different values of cardiac responses were taken during the resting period, at the end of the warm-up, at the beginning and end of each sprint and at the end of the final passive recovery period. However, during E, the cardiac responses values were also taken at the rest period, the end of the warm-up, the beginning and the end of E, and then at the end of the final passive recovery period. To specify the cardiac responses obtained at every 25 m in both tests, we did match the time recorded by the photoelectric cell with time inscribed on the heart rate monitor.

The Staview software (StatView*SE*-Graphics, Abacus Concepts, Berkely, CA) was used for all statistical analyses. The means and standard deviations of the TT, APmax, APmin, PDP, and FI of both tests were compared using Anova test (one group). Every 25 m the evolution of race times and cardiac responses were compared using Anova repeated measures. When the differences appeared, Post-hoc test of Bonféronni correction was used to localize them. Significance was accepted when $p<0.05$.

Results

During both tests (Table 1), TT was smaller ($p<0.001$) in S than in E, on the order hand, calculated AP_{max} and AP_{min} were greatest ($p<0.001$) in S than in E. However, no significant difference was observed for PDP in S and E despite a greater ($p<0.001$) IF observed in S compared to that of E. Race time (Figure 2) of all the children increases significantly ($p<0.001$) from the first to the last 25 m during S and E with lower values in S. For each age class, significant differences were observed between S and E on every 25 m (Figure 3). HR increases rapidly in the first 25 m for both tests to reach an unstable shelf until the end of each test without significant difference between S and E. For all the participants, significant difference appeared in cardiac response between S and E only during recovery period from the second ($p<0.05$) until the fifth minute ($p<0.01$) (Figure 4).

Table 1.Comparison of performance indices between S and E among 10-13 years

	S	E
TT	78.4±9.1	89.7±8.7***
AP_{max}	166.9±67.6***	104.9±43.7
AP_{min}	72.7±28.6***	46.3±14.6
PDP	119.71±6.34	118.01±6.36
IF	1.26±0.10***	0.68±0.44

Anaerobic power (AP_{max} and AP_{min}) in watts, E: endurance race (300 m), index fatigue (IF) in arbitrary unit, percentage of decrement performance (PDP) in %, S: repeated sprints (25 m x 12), total time (TT) in seconds, *** = $p<0.001$.

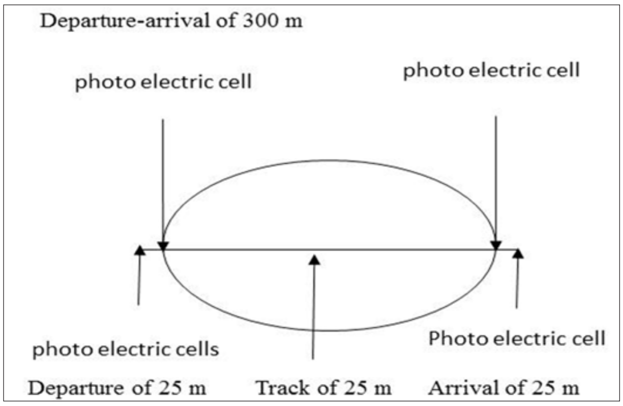

Figure 1.Tracks for S and E

S: repeated sprints (25 m x 12), E: endurance race (300 m)

Discussion

The aim of this study was to compare performance and cardiac responses in children aged 10-13 years during endurance race and repeated sprints on a small field (Figure 1). The results of this study were characterized by measures the race durations and cardiac response. The study showed similar cardiac responses between S and E for the entire population and even for age classes despite differences in race times with smaller values for S between both tests.

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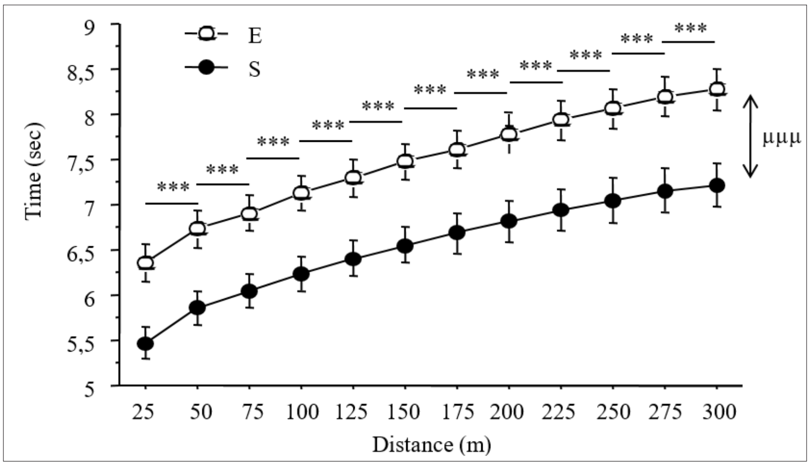

Figure 2.Evolution of the durations each 25 m during S and E

S: repeated sprints (25 m x 12), E: endurance race (300 m), *** = p<0.001: differences between times on successive 25 m, and µµµ = p<0.001 for difference between S and E during successive durations on 25 m

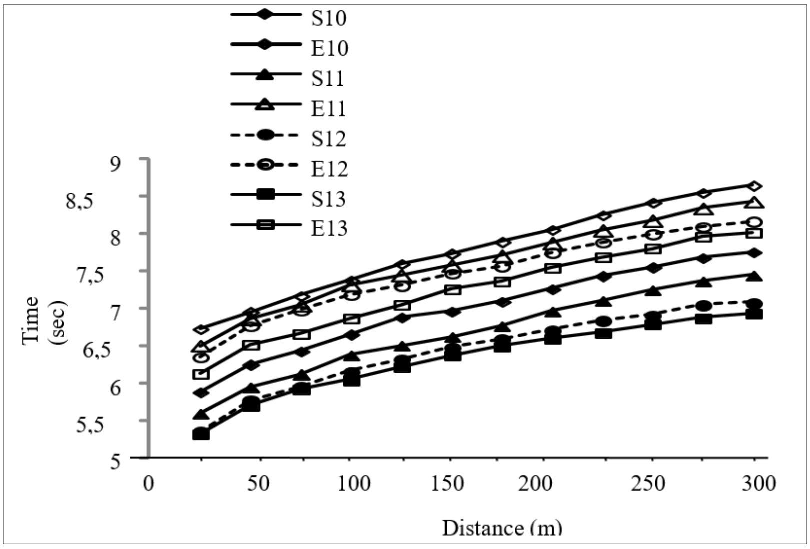

Figure 3.Evolution of the durations each 25 m races in relation to age during S and E

S: repeated sprints (25 m x 12), E: endurance race (300 m)

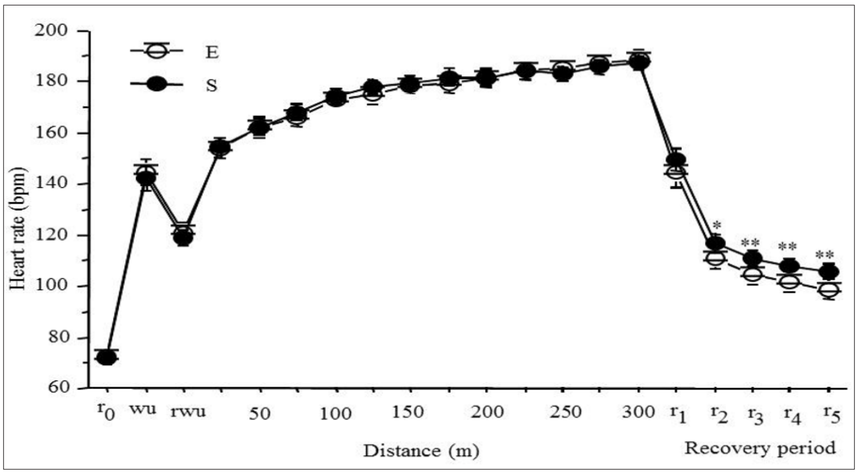

Figure 4.Cardiac response during S and E

At rest (r0); warm-up (wu); recovery after warm-up (rwu); recovery period during each test, after 1, 2, 3, 4, and 5 min (r1, r2, r3, r4, and r5). S: repeated sprints (25 m x 12); E: endurance race (300 m); * P < 0.05; ** P <0.01.

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Anaerobic performance of repeated brief efforts imposes a physiological stress, different from that of a single prolonged activity and, thus, may reflect different physiological capabilities.[15] Table 1 presents the differences between the performance indices (TT, APmax, APmin, PDP and IF) of both tests. Although, the total running distance in both tests was identical, the TT was significantly higher during endurance test. This difference could be the benefit of the recovery between sprints during S. Thanks to aerobic metabolism, recovery (in the present study, passive and active recovery) which is slipping between periods of efforts, would have allowed partially the restocking of phosphocreatine (PCr) and the decrease of blood acidosis, by the metabolic waste disposal like ions H^+ through the process of hyperventilation.[16] On the other hand, during the continuous activity (endurance), no recovery was occurred during the race. This is shown up by the reduction of restocking opportunities of PCr, as well as the waste disposal, because of the lack of oxygen (O_2). Thus, these two factors may be the cause of the significant decrease of performance during continuous activity as E.

Power is the product of force and velocity. Muscular power is an explosive aspect of strength. In our study the developed anaerobic power (APmax and APmin) was significantly greater in repeated sprints than during endurance (Table 1). This could be explained by a low TT obtained during the 25 m x 12 because the power is dependent on the race velocity. This result is all right with those of previous study[5] which reported an increasing of AP with age accompanied by the decrease of the TT in children less than 10 years during S. Furthermore, the control of the race by children could also explain differences of maximum and minimal power during repeated sprints and endurance. Indeed, sprint exercise control is different from the endurance one, because during a sprint, the individuals run at a maximum speed, while in endurance, speed is moderate to resist going through distance. However, during both races, all children received instructions to do their best. Thus, this control of the race had been possible due to familiarization effect of subjects with the protocol, which permit them to reach the end of each test. Indeed, Glaister M et al.[12] showed that learning (adaptation) sessions conducted before the test had an influence on the outcome of the test. To do this, they recommended reducing trial time before the test as far as possible.

The low TT obtained during S was accompanied by high AP_{max} and AP_{min} compared to those of E. Despite the lack of significant difference between the both races PDP, higher IF was obtained in S compared to that of E (Table 1). Therefore, more TT is small, great are AP and IF. Wadley G and Rossignol P.[10] showed that persons who are able to produce important maximal powers associated with best sprints times were probably more tired than their homologue who have not obtained the same results. This fatigue comes from their ability to use their stocks of PCr; understanding that the low recovery period did not completely restore stocks of PCr necessary for the next sprint and therefore the tiredness effect was more present. Hureau TJ et al.[18] demonstrated that both the peripheral and central fatigue contribute significantly to the decline in power output elicited via repeated sprints. In our study the variations between APmax and APmin during both tests confirm the fact that subjects who take part in repeated sprints were more tired than their endurance counterpart. For PDP, the lack of difference between S and E was in accordance with the findings of Meckel Y et al.[11] These authors found no significant difference in the performance decrement during the running sprint test of 20 m × 12 a full soccer game after warm-up before the game, at half-time, or the end of the game.

For all the participants and for the two races, the race time has increased from the first to the last 25 m, with significant differences between each pair of 25 m ($p<0.001$) (Figure 2). Also, differences of race times between pairs of 25 m increased with distance. At first, these results showed that the performance (race time) becomes weak with distance, but more during the continuous race than during repeated sprints. In fact, this result is in line with the study of Temfemo A et al.[5] that showed a significantly sprint times decreased from the third to the final sprint. Secondly, they demonstrate also the importance of the recovery on the capacity to maintain a consistent level of performance during the race. And finally, they point the possible role of metabolic waste accumulation in the performance decrease up. Milioni F et al.[20] showed that the oxidative pathway appears to play an important role in better recovery between sprints. Indeed, children should enjoy a recovery between sprints. That would allow maintenance of oxidative metabolism, rapid resynthesize of phosphocreatine, reduction of the glycolysis potential, which is able to cause a lower accumulation of lactate and/or a greater capacity of exchange and hydrogen ion disposal in the muscles, and also lactate disposal.[11] These results contrasted with E without recovery and with poor performance compared to S. In the present study, it correctly the faster sprinters will inevitably have a longer rest period between sprints than the slower sprinters - therefore greater recovery time, greater re-synthesis of PCr before following sprint. Besides, though we have not performed lactatemia measures in our study, we suggested it to be one of the responsible of the tiredness.[21] This is especially true when no possibility of recovery allows attenuating it concentration in the body (case of E). Dotan R et al.[22] showed that an elevated oxidative metabolism during active recovery, affects positively lactate removal.

The ability to perform anaerobic work increases progressively

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with age.[23] Temfemo A et al.[5] showed a decrease in total sprint time in older children and suggested that sprint performance in repeated high intensity exercise improves with age. However, no significant difference in race time on every 25 m was observed between age groups in their study. For Valente-Dos-Santos J et al.[24] the performance difference between early and late maturing players was consistent after about 13 years of age. Thus, the present study which showed an increase in race time (Figure 3) without significant difference between ages under 13 years was in agreement with the previous findings despite significant difference found between S and E with better performance during S. In fact, the anthropometric characteristics (size and weight) play an important role in the production of a better performance in sprints repetition.[25] This result underlined importance of race distance reduction and the recovery periods at 25 m x 12 for children.

The similar HR despite the higher TT obtained during the endurance race compared to those obtained during the repeated sprints suggest that repeating sprints could be used to aerobic training. In our study, cardiac response remained similar except during post exercise recovery ($p<0.001$) (Figure 4) (we observe from the second minute a decrease of HR more marked in continuous race compared to sprints). The recovery HR at the end of sprints remained higher compared to that of the endurance race. This is likely to eliminate the metabolic by products (lactate and H + ions) produced more markedly during the S. Indeed, Buchheit M et al.[26] showed that heart rate deceleration may be related, at least partly, to muscle power output and (or) associated blood acidosis and lactate accumulation in children after intense exercise, as well as the fact that, neural sympathetic activity may remain accentuated in individuals with higher post sprint blood acidosis, which likely slows recovery heart rate. Moreover, the recovery cardiac response is function of exercise work load;[27] and more the intensity of exercise is important, recovery is slow. In our study, AP results during sprints testify to the intensity with which made S compared to E. However, during the first minute, we no found difference between both races. This result is contrary to those of Ostojic SM et al.[28] who found that intermittent exercises caused a more decrease marked of HR compared to continuous exercises. The difference between their study and the present study could be due to the fact that they have worked with athletes specialized in each race and it weren't the same who participated in the two races. Specifically, during our study HR falls during the first two minutes of final recovery before declining gradually without reaching resting values. HR deceleration following exercise is controlled by complex interactions between neural and humoral factors.[29] Although, probably the strongest determinant of HR recovery is parasympathetic reactivation,[29] the progressive withdrawal of sympathetic nerve activity (with a decrease in the concentration of catecholamine) is also important.[30, 31] According to Perini and Veicsteinas[31] this decrease is between 30 and 35 beats per minute (in this study, the fall was approximately 35 to 40 beats per minute). Nevertheless, the cardiac response remained similar at rest, warm-up, and during S and E. The exercise HR increases quickly in proportion to the intensity of the exercise until a balance tray which will enable it to meet the energy needs of the body. This tray balance would be near to the maximal HR beyond which any increase in intensity does no increase in heart rate,[32] which may explain the similar cardiac responses between E and S.

Conclusion

The results of our study made it possible to understand that the practice of repetitive sprints in children could be used as much as the endurance race. The performance in both races was more efficient during the repetition of the sprints despite a similar heart rate. For this reason, the repeated sprints could be more offered to students during physical education and sports to increase their performance and aerobic capacity.

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Conflicts of Interest: None

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